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FULL REPORT:

Investigating the Differential Academic Outcomes of Career and Technical Education (CTE) Students in Pennsylvania (PA) Secondary Schools

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Pennsylvania Department of Education

Office of Administration



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**Research and
Evaluation**

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Abstract

The present study compared academic outcomes for career and technical education (CTE) students and non-CTE students in Pennsylvania (PA). Using statewide student population data from the Pennsylvania Information Management System (PIMS), three cohorts of Pennsylvania high school students ($N = 418,341$) were tracked from Grade 9 entry to various points in their postsecondary education through 2017-18. Academic outcomes (standardized state assessment performance, on-time high school graduation, postsecondary enrollment, persistence, retention, and degree completion) were compared based on CTE participant status, defined by the Pennsylvania Department of Education (PDE) as the completion of at least 10% of a CTE program. Outcomes within the CTE student population were likewise differentiated based on the percentage of the program that students completed (i.e., program intensity, CTE concentration, and CTE completion status) and the program characteristics (i.e., internship, work-based experience, postsecondary credit earning, etc.) in which students elected to participate. Results of the chi-square and logistic regression analyses found that CTE participants in PA had significantly lower odds of achieving all academic outcomes, except graduating on-time from high school. These odds differed for CTE participants by the intensity of students' respective programs, such that CTE students who persisted along their program sequences to concentration or completion were often less involved in traditional 4-year degree seeking opportunities. Finally, CTE participants who took advantage of the various program characteristics available to them often had higher odds of pursuing further postsecondary education. Implications and recommendations for state stakeholders are discussed.



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Career and technical education in Pennsylvania offers unique academic experiences and is therefore associated with distinctive student outcomes.

Introduction

It is estimated that six million jobs were available in the United States by the first quarter of 2017 (Ydstie, 2017), yet 7.6 million Americans remained unemployed (Brundage & Cunningham, 2017). The United States Bureau of Labor Statistics reports that as workers pursue further educational attainment, the unemployment rate decreases, while median earnings increase (Chen, 2017). It is therefore concerning that as of 2015, 67.5% of the nation's population over the age of 25 had less than a bachelor's degree (U.S. Census Bureau, 2015). Relative to higher degree earners, this demographic majority has struggled to find jobs earning middle-class wages, contributing to an economic gap based on educational attainment. Career and technical education (CTE) aims to address this gap by offering high school students the opportunity to develop pertinent skills for workforce entry or further postsecondary education.

Career and technical education in Pennsylvania offers unique academic experiences and is therefore associated with distinctive student outcomes. This study is intended to inform the Pennsylvania Department of Education's efforts to improve educational outcomes for students in the state by investigating a) which student groups in Pennsylvania schools elect to participate in CTE programs, b) how these students differ from non-CTE students in terms of educational outcomes such as academic performance, high school graduation, and postsecondary enrollment, and c) how CTE student outcomes differ depending on the circumstances of students' respective CTE programs (i.e. participation in work-based learning experiences, postsecondary credit earning, and percentage of the program they complete).

History of Career and Technical Education

When the National Commission on Excellence in Education released their report in 1982, *A Nation at Risk*, it disrupted the status quo in public education by calling for higher academic expectations of students through a more standardized national curriculum (NCEE, 1982). The United States, it argued, could no longer compete in a global economy without the appropriately skilled labor force that the new 'Information Age' demanded. All educational programs, including CTE, should instead be equipped to prepare students with an academic competence far and above what was provided by the education system of the time (NCEE, 1982).

In response, the United States reauthorized a version of the Carl D. Perkins Career and Technical Education Act, known as Perkins IV (2006) [later reauthorized in 2018 as Perkins V], with the explicit purpose to “develop more fully the academic and career and technical skills of secondary education students who elect to enroll in CTE programs” (Carl D. Perkins Career and Technical Education Improvement Act, 2006). Notably, the Act introduced national standards for career and technical programs of study (POS). Career and technical POS are focused and structured course sequences which aim to prepare students for high-skill occupational trajectories by accomplishing the following: combining secondary and postsecondary educational opportunities; synthesizing appropriately rigorous career and technical, as well as academic, curricula; offering dual/concurrent enrollment opportunities, when possible; and priming students for industry certification or further postsecondary degree acquisition (Carl D. Perkins Career and Technical Education Improvement Act, 2006).

In Pennsylvania, the Students Occupationally and Academically Ready (SOAR) educational plan establishes the state’s standards for POS in PA schools (Pennsylvania Department of Education, 2017). SOAR requirements mirror those outlined in Perkins IV, with the added stipulation that programs must align with High Priority Occupations (HPO) identified by the PA Department of Labor and Industry, collaborate with postsecondary institutions by providing opportunities for postsecondary credit-earning or industry certification, and culminate in an end of program assessment (Pennsylvania Department of Education, 2017).

Key definitions related to career and technical education changed with the passing of Perkins V in 2018. As the present study utilizes data from 2010-11 through 2017-18, the researchers defer to PDE’s definitions during Perkins IV. Federal accountability during Perkins IV required all states to annually report on key CTE performance indicators; however, states often used different definitions to identify their CTE student populations. While many states defined CTE participation and concentration based on the number of CTE credits students earned, Pennsylvania’s definitions relied on the percentage of technical hours completed during a CTE program. During Perkins IV PDE defined a CTE participant as “a student, who by the end of the reporting school year, was reported as having earned at least 10% of the minimum technical instructional hours required for Pennsylvania Department of Education program approval (Pennsylvania Department of Education, n.d.-a).” Students could likewise qualify as CTE concentrators by earning at least 50% of the minimum technical hours for their program (Pennsylvania Department of Education, n.d.-a). For more detail on the terms and definitions used throughout this report, refer to the Methods section or Appendix A.

In Pennsylvania, the Students Occupationally and Academically Ready (SOAR) educational plan establishes the state’s standards for POS in PA schools (Pennsylvania Department of Education, 2017).

CTE Student Population

The issue of exactly *who* commonly elects to participate in CTE is clarified by national and state research. According to the National Center for Education Statistics (2013), most high school graduates in 2013 participated in at least one CTE credit, although males did so at a slightly higher rate (84.7%) than females (76.9%). In a sample of 2016 high school graduates, female students in Texas had a higher rate of CTE ‘concentration’, indicating enrollment in three or more CTE credits in a particular subject field of study (Giani, 2019). In terms of race, the National Center for Education Statistics (2013) found that white

and Black students had similar rates of CTE course enrollment, although a greater proportion of white students ‘concentrated’ in a particular field of CTE. These racial differences may be attributed to differences in access; in fact, a national study by the U.S. Department of Education found that Black students had less access to CTE than white students (Arbeit et al., 2017).

CTE enrollment likewise appears to differ by socio-economic status (SES). In one study, students in the highest SES quartile were less likely to participate in CTE than those in the second SES quartile (Arbeit et al., 2017). Although the CTE population overall appears more likely than non-CTE students to have experienced economic disadvantage (Palmer & Gaunt, 2007), Texas students ‘concentrated’ in CTE at a similar rate, regardless of economic status (Giani, 2019). Participation in CTE may also differ by Special Education and English learner (EL) status. Special Education and EL students in Oregon had lower rates of participation in CTE compared to other student groups (Arneson et al., 2020), although other studies (Arbeit et al., 2017) report inverse or negligible differences in CTE involvement. Finally, noted disparities in access based on geographic locale may be associated with CTE enrollment. The U.S. Department of Education found that nationally, students from urban areas were more likely to have access to CTE than suburban students in the cohort (Arbeit et al., 2017). While these findings describe the demographics of former CTE secondary students across the nation, more research is needed to identify the CTE population in Pennsylvania schools.

In terms of race, the National Center for Education Statistics (2013) found that white and Black students had similar rates of CTE course enrollment, although a greater proportion of white students ‘concentrated’ in a particular field of CTE.

Academic Outcomes of CTE

Academic Performance

CTE students appear to differ from non-CTE students in terms of academic performance. Several studies have found that CTE students are likely to have lower grades and GPAs than non-CTE students (Dietrich et al., 2016; Palmer & Gaunt, 2007; Stone & Aliaga, 2005). This disparity in academic performance may even differ within the CTE population, depending on the percentage of the program students complete. One study comparing CTE programs of study at three school districts found that CTE ‘completers’, who successfully finished their POS, had higher GPAs than CTE concentrators (Castellano et al., 2014).

Still, research comparing CTE student performance on standardized assessments is more ambiguous. Despite research from Dietrich et al. (2016) which found that community college applicants who had participated in CTE during high school had lower ACT scores compared to college preparatory or general curriculum students, it is unclear whether CTE students differ substantially from their non-CTE peers in terms of state standardized test performance. Although there is evidence that Reading integration in CTE courses may improve subject assessment outcomes (Pierce & Hernandez, 2014), studies identifying a clear difference in standardized test performance depending on CTE enrollment are lacking.

Several studies have found that CTE students are likely to have lower grades and GPAs than non-CTE students (Dietrich et al., 2016; Palmer & Gaunt, 2007; Stone & Aliaga, 2005).

In Pennsylvania, Keystone state standardized exams satisfy national accountability requirements established in the Every Student Succeeds Act (ESSA). Secondary students can demonstrate readiness for graduation by proving subject-matter competency through grades, plus any of the following: satisfying a composite score on the Keystone state assessment exams or passing each subject test individually (Algebra, Biology, and Literature); satisfactorily completing approved additional coursework (AP, IB, concurrent enrollment) or assessments (SAT, PSAT, ACT, ASVAB); exhibiting clear evidence related to postsecondary plans; or, in the case of CTE concentrators, proving success through the National Occupational Competency Testing Institute (NOCTI)/National Institute for Metalworking Skills (NIMS) assessments (Pennsylvania Department of Education, n.d.-b).

The Keystone exams have been a graduation requirement for PA students since their introduction in 2013-14, when they replaced the Pennsylvania System of School Assessment (PSSA) for high school students. However, these additional routes to graduation do not become effective for students until the 2021-22 school year. Although the Keystone exams have been used as one standardized method to evaluate students' readiness for high school graduation, future cohorts of PA students will be able to prove postsecondary readiness by other routes than standardized test scores. Regardless of how students ultimately prove postsecondary readiness, all Pennsylvania students are required to take the Keystones as end-of-course assessments. The present study uses Keystone exam achievement data to make comparisons between CTE and non-CTE students regarding academic performance in high school.

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High School Graduation

Several studies indicate that CTE coursetaking in general is associated with high school graduation (Dougherty, 2016; Castellano et al., 2014). However, considering the various student groups who participate in CTE courses, it is unsurprising that this positive influence on high school graduation is inequitably experienced throughout the CTE student population. Certain factors, like course load, gender, and Special Education status may modulate a student's likelihood of graduating high school.

Certain factors, like course load, gender, and Special Education status may modulate a CTE student's likelihood of graduating high school.

Student outcomes appear to differ based on the particular course load that CTE students adopt. Plank (2001) found that the odds of a student dropping out of high school were lowest for students taking a ratio of 3 CTE credits for every 4 academic credits, particularly for students considered 'high risk' of dropping out. Likewise, Dougherty (2016) found that CTE concentrators had higher rates of high school graduation than non-concentrators with similar demographic characteristics. These findings suggest that beyond mere CTE enrollment, student outcomes like high school graduation differ depending on the amount, or *intensity*, of career and technical education that students adopt in their course loads.

The intensity of student course loads is somewhat moderated by demographic characteristics like gender and Special Education status. Although Dougherty (2016) found that female students were more likely than males to concentrate in a CTE field of study, the benefits of CTE concentration for high school graduation were especially positive for male students. Likewise, CTE concentration has been

linked to increased high school graduation for secondary Special Education students (Theobald et al., 2019). These benefits to high school graduation rates based on CTE concentration are notable, yet the majority of CTE students are non-concentrators. According to the U.S. Department of Education (2019), while most national graduates participate in at least one CTE course during their high school career (commonly Home Economics or Technical Education), only 37% elect to concentrate in an occupational field. It is also important to note that while CTE participation may be associated with increased high school graduation rates, whether CTE concentrators graduate at higher or lower rates than ‘academic concentrators’ or college prep students is ambiguous in the literature (Loveless, 2011; Stone & Aliaga, 2005).

Student high school graduation status appears to also depend in part on the characteristics of the CTE program of study. Work-based learning (WBL) opportunities are key characteristics offered in many CTE programs. The U.S. Department of Education (2019) reports that most CTE programs offer WBL experiences, such as the following: on-the-job training, internships, practicums, clinical experiences, or cooperative education (77%); postsecondary credit-earning opportunities (73%); and mentoring by local employers (65%). Apprenticeship and pre-apprenticeship opportunities are less common, offered by only 31% of school districts with CTE programs.

Several studies highlighting the role of WBL revolve around the School-to-Work (STW) initiative of 1994, during which schools in the United States developed systems of partnership with business and community organizations to prepare students for transition to the workplace. Rivera-Batiz (2003) found that participation in any WBL opportunity (internships, apprenticeships, career academies) during STW significantly reduced the likelihood of high school dropout for students in the study. Likewise, according to the Westchester Institute for Human Services Research (1997), STW elicited positive effects on attendance, a factor related to increased odds of high school graduation (Allensworth & Easton, 2007), even and especially for students considered to be a ‘high risk’ of dropout.

While these findings highlight the effects of STW on high school graduation, they provide insight to the outcomes associated with WBL opportunities in general. Despite evidence suggesting the benefit of WBL experiences, twenty-five percent of U.S. school districts in the 2016-17 school year did not require a WBL experience during the course of their CTE programs (Gray & Lewis, 2018).

Although participation in CTE has differential effects on high school graduation depending on a variety of student- and program-level factors, the research clearly suggests increased odds of high school graduation for the CTE student population, though not necessarily greater odds than non-CTE students.

According to the U.S. Department of Education (2019), while most national graduates participate in at least one CTE course during their high school career (commonly Home Economics or Technical Education), only 37% elect to concentrate in an occupational field.

Postsecondary Enrollment

Perkins IV introduced CTE programs of study because educators and legislators recognized the need for curriculums that serve the interests of non-college bound students. It is therefore unsurprising that CTE students also tend to differ from non-CTE students in terms of their academic trajectories after high school. The National Center for Education Statistics (2017) reports that it is less common for CTE students to enroll in postsecondary education after high school than their non-CTE peers. Moreover, students who earn more CTE credits in high school enter postsecondary at lower rates than students who

take fewer CTE courses, with CTE concentrators having the lowest rates of postsecondary enrollment (National Center for Education Statistics, 2017). Combined with research on student attitudes, which revealed that CTE concentrators had lower expectations of completing a 4-year degree than students enrolled in a general or primarily academic curriculum (Stone & Aliaga, 2005), it is evident that students who participate in career and technical education in high school are less likely to pursue the same postsecondary trajectories as their non-CTE peers.

One possibility is that students who participate in CTE simply prioritize different postsecondary programs. According to one source, most students aspire to some form of postsecondary degree completion, regardless of their high school curriculum-type (Bromberg & Theokas, 2016). Furthermore, Dietrich et al. (2016) found that community college students who enrolled in CTE during high school were less likely to continue to a 4-year institution, but more likely to earn an associate degree or certificate than their non-CTE peers. Another study found that CTE students who enrolled in college completed ‘vocational’ programs at a higher rate than non-CTE students, while those who did not enroll in college were more likely to find full-time work in the three years following high school graduation (Cowan et al., 2020). These combined findings suggest that CTE participation in high school is associated with lower rates of enrollment at 4-year postsecondary institutions, but increased participation in alternative, shorter-term credential programs and full-time employment opportunities.

Main and Secondary Research Questions

Considering the previous literature, the current study addresses the following question from the PDE research agenda, which was identified as a priority by state stakeholders:

How do the educational and labor market outcomes for students who completed career and technical education coursework and programs of study in high school compare with students who did not complete CTE coursework in high school?

Although the researchers did not have access to the workforce data necessary to answer the above question in its entirety, the educational outcomes of CTE students in Pennsylvania remain of interest to state policymakers. The present study investigated the following research questions specifically, including one main research question and two secondary research questions.

Main Research Question:

1. How do CTE students differ from non-CTE students in Keystone exam performance, and rates of on-time high school graduation, postsecondary enrollment, persistence, retention, and degree completion?

Secondary Research Questions:

1. What is the demographic description and breakdown of the CTE student population?
2. To what extent do CTE student outcomes differ depending on the characteristics (i.e. work-based experiences, internships, postsecondary credits earned) and ‘intensity’ (i.e. CTE concentrator and CTE completer status) of the CTE program curriculum?

Method

Sample

Three cohorts of Pennsylvania students were followed from Grade 9 entry until varying points in their postsecondary education by 2017-18. The first cohort followed 140,299 students from Grade 9 in the 2010-11 school year until on-time college graduation in school year 2017-18. The second cohort followed 139,071 students from Grade 9 entry in 2011-12 until their third year of college in 2017-18. The final student cohort followed 138,971 students from Grade 9 entry in 2012-13 until their second year in college during school year 2017-18. All 418,341 students across the three cohorts attended a public Pennsylvania local educational agency (LEA), Intermediate Unit (IU), public charter school, or public cyber charter school. Table 1 displays the educational outcomes that could be tracked for each cohort of students. For a full demographic breakdown of all students included in the cohort files, refer to Table B1 of Appendix B.

TABLE 1: Educational Outcomes by 9th Grade Cohort

Outcome	Cohort 1 2010-11 (N = 140,299)	Cohort 2 2011-12 (N = 139,071)	Cohort 3 2012-13 (N = 138,971)
Keystone Exam Performance			✓
On-time High School Graduation	✓	✓	✓
College Enrollment	✓	✓	✓
Persistence & Retention to Year 2	✓	✓	✓
Persistence & Retention to Year 3	✓	✓	
College Graduation (with any degree, within 4 years)	✓		
Retention to College Graduation	✓		
Highest Degree Type	✓		

*Note: Although the Keystone exams were a graduation requirement for students in all 3 cohorts, Keystone exam data were only available in PIMS for the 2014-15 school year and beyond, limiting analysis to the 2012-13 cohort.

Identifying Pennsylvania's CTE Population

To answer the main research question, the CTE student population needed to be identified in contrast to the non-CTE population. Students were identified as *CTE participants* if they completed at least 10% of their PDE-approved CTE program, according to the CTE Student Fact template of the Pennsylvania Information Management System (PIMS). CTE participants were not differentiated based on CTE delivery method (i.e., occupational, tech prep, POS), although Adult Affidavit Program students were excluded from analysis. To answer this primary research question, academic outcomes were compared between CTE participants and non-CTE students.

The secondary research questions required the comparison of outcomes depending on CTE participants' program characteristics and the percentage of the program they completed. Variables indicating percentage completed, or program *intensity*, included whether the student completed their CTE program (*CTE Completion*) or if they met PDE's definition for CTE program concentration by completing at least 50% of their program (*CTE Concentration*). Variables of intensity indicate how far CTE participants elected to progress along their respective program sequences; they are not an indicator of the quality or difficulty of the program itself.

Students were likewise differentiated depending on their participation in any of the CTE *program characteristics* listed below. Program characteristics of interest included whether the CTE participant was reportedly involved in an internship, cooperative work experience, job exploration, work-based experience (*WBE*), or earned postsecondary credit at some point during their high school CTE program. This study aims to inform career and technical education policy by clarifying the impact of these program experiences on students' educational trajectories.

Procedures and Data File Preparation

This study utilized population cohort files assembled for previous Commonwealth reports (Miller et al., 2019; Miller, Hutchison, & Riccardo, 2019). All data used for these files were pre-existing, housed in various locations. Research questions were addressed through the analysis of linked PIMS datasets and National Student Clearinghouse (NSC) records. For the three cohorts studied, PIMS data were obtained for school years 2010-11 through 2016-17, while NSC records were obtained through 2017-18 for PA high school graduates from the class of 2014, 2015, and 2016.

PIMS data were used to gather demographic and descriptive information for the sample. The PIMS Student template was used to report student-level demographic data, including gender, race/ethnicity, Special Education status, EL status, and economic disadvantage status. Graduation Cohort data files compiled by PDE described the status of each year's graduating high school class, including demographic information.

The CTE Student Fact template described vital information specific to career and technical education students, such as the percentage of the program students completed, and indicators describing a CTE student's program, internship, or work-based experiences. Students present in the CTE Student Fact template during the years studied must have been "actively enrolled in the technical component of a PDE-approved secondary reimbursable CTE program during the reporting year and have a completed and signed 'Annual Educational and Occupational Objectives for Students Enrolled in a PDE-Approved CTE Program' form (PDE-408) or a similar, locally-developed form directly related to the student's enrollment in the CTE program reported within PIMS". Students in these files may have participated in "occupational," "tech prep" or "program of study" program delivery for secondary CTE. This study excluded students registered for the adult affidavit program.

Data from the Pennsylvania Keystone standardized exams were included to indicate students' academic performance. The Keystone tests are end-of-course exams which measure achievement in various subject areas, including algebra, biology, and literature. Dichotomous indicators of overall achievement level reflecting advanced/proficient and basic/below basic were used in analysis. Keystone end-of-course assessment performance was limited to the 2012-13 cohort because Keystone data were not available in PIMS until the 2014-15 school year. Due to limitations in data access, CTE students' performance on NOCTI/NIMS assessments or certifications were not included in analysis. Using Keystone exam achievement to indicate academic performance also allowed for comparison between CTE and non-CTE students.

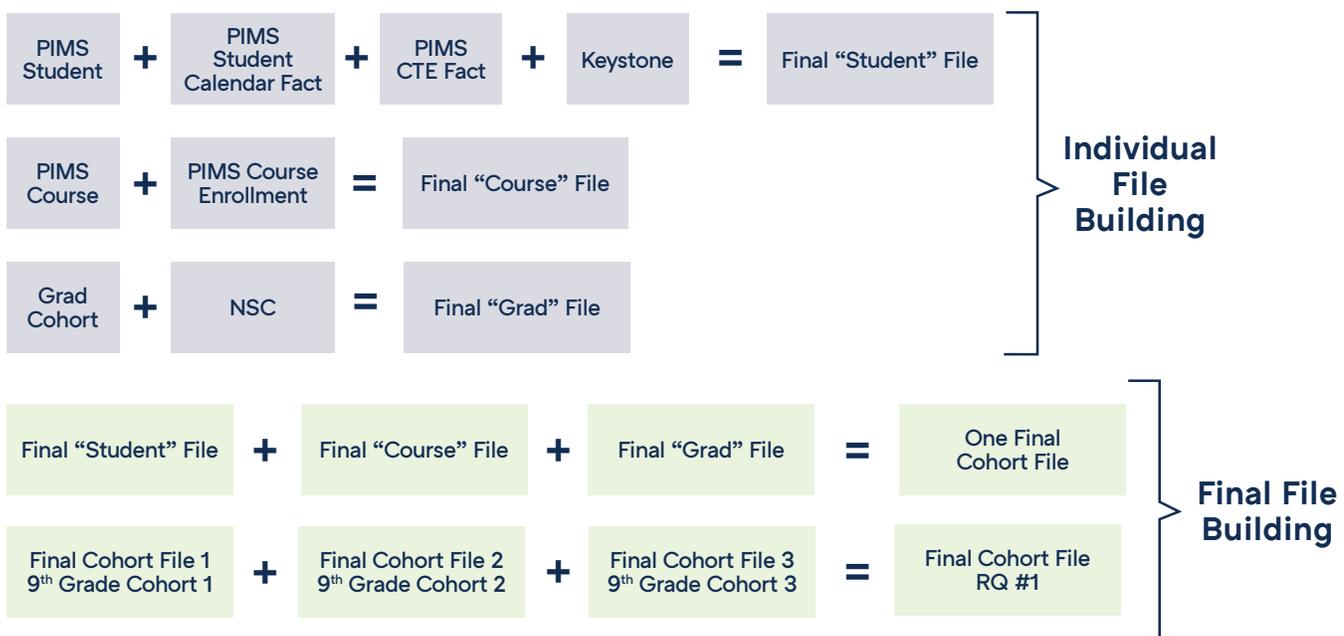
Two main data sources were used to determine high school graduation status and postsecondary trajectory. The Graduation Cohort data files provided high school graduation records, including an indicator for four or five-year high school graduation. National Student Clearinghouse data tracked students' postsecondary trajectories after high school graduation. The NSC data reported student records for college enrollment, institution type (2-year versus 4-year), enrollment status (part-time versus full-

time), graduation status, degree type (associate/certificate versus bachelor’s), and other information related to a student’s postsecondary tenure. NSC files were matched with Graduation Cohort data files based on high school graduation year.

As previously mentioned, the current study relied on cohort files assembled for other PDE reports. The linkage process for the above datasets, in chronological order, can be found in Figure 1. The PIMS Student template was linked to the PIMS Student Calendar Fact to observe student characteristics, including demographic and enrollment information. This combined file was then merged with the PIMS CTE Student Fact template, centrally locating all student-level descriptive information. Next, the PIMS Course template was linked with the PIMS Course Enrollment template to obtain detailed course enrollment records for each student in all cohorts. These course data were necessary for previous PDE reports; however, student course data were not utilized in the present study. At this time, the file containing all student-level descriptive data was linked to the file containing all course and course-enrollment information. Next, Keystone data were linked only for the third cohort, as reporting of this information did not become standard in PIMS until the 2014-2015 school year.

After these steps were completed, three cohort files were built to represent each Grade 9 cohort. Students who entered Grade 9 during the 2010-11 school year were contained in the first cohort file, those who entered Grade 9 in 2011-12 in the second, and students who entered Grade 9 in 2012-13 in the final cohort. Each cohort file was then linked to corresponding NSC data to match the cohort’s high school graduation year. Finally, all three cohort datasets were combined to create one file with the final sample for analysis.

FIGURE 1: Linking Process for all Data Files



These data were analyzed using varied analytic methods, that included descriptive statistics, chi-square, and binary logistic regression analyses. Results were disaggregated and differentiated by student groups that are of interest to state policymakers, including race/ethnicity, gender, socioeconomic status, English learner (EL) status, and Special Education status. The analyses were exploratory in nature, which allowed for examination of several individual variables that could be associated with high school and postsecondary outcomes. In the first phase of analysis, CTE student population characteristics were compared and examined descriptively to explore patterns and differences in outcomes associated with each independent variable individually. In the second phase of analysis, logistic regression was used to explore the cumulative effects of variables associated with each outcome in the final statistically significant model.

Results

What is the description and breakdown of the CTE student population?

In this section, the demographic breakdown of the CTE student population is discussed. For a detailed descriptive breakdown of the overall student population by cohort, see Table B1 in Appendix B.

Among the 418,341 students in all cohorts, 18.7% ($N = 78,228$) of the total population were identified as CTE participants, indicating they remained in a PDE-approved CTE program for at least 10% of its duration.

Among CTE participants, 57.5% were male. The majority of CTE participants were white (73.3%), followed by Black/African American (13.7%), Hispanic (10.0%), Multi-racial (1.5%), and Asian (1.3%). American Indian/Alaskan Native and Native Hawaiian or other Pacific Islander students constituted a combined 0.2% of the population.

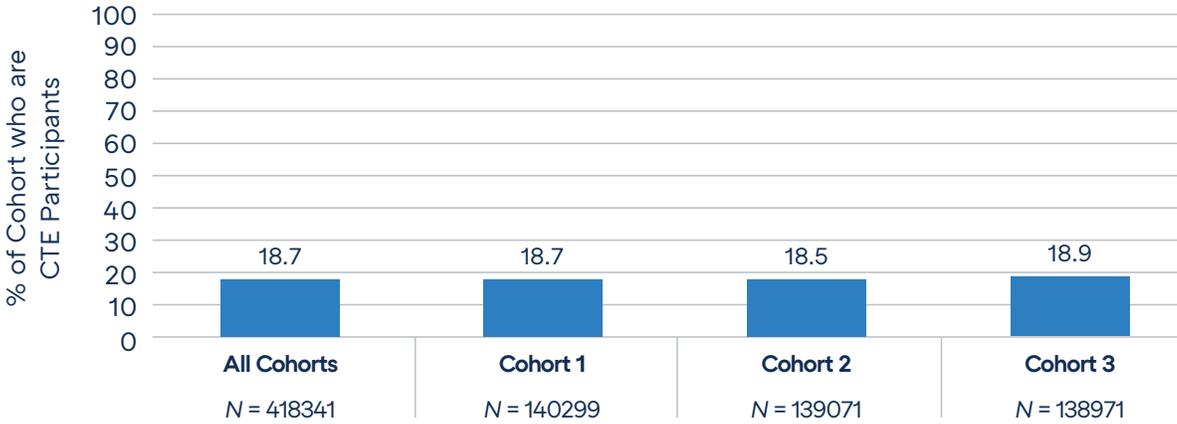
Most CTE participants (62.7%) qualified as historically underperforming (either EL, Special Education, or economically disadvantaged). Over half (51.4%) of CTE participants were economically disadvantaged, 25.6% were Special Education students, and 1.9% were EL.

Finally, the CTE student population attended high schools in various geographic locales. The greatest proportion of CTE participants attended high schools in suburban areas (32.4%), followed by 22.6% from rural areas, 17.2% from urban/city areas, and 13.7% from towns. The remaining 14.2% of CTE participants were missing geographic data, indicating students who attended more than one LEA, from different geographic locales. These transfer students were excluded from the geographic analysis.

The greatest proportion of CTE participants attended high schools in suburban areas (32.4%), followed by 22.6% from rural areas, 17.2% from urban/city areas, and 13.7% from towns.

Table B2 in Appendix B provides the CTE student demographic breakdown by cohort. Demographic proportions were relatively stable across cohorts. As the proportion of CTE participants remained similar across years (see Figure 2), the researchers felt justified in combining cohorts for analysis.

FIGURE 2: CTE Participants by Cohort



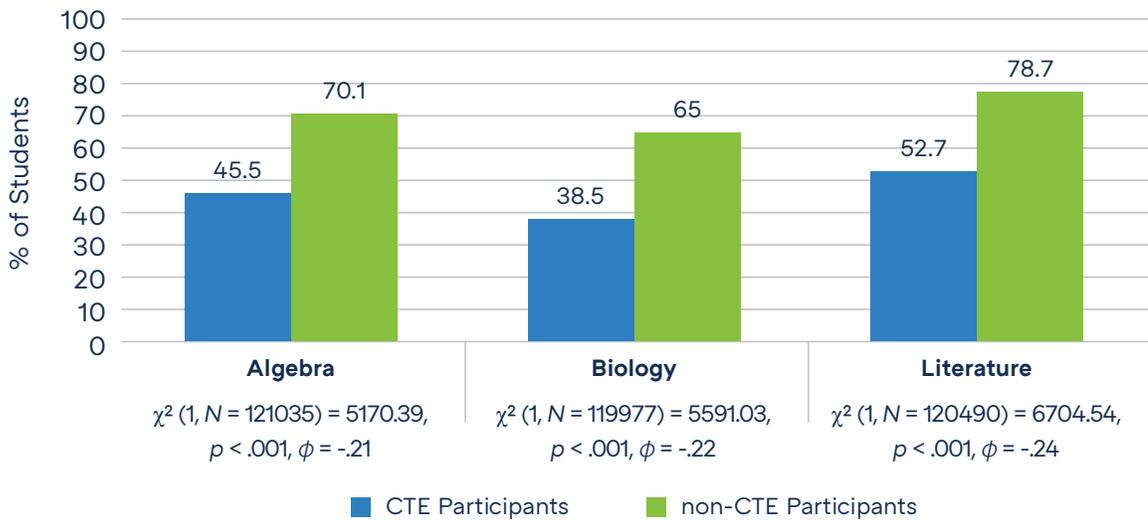
How do CTE students differ from non-CTE students in rates of Keystone exam passing, on-time high school graduation and postsecondary enrollment, persistence, retention, and degree completion?

Chi-square Analyses

Keystone Exam Performance

Analysis of Keystone end-of-course assessment performance was limited to the 2012-13 cohort because Keystone exam data were not available in PIMS until the 2014-15 school year. Figure 3 shows the percentage of students who scored advanced/proficient on each Keystone exam, by CTE participant status. A significantly lower percentage of CTE participants scored advanced or proficient on the Algebra (45.5%), Biology (38.5%), and Literature (52.7%) exams when compared to non-CTE students (70.1%, 65.0% and 78.7% respectively). These differences were found to have moderate effects ($\phi = -.21$, $\phi = -.22$, and $\phi = -.24$).

FIGURE 3: Advanced/Proficient Performance on the Keystone Exams by CTE Participant Status

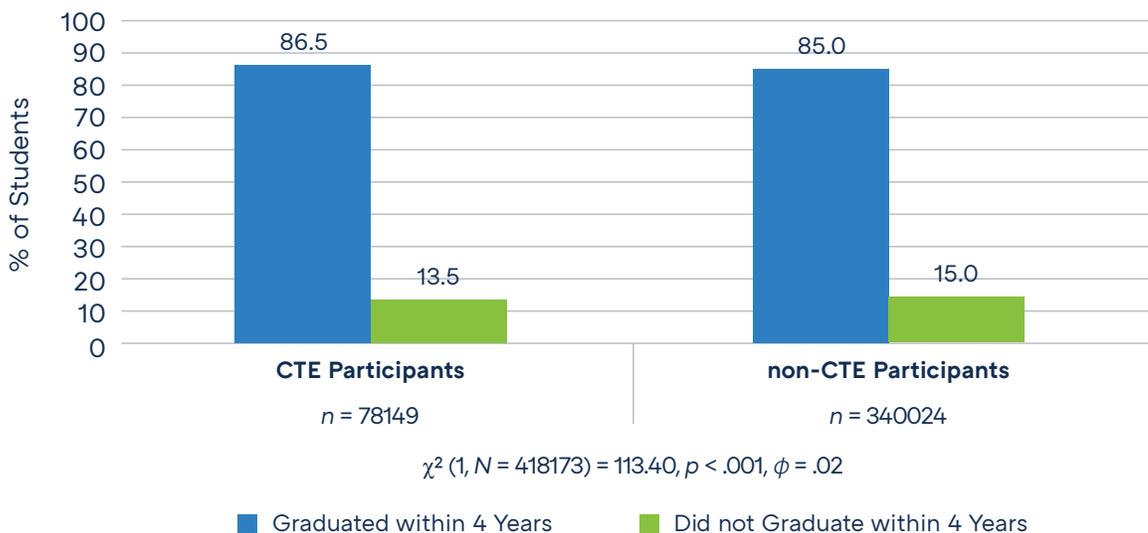


*Note: 2012-13 Cohort only

On-time High School Graduation and Postsecondary Enrollment

There was a small but significant difference in the rates of on-time high school graduation (Figure 4) based on CTE participant status ($\chi^2 (1, N = 418,173) = 113.40, p < .001; \phi = .02$), such that CTE participants graduated on-time within four years at a slightly higher rate (86.5%) than non-CTE students (85.0%). However, as Figure 5 shows, a significantly higher percentage of non-CTE students (76.6%), compared to CTE participants (43.5%), enrolled in a postsecondary institution following high school graduation. This difference was statistically significant ($\chi^2 (1, N = 350,972) = 28,249.16, p < .001$) with a moderate association ($\phi = -.28$), showing that CTE participants in PA enrolled in a postsecondary program at a significantly lower rate than non-CTE students.

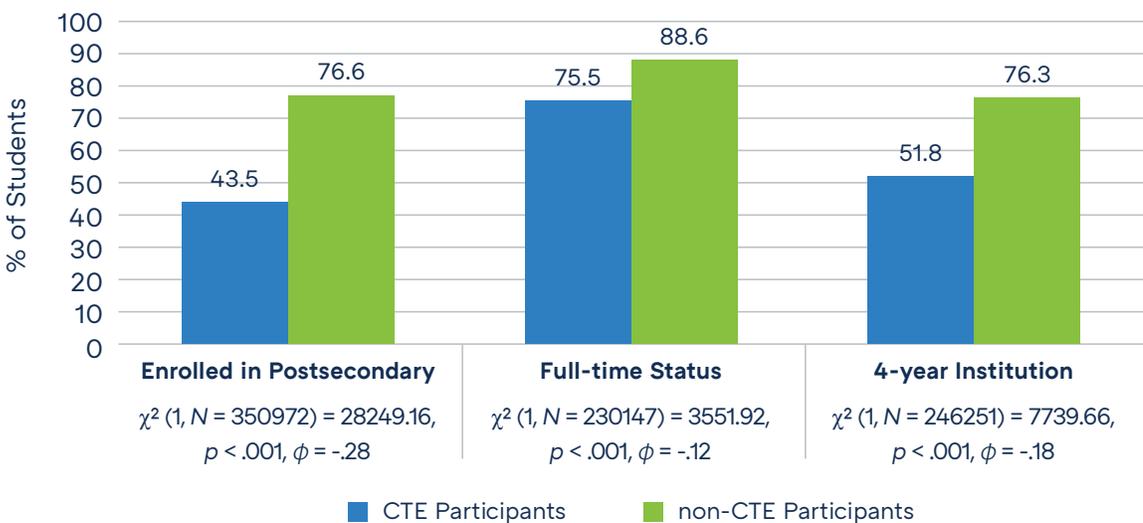
FIGURE 4: On-time High School Graduation by CTE Participant Status



Among the students who ever entered postsecondary, enrollment status (full-time versus part-time) and institution type (2-year versus 4-year) were also analyzed. Figure 5 depicts that while the majority of both CTE and non-CTE students who entered postsecondary initially did so at a full-time status, a slightly larger percentage of non-CTE students (88.6%) were full-time when compared to CTE participants (75.5%). This difference was statistically significant ($\chi^2(1, N = 230,147) = 3,551.92, p < .001$) but the association was small ($\phi = -.12$).

Likewise, Figure 5 shows that among non-CTE students, the rate of initial enrollment at a 4-year institution (76.3%) was significantly higher than that of CTE participants (51.8%). This difference was statistically significant ($\chi^2(1, N = 246,251) = 7,739.66, p < .001$) with a small association ($\phi = -.18$). This finding shows that, for these cohorts, CTE participants who entered postsecondary were significantly less likely to enroll at a 4-year institution than non-CTE students; however, they still enrolled at 4-year institutions at a slightly higher rate than at 2-year institutions.

FIGURE 5: Postsecondary Enrollment by CTE Participant Status



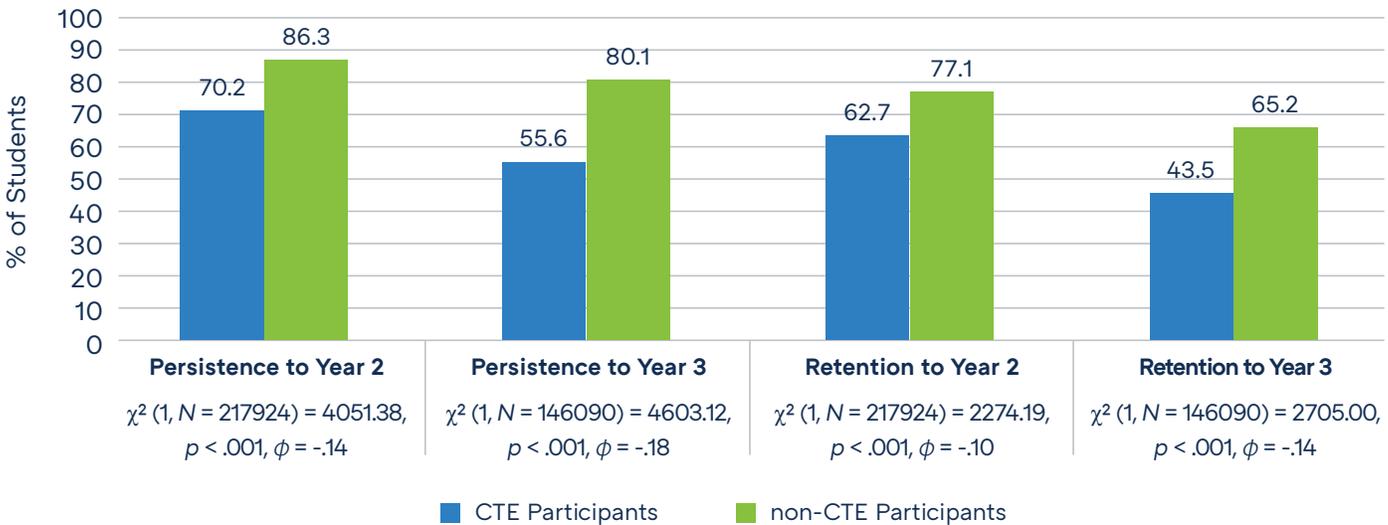
Persistence and Retention

Persistence and retention to year two were tracked for students who graduated high school on-time and entered postsecondary by the fall after high school graduation (Figure 6). For a detailed explanation of how these outcomes were defined, see Appendix A. Chi-square results indicate that non-CTE students had significantly higher rates of persistence and retention to year two compared to CTE participants. For non-CTE students, 86.3% persisted to year two and 77.1% returned to the same postsecondary institution. In contrast, 70.2% of CTE participants persisted and 62.7% returned to the same institution for a second year. This difference in rates of persistence to year two was statistically significant ($\chi^2(1, N = 217,924) = 4,051.38, p < .001$) with a small association ($\phi = -.14$), as was the difference in rates of retention to year two ($\chi^2(1, N = 217,924) = 2,274.19, p < .001; \phi = -.10$). It should be noted that although non-CTE students had significantly higher rates of persistence and retention to year two, a majority of students in both groups persisted and returned to the same institution for a second year.

Persistence and retention to year three were tracked for students in the 2010-11 and 2011-12 Grade 9 cohorts who graduated high school on-time and entered college in the fall after graduation (Figure

6). Non-CTE students persisted to year three at a rate of 80.1% and had a retention rate of 65.2%. In comparison, only 55.6% of CTE participants persisted to year three and 43.5% returned to the same school for a third year. The difference in rates of persistence to year three was statistically significant ($\chi^2(1, N = 146,090) = 4,603.12, p < .001$) with a small association ($\phi = -.18$), as was the difference in rates of retention to year three ($\chi^2(1, N = 146,090) = 2,705.00, p < .001, \phi = -.14$). Although these associations were small, like those of persistence and retention to year two of postsecondary, the proportional difference in rates of persistence and retention based on CTE participant status were larger for year three than year two.

FIGURE 6: Persistence and Retention to Years 2 and 3 of Postsecondary by CTE Participant Status



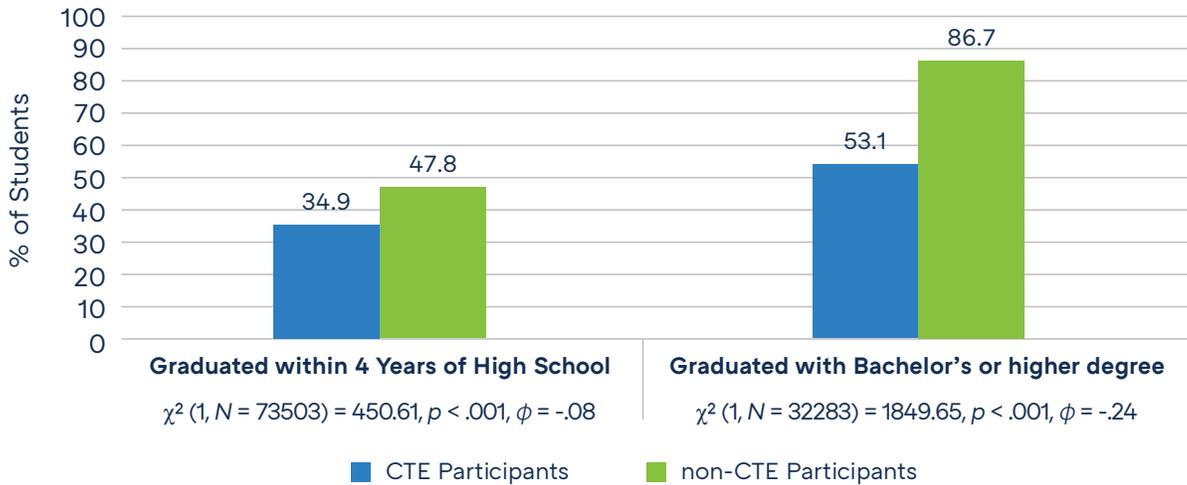
**Note: year 3 analyses limited to 2010-11 and 2011-12 Cohorts only*

Postsecondary Graduation/Degree Completion

Persistence and retention to postsecondary graduation (within four years of high school) were tracked for students in the 2010-11 Grade 9 cohort who graduated high school on-time and entered postsecondary in the fall after graduation. Although there was no real difference between non-CTE students and CTE participants in the percentage of students who graduated from the same institution (90.7% versus 89.3%), Figure 7 shows that a higher percentage of non-CTE students graduated college with any degree within four years (47.8%) compared to CTE participants (34.9%). The difference in rates of persistence to graduation was statistically significant ($\chi^2(1, N = 73,503) = 450.61, p < .001$) with a small association ($\phi = -.08$).

Figure 7 also shows that for students from the 2010-11 cohort who persisted to graduation within four years of high school completion, a substantially higher percentage of non-CTE students (86.7%) earned a bachelor's degree or higher compared to CTE participants (53.1%). The difference was statistically significant ($\chi^2(1, N = 32,283) = 1,849.65, p < .001$) with a moderate association ($\phi = -.24$). This shows that although a majority of CTE participants who graduated within four years of high school earned at least a bachelor's degree, they did so at a meaningfully lower rate than non-CTE students. Inversely, this means that a greater proportion of CTE participants (46.9%) earned an associate degree or certificate as their highest degree compared to non-CTE students (13.3%).

FIGURE 7: Persistence to Postsecondary Graduation and Bachelor’s Degree Attainment within 4 Years by CTE Participant Status



**Note: 2010-11 Cohort only*

Logistic Regression Analysis

This phase of analysis utilized binary logistic regression to examine CTE participant odds of achieving all academic outcomes, including Keystone exam performance, postsecondary enrollment, persistence, retention, and degree attainment within four years of high school graduation. Logistic regression was used because all outcomes were binary.

Figure 8 displays the odds ratios ($\text{Exp}(\beta)$) from the final models of the logistic regression analysis. The figure compares the odds of CTE participants accomplishing each outcome in comparison to non-CTE students, after controlling for student demographics. After statistically controlling for other student-level factors, the odds ratio for retention to graduation from postsecondary was no longer significant and was therefore excluded from the figure.

In all cases except one, non-CTE students had higher odds than CTE participants of achieving each outcome. On-time high school graduation is the only outcome for which CTE students had higher odds, albeit minimally ($\text{Exp}(\beta) = 1.312$), equivalent to 31.2% higher odds of graduating than non-CTE students.

For all but two of the remaining outcomes (retention to year two of postsecondary and persistence to postsecondary graduation), non-CTE students had at least double the odds of CTE participants. The largest odds ratio was for highest degree earned ($\text{Exp}(\beta) = 4.894$), equivalent to odds that are almost five times higher (389.4% higher odds) for non-CTE students than CTE participants of attaining a bachelor’s degree within four years.

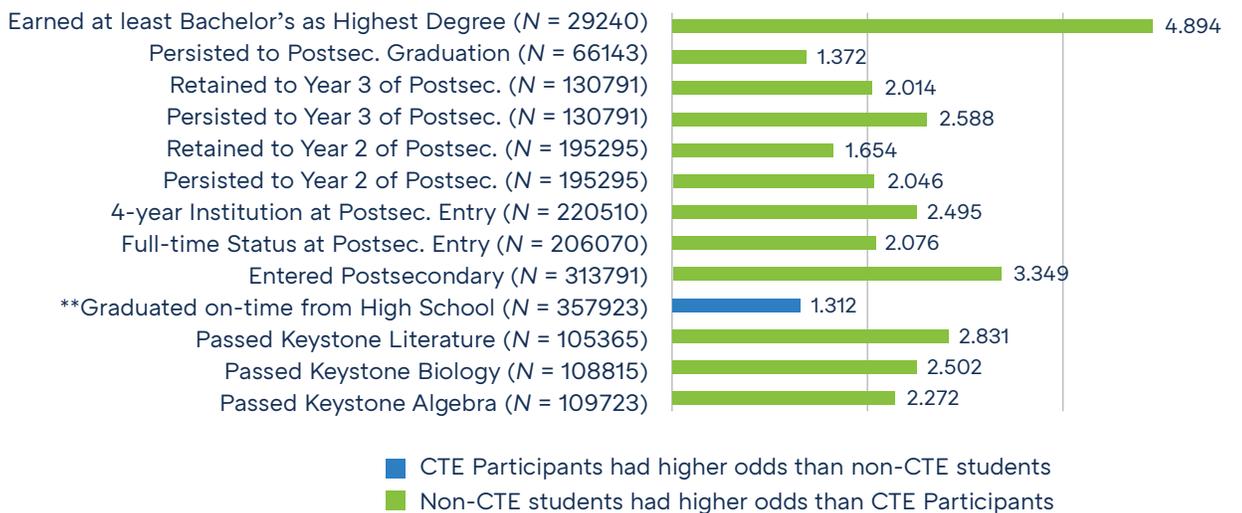
On-time high school graduation is the only outcome for which CTE students had higher odds, albeit minimally ($\text{Exp}(\beta) = 1.312$), equivalent to 31.2% higher odds of graduating than non-CTE students.

Demographically, CTE participants consisted of double the proportion of Special Education students (25.6% versus 12.4%) and a significantly higher percentage of students who were economically disadvantaged (51.4% versus 36%) compared to non-CTE students. Even after controlling for student demographic

differences such as these, non-CTE students had greater than two times higher odds of performing at the advanced or proficient level on all Keystone subject tests.

The results of this logistic regression analysis affirm that even after controlling for student demographics, non-CTE students had higher odds than CTE participants of achieving each academic outcome. The notable exception is on-time high school graduation, for which CTE participants had slightly higher odds than non-CTE students.

FIGURE 8: Odds Ratio (Exp(β)) for all Outcomes by CTE Participant Status



To what extent do CTE student outcomes differ depending on the characteristics (i.e., participation in work-based learning experiences, internships, postsecondary credits earned, etc.) and intensity (i.e., percentage of program completed, CTE concentration/completion status) of the CTE program curriculum?

To answer this research question, the researchers used two categories to describe the percentage of the program completed by CTE participants, i.e., program intensity. These included binary variables indicating whether or not a student completed their CTE program (*CTE Completion*) or met PDE’s definition for CTE program concentration by completing at least 50% of their program (*CTE Concentration*). Variables of intensity indicate how far CTE participants elected to progress along their respective program sequences; they are not an indicator of the quality or difficulty of the program itself. CTE participants were likewise differentiated depending on their participation in any of the CTE program characteristics listed below. Program characteristics of interest included whether the CTE participant was reportedly involved in an internship, cooperative work experience, job exploration, work-based experience (WBE), or earned postsecondary credit at some point during their high school CTE program. For a detailed definition of each variable see Appendix A, where the PIMS reporting criteria are provided for each.

Analysis in this section was three-fold. First, Pearson chi-square tests were run comparing outcomes for CTE participants depending on their CTE concentration status and CTE completion status. Second, student outcomes were compared depending on whether students had participated in at least one

program characteristic during their CTE program; in turn, each program characteristic of interest was also analyzed in order to determine its individual relationship to each outcome. Finally, in order to isolate the role that program characteristics and intensity play in shaping student outcomes, binary logistic regression analyses were conducted to model the program- and student-level factors which contribute to outcomes in context.

Sample

Demographics by Intensity

The full demographic makeup of CTE participants based on their level of program intensity can be found in Table B3 of Appendix B. The following section highlights notable demographic differences throughout the CTE student population based on the percentage of the program students completed.

Among 78,228 CTE participants, 19,564 students (25%) were never CTE concentrators or CTE completers. The majority of students who were never CTE concentrators/completers were male (56.3%). In terms of race and ethnicity, most students at this low intensity threshold were white (69.6%), followed by Black/African American (16.8%), and Hispanic students of any race (10.3%). Over half (53.0%) of the students in this category of program intensity qualified as economically disadvantaged. Roughly one quarter (25.3%) of these students received Special Education services at some point in high school, while only 2.1% were English Learners. Geographically, students from suburban schools were the most represented locale (27.1%), followed by rural schools (22.6%), and city schools (17.7%). Notably, a greater proportion of students in this group were missing geographic data (16.9%) than were labeled as originating from towns (15.8%).

Across all cohorts, 58,664 students (75%) qualified as CTE concentrators. Students who qualified as concentrators were majority male (58.0%) and identified as white (74.6%). Close to 13% of concentrators identified as Black/African American and 9.9% identified as Hispanic. Roughly half (50.9%) of CTE concentrators were economically disadvantaged, and one quarter (25.7%) received Special Education services at some point. EL students composed 1.8% of this group. A notably greater proportion of CTE concentrators came from suburban locales (34.1%) than students who were never CTE concentrators or CTE completers. Just over 22% of CTE concentrators were from rural locales, 17.0% from cities, and 13.0% from towns. The remaining 13.3% were missing geographic data.

Among the CTE student population, 45,314 students (58%) qualified for the highest threshold of intensity, CTE completion. It is important to note that these students were also demographically represented among CTE concentrators, as CTE completers also qualify for CTE concentration because they completed over 50% of their program. As such, CTE completers were demographically similar to CTE concentrators. For a more detailed comparison, see Table B3 of Appendix B.

Students who qualified as concentrators were majority male (58.0%) and identified as white (74.6%). Close to 13% of concentrators identified as Black/African American and 9.9% identified as Hispanic.

Demographics by Participation in Program Characteristics

There are more notable differences in demographic makeup based on the program characteristics in which students participated. Any student who participated in each program characteristic was demographically represented in that category, regardless of whether they also participated in another or several other characteristics. This means that in many cases, CTE students are demographically represented in multiple categories. For a full demographic comparison by program characteristic, refer to Table B4 of Appendix B.

Among the 78,228 CTE participants, 59,818 students (76.5%) did not participate in any of the program characteristics of interest. This group of students was predominantly male (57.9%) and racially white (71.7%), followed by Black/African American (15.1%), and Hispanic students of any race (10.3%). Over half (53.4%) qualified as economically disadvantaged, 27.0% received Special Education services, and 2.0% were EL. Geographically, 31.2% attended schools in suburban locales, 22.8% in rural locales, 17.3% in cities, and 14.2% in towns. The remaining 14.5% of students who did not participate in any program characteristics were missing geographic data.

Only 3,211 CTE students (4.1% of CTE participants) participated in an internship during the course of their high school CTE experience. Over two-thirds (67.2%) of the students who participated in an internship were female, distinguishing students with internship experience from all other program characteristics, which were majority male. Although white students still had the highest representation of all racial and ethnic groups (51.8%), this proportion is notably lower than in other program characteristics. A greater proportion of Black/African American and Hispanic students participated in an internship experience relative to other program characteristics, constituting 24.3% and 17.2% of this group, respectively. Of all program characteristics, students with internship experience had the highest proportion of economically disadvantaged students (61.4%) and EL students (3.3%), but the lowest proportion of students who received Special Education services (15.5%). Finally, close to half (44.6%) of the students who participated in an internship came from cities, making this the only program characteristic for which suburban areas were not the predominant geographic locale.

Over two-thirds (67.2%) of the students who participated in an internship were female, distinguishing students with internship experience from all other program characteristics, which were majority male.

A greater percentage (7.8%) of CTE students participated in a cooperative work experience ($N = 6,093$). Nearly three quarters (74.0%) of these students were male, and 89.5% were white. Hispanic students of any race and Black/African American students were the next highest represented racial or ethnic groups, but only constituted 6.0% and 2.8% of students with cooperative work experience, respectively. The majority of students who participated in this program characteristic did not experience economic disadvantage (65.0%) or receive Special Education services (77.0%). In terms of geographic locale, 36.2% of students were from suburban areas, 28.8% rural, 13.2% from towns, and 9.0% from cities. The remaining 12.7% were missing geographic data.

The most common program characteristic, in which 8.7% of CTE students participated, was job exploration ($N = 6,778$). Just over half (50.8%) of the students who participated in a job exploration experience were male. In terms of racial and ethnic makeup, the majority (70.3%) were white, followed by Black/African American (16.3%), and Hispanic students of any race (8.8%). Over half (53.5%) qualified as economically disadvantaged, 22.0% received Special Education services, and 1.9% were EL. Geographically, 34.1% of students with job exploration experience were from suburban locales, 28.7% from cities, 15.0% from rural locales, and 10.9% from towns. The remaining 11.3% were missing geographic data.

Of the CTE student population, 2,390 (3.1%) participated in a work-based experience during high school. Just over half of these students (50.6%) were male. Students with work-based experience were majority white (77.0%), followed by Hispanic (14.7%), and Black/African American (6.4%). The majority of students with work-based experience (55.1%) were not economically disadvantaged, and only 17.6% received Special Education services. English Learners constituted 2.2% of this group. Students with work-based experience were from largely suburban locales (29.7%) or cities (28.7%), while only 7.8% and 6.8% attended schools in rural locales and towns, respectively. A larger proportion of work-based experience students were missing geographic data (26.9%).

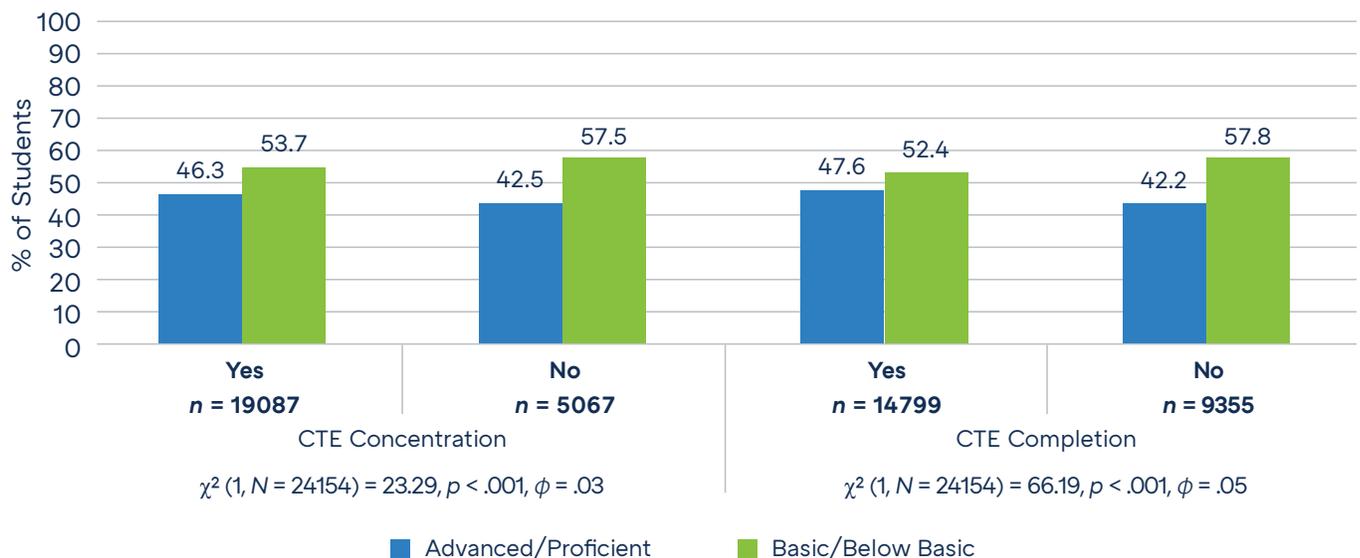
Finally, 4,791 CTE participants (6.1%) earned postsecondary credit during their high school CTE experience. These students were majority male (51.3%) and racially white (81.6%), followed by Hispanic (7.5%) and Black/African American students (7.1%). The majority of students who earned postsecondary credit (59.8%) were not economically disadvantaged, and 18.5% received Special Education services. Only 1.0% were EL. Students who earned postsecondary credit were from predominantly suburban locales (41.2%), followed by rural locales (28.3%), towns (13.2%), and cities (7.0%). The remaining 10.3% were missing geographic data.

Chi-square Analyses

Keystone Exam Performance

Keystone Algebra. Figure 9 shows how Keystone Algebra performance levels differed for students in the 2012-13 cohort depending on the percentage of the program completed, or intensity. CTE concentrators passed the Keystone Algebra exam at a slightly higher rate (46.3%) than non-concentrators (42.5%). Although the difference in proportions was large enough to be statistically significant ($\chi^2 (1, N = 24,154) = 23.29, p < .001$), the association between variables was minimal ($\phi = .03$). Likewise, a greater proportion of CTE completers (47.6%) than non-completers (42.2%) passed the Keystone Algebra exam ($\chi^2 (1, N = 24,154) = 66.19, p < .001, \phi = .05$).

FIGURE 9: Keystone Algebra Performance Levels by CTE Concentration and Completion Status



*Note: 2012-13 Cohort only

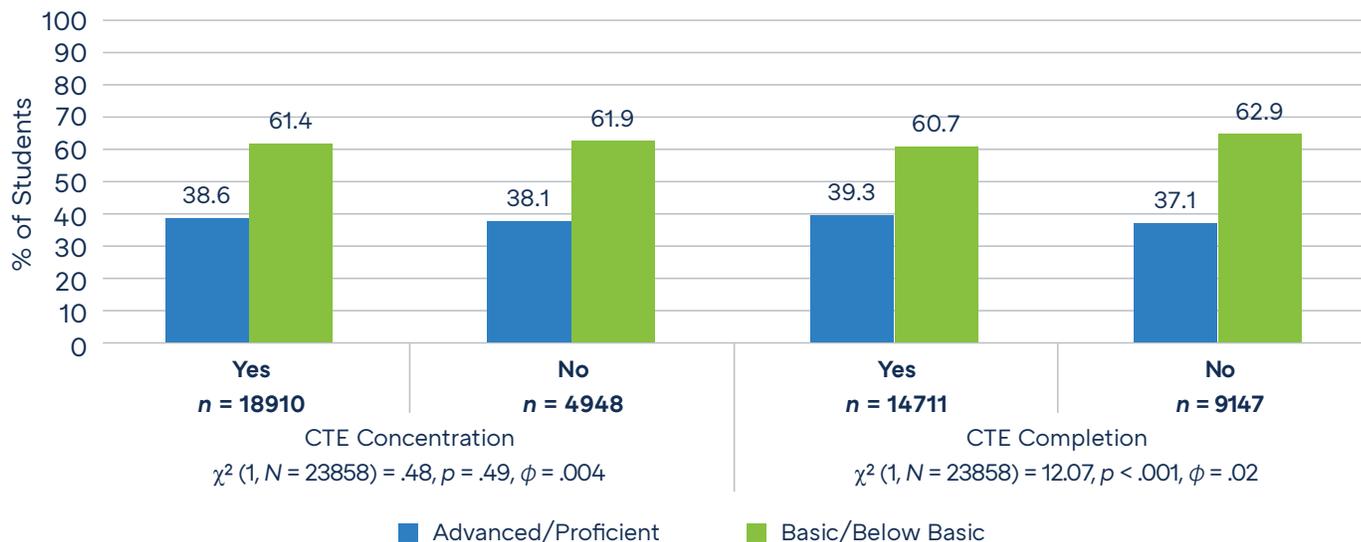
The rate of CTE participants who received a passing score on the Keystone Algebra exam can be found in Table 2, differentiated by their participation in the individual program characteristics of interest. Students who participated in at least one program characteristic during their high school CTE experience passed the Keystone Algebra exam at a significantly higher rate (53.2% versus 43.0%) than students who did not participate in any program characteristics ($\chi^2(1, N = 24,154) = 185.23, p < .001, \phi = .09$). Students who participated in all individual variables of interest passed the Keystone Algebra exam at a slightly higher rate than students who did not, with Earned Postsecondary Credit having the largest effect, albeit small ($\phi = .09$).

TABLE 2. Keystone Algebra Exam Passing by Individual CTE Program Characteristics

	% Passed Keystone Algebra	<i>N</i>	<i>df</i>	χ^2	<i>p</i>	ϕ
Participated in at Least 1 Program Characteristic						
Yes	53.2	24154	1	185.23	< .001	.09
No	43.0					
Internship						
Yes	50.9	24154	1	13.54	< .001	.02
No	45.2					
Cooperative Work Experience						
Yes	53.5	24154	1	58.53	< .001	.05
No	44.7					
Job Exploration						
Yes	49.7	24154	1	18.34	< .001	.03
No	45.0					
WBE						
Yes	56.2	24154	1	37.00	< .001	.04
No	45.1					
Earned Postsecondary Credit						
Yes	65.2	24154	1	178.43	< .001	.09
No	44.6					

Keystone Biology. Keystone Biology exam performance differed for students in the 2012-13 cohort by program intensity (Figure 10). Although there was no statistical difference in Keystone Biology exam performance based on CTE concentration status ($\chi^2 (1, N = 23,858) = .48, p = .49$), CTE completers passed the Keystone Biology exam at a significantly higher rate (39.3% versus 37.1%) than students who did not complete their program ($\chi^2 (1, N = 23,858) = 12.07, p < .001, \phi = .02$). Still, CTE completers passed at a rate (39.3%) similar to CTE concentrators (38.6%).

FIGURE 10: Keystone Biology Performance Levels by CTE Concentration and Completion Status



*Note: 2012-13 Cohort only

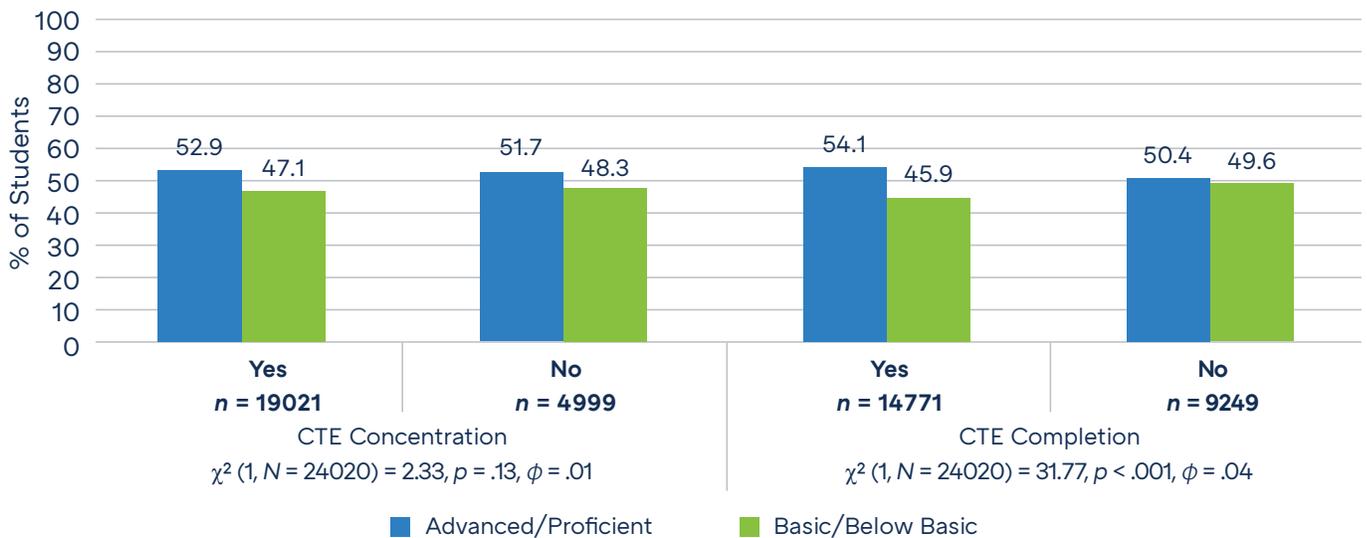
Table 3 displays the proportion of CTE participants who passed the Keystone Biology exam by their participation in the program characteristics of interest. Students who participated in at least one program characteristic during their high school CTE experience scored advanced/proficient (42.8%) at a higher rate than students without any program characteristic participation (37.1%) on the Keystone Biology exam ($\chi^2 (1, N = 23,858) = 60.18, p < .001, \phi = .05$). Two CTE program variables in particular (Internship and Job Exploration) did not yield significant differences in Keystone Biology performance. Participation in the remaining characteristics was found to be significantly associated with passing the Keystone Biology exam.

TABLE 3. Keystone Biology Exam Passing by Individual CTE Program Characteristics

		% Passed Keystone Biology	N	df	χ^2	p	ϕ
Participated in at Least 1 Program Characteristic							
	Yes	42.8	23858	1	60.18	< .001	.05
	No	37.1					
Internship*							
	Yes	35.9	23858	1	3.24	.07	-.01
	No	38.6					
Cooperative Work Experience							
	Yes	42.9	23858	1	18.40	< .001	.03
	No	38.1					
Job Exploration*							
	Yes	39.6	23858	1	1.34	.25	.01
	No	38.4					
WBE							
	Yes	45.9	23858	1	18.59	< .001	.03
	No	38.2					
Earned Postsecondary Credit							
	Yes	52.9	23858	1	101.04	< .001	.07
	No	37.8					

Keystone Literature. Figure 11 shows how Keystone Literature performance levels differed for students in the 2012-13 cohort by program intensity. CTE concentrators (52.9%) and non-concentrators (51.7%) passed the Keystone Literature exam at a similar rate ($\chi^2 (1, N = 24,020) = 2.33, p = .13$). In contrast, CTE Completion was significantly associated with Keystone Literature performance, such that a significantly higher percentage of CTE completers than non-completers (54.1% versus 50.4%) passed the exam ($\chi^2 (1, N = 24,020) = 31.77, p < .001, \phi = .04$).

FIGURE 11: Keystone Literature Performance Levels by CTE Concentration and Completion Status



*Note: 2012-13 Cohort only

Table 4 displays differences in the Keystone Literature exam pass rate based on student participation in CTE program characteristics. Students who participated in at least one program characteristic during their high school CTE experience passed the Keystone Biology exam at a significantly higher rate (57.9% versus 51.0%) than students without experience in any program characteristics ($\chi^2 (1, N = 24,020) = 85.41, p < .001, \phi = .06$). In terms of how specific variables are related to Keystone Literature performance levels, all but one program characteristic (Cooperative Work Experience) were found to be significantly associated with Keystone Literature performance. Chi-square results show that students who participated in individual program characteristics had a slightly higher rate of Keystone Literature exam passage than students without each program experience, with Earned Postsecondary Credit having the largest, albeit small, effect ($\phi = .09$).

TABLE 4. Keystone Literature Exam Passing by Individual CTE Program Characteristics

	% Passed Keystone Literature	N	df	χ^2	p	ϕ
Participated in at Least 1 Program Characteristic						
Yes	57.9	24020	1	85.41	< .001	.06
No	51.0					
Internship						
Yes	60.6	24020	1	28.48	< .001	.03
No	52.3					
Cooperative Work Experience*						
Yes	52.8	24020	1	0.02	.90	.001
No	52.7					
Job Exploration						
Yes	57.5	24020	1	24.02	< .001	.03
No	52.2					
WBE						
Yes	56.2	24020	1	3.88	.049	.01
No	52.6					
Earned Postsecondary Credit						
Yes	71.6	24020	1	164.80	< .001	.09
No	51.8					

On-time High School Graduation for CTE participants

Figure 12 shows how the rate of on-time high school graduation differed by the students' thresholds of intensity. CTE concentrators graduated on-time at a significantly higher rate of 91.7%, compared to the 70.9% graduation rate for non-concentrators ($\chi^2 (1, N = 78,149) = 5,432.52, p < .001$), with a moderate effect ($\phi = .26$). Similarly, a larger proportion of CTE completers (95.5%) graduated compared to non-completers (74.1%), with a likewise moderate association ($\chi^2 (1, N = 78,149) = 7,478.23, p < .001, \phi = .31$). As such, both CTE concentration and CTE completion are associated with the rate of on-time high school graduation to a seemingly meaningful degree.

FIGURE 12: On-time High School Graduation by CTE Concentration and Completion Status

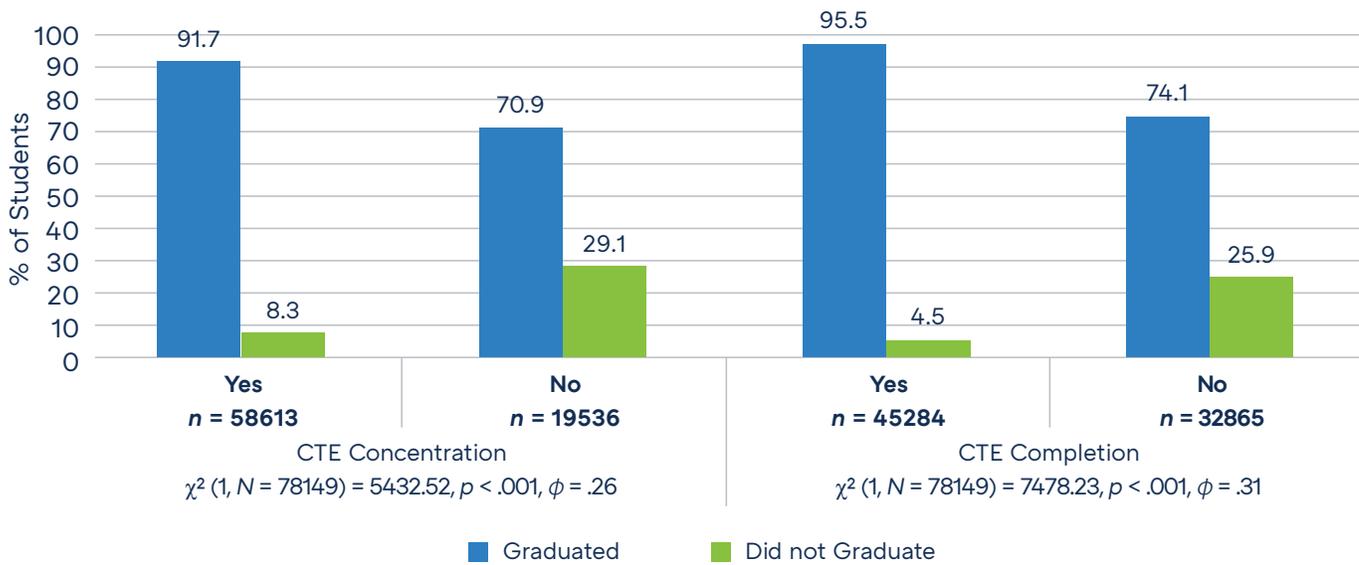


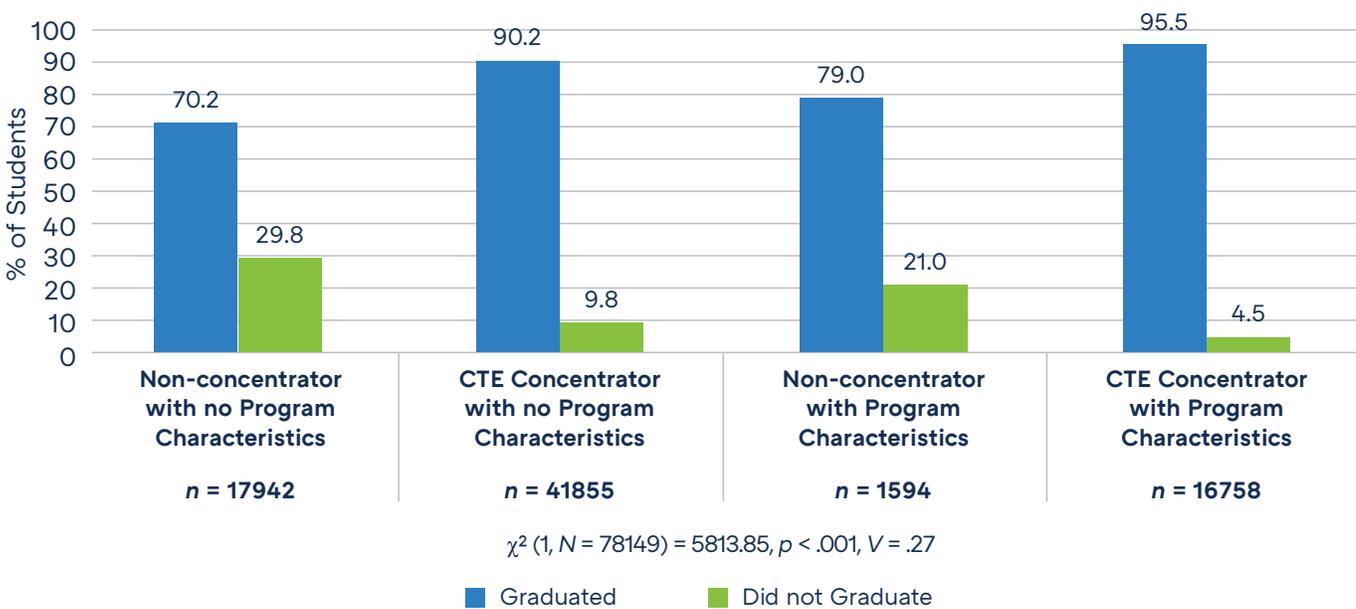
Table 5 displays the rates of on-time high school graduation for students with and without experience in all individual program characteristics. A larger proportion of students who participated in at least one program characteristic during their high school CTE experience (94.0%) graduated on-time compared to students who participated in none (84.2%), although the association was small ($\chi^2 (1, N = 78,149) = 1,164.67, p < .001, \phi = .12$). For all variables, the rate of on-time high school graduation was significantly higher for CTE students who participated in each experience than for students who did not.

TABLE 5. On-time High School Graduation by Individual CTE Program Characteristics

	% Graduated High School On-time	N	df	χ^2	p	ϕ
Participated in at Least 1 Program Characteristic						
Yes	94.0	78149	1	1164.67	< .001	.12
No	84.2					
Internship						
Yes	96.9	78149	1	311.00	< .001	.06
No	86.1					
Cooperative Work Experience						
Yes	96.7	78149	1	588.57	< .001	.09
No	85.6					
Job Exploration						
Yes	93.6	78149	1	323.83	< .001	.06
No	85.8					
WBE						
Yes	91.2	78149	1	45.92	< .001	.02
No	86.4					
Earned Postsecondary Credit						
Yes	94.1	78149	1	246.58	< .001	.06
No	86.0					

Finally, Figure 13 displays the results of the chi-square analysis comparing the rate of on-time high school graduation for CTE participants by their CTE concentration status and participation in at least one program characteristic. Non-concentrators who did not participate in any program characteristics graduated on-time at a substantially lower rate (70.2%) than non-concentrators who participated in program characteristics (79.0%). In contrast, both categories of CTE concentrators graduated at much higher rates; CTE concentrators with no characteristics graduated at a rate of 90.2%, while CTE concentrators who participated in at least one program characteristic graduated at the highest rate (95.5%). Chi-square results indicate this difference in proportions was significant ($\chi^2 (3, N = 78,149) = 5,813.85, p < .001$) with a moderate association between variables ($V = .27$), once again suggesting that the percentage of the program completed by CTE participants is a meaningful factor in the rate of on-time high school graduation.

FIGURE 13: On-time High School Graduation by CTE Concentration vs. Program Characteristics



Postsecondary Enrollment

Postsecondary Entry. Figure 14 shows how the rate of postsecondary enrollment/entry differed for on-time high school graduates by the percentage of the CTE program they completed. CTE concentrators enrolled in postsecondary at a slightly lower rate than non-concentrators (42.1% versus 49.2%), although the association between variables was minimal ($\chi^2 (1, N = 66,255) = 216.50, p < .001, \phi = -.06$). Likewise, CTE completers enrolled in college at a slightly lower rate (41.4%) compared to the 47.4% enrollment rate of non-completers ($\chi^2 (1, N = 66,255) = 228.92, p < .001, \phi = -.06$). These results suggest that both CTE concentration and CTE completion are related to slightly lower rates of postsecondary enrollment for CTE participants.

FIGURE 14: Postsecondary Enrollment by CTE Concentration and Completion Status

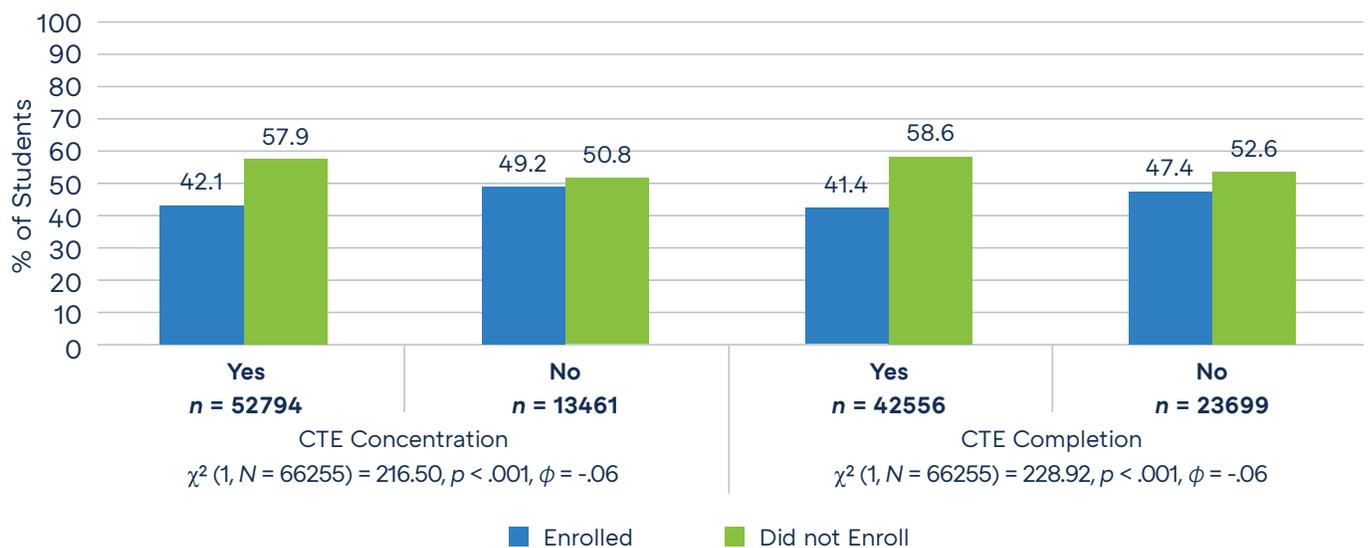


Table 6 displays CTE participants' postsecondary enrollment by their participation in the program characteristics of interest. Students who participated in at least one program characteristic during their high school CTE experience enrolled in college at a slightly higher rate of 46.3%, compared to the 42.6% enrollment rate of students who did not participate in a program characteristic ($\chi^2 (1, N = 66,255) = 72.08, p < .001, \phi = .03$). While participation in most of the program characteristics of interest (Internship, Job Exploration, WBE, and Earned Postsecondary Credit) was associated with higher rates of postsecondary enrollment, the exception was Cooperative Work Experience, for which students who participated enrolled at a significantly lower rate (33.2%) than students who did not (44.5%).

TABLE 6. Postsecondary Enrollment by Individual CTE Program Characteristics

	% Enrolled in Postsecondary	N	df	χ^2	p	ϕ
Participated in at Least 1 Program Characteristic						
Yes	46.3	66255	1	72.08	< .001	.03
No	42.6					
Internship						
Yes	61.6	66255	1	427.48	< .001	.08
No	42.7					
Cooperative Work Experience						
Yes	33.2	66255	1	274.25	< .001	-.06
No	44.5					
Job Exploration						
Yes	50.7	66255	1	143.85	< .001	.05
No	42.8					
WBE						
Yes	51.0	66255	1	49.65	< .001	.03
No	43.3					
Earned Postsecondary Credit						
Yes	53.4	66255	1	183.80	< .001	.05
No	42.9					

Enrollment Status at Postsecondary Entry. Figure 15 shows how enrollment status at college entry differed by participants’ CTE program intensity, for on-time high school graduates who entered postsecondary by 2017-18. CTE concentrators entered postsecondary at full-time status at a slightly lower rate (74.4%) than non-concentrators (79.3%), with a minimal association between variables ($\chi^2 (1, N = 26,121) = 59.36, p < .001, \phi = -.05$). Similarly, CTE completers were full-time status at postsecondary entry at a slightly lower rate (74.3%) than non-completers (77.6%), but again the association was minimal ($\chi^2 (1, N = 26,121) = 37.14, p < .001, \phi = -.04$). Although a majority of all CTE participants entered postsecondary at a full-time status, CTE concentrators and CTE completers had slightly lower rates of full-time entry status than other CTE participants.

FIGURE 15: Enrollment Status at Postsecondary Entry by CTE Concentration and Completion Status

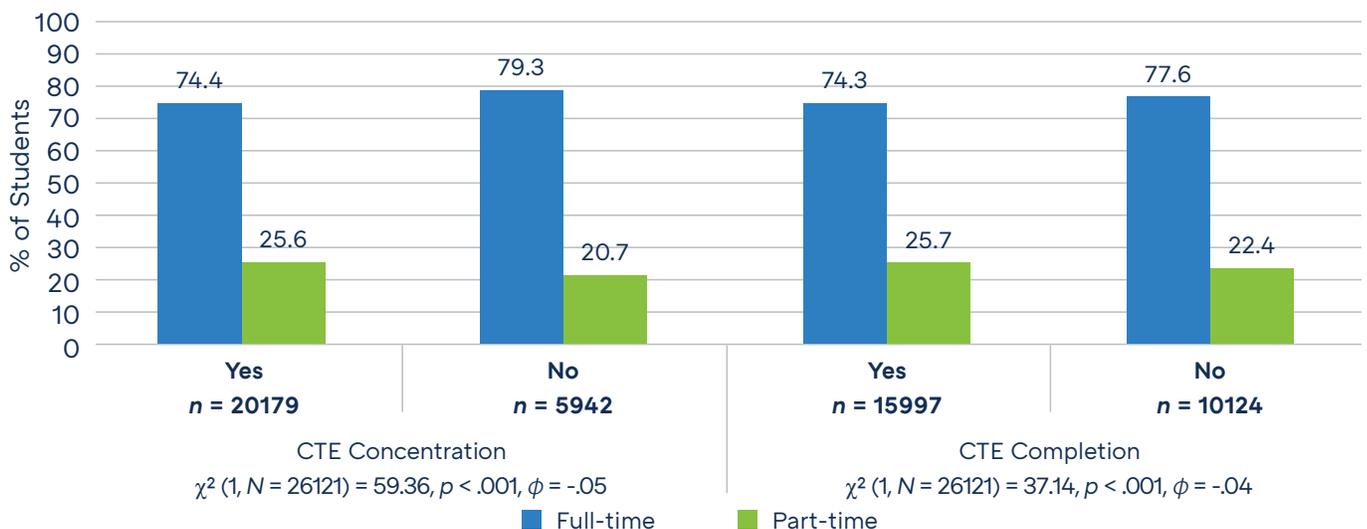


Table 7 shows that students who participated in at least one program characteristic during their high school CTE experience were full-time at postsecondary entry at a slightly higher rate (76.7%) than students who participated in no program characteristics (75.1%), but again the association was minimal ($\chi^2(1, N = 26,121) = 7.24, p = .01, \phi = .02$). In terms of how specific variables impacted enrollment status at college entry, only one program characteristic of interest (Earned Postsecondary Credit) was found to be significantly associated with full-time entry status. Chi-square results reveal that students who earned postsecondary credit during their CTE program entered college at full-time status at a significantly higher rate (79.8%) than those who did not (75.2%). These findings suggest that although participation in program characteristics overall was significantly associated with higher rates of full-time enrollment, it is more likely that postsecondary credit earning in high school is driving this result.

TABLE 7. Full-time Status at Initial Entry by Individual CTE Program Characteristics

		% Initial Full-time Enrollment	N	df	χ^2	p	ϕ
Participated in at Least 1 Program Characteristic							
	Yes	76.7	26121	1	7.24	.01	.02
	No	75.1					
Internship*							
	Yes	73.6	26121	1	3.84	.05	-.01
	No	75.7					
Cooperative Work Experience*							
	Yes	73.6	26121	1	3.72	.05	-.01
	No	75.7					
Job Exploration*							
	Yes	76.7	26121	1	2.22	.14	.01
	No	75.4					
WBE*							
	Yes	78.1	26121	1	3.82	.05	.01
	No	75.4					
Earned Postsecondary Credit							
	Yes	79.8	26121	1	21.93	< .001	.03
	No	75.2					

Institution Type at Postsecondary Entry. Figure 16 shows how the institution type (2-year versus 4-year) at college entry differed for on-time high school graduates who entered postsecondary by the percentage of the program they completed. CTE concentrators initially enrolled at a 4-year postsecondary institution at a significantly lower rate (49.4%) than non-concentrators, who did so at a rate of 59.8% ($\chi^2(1, N = 28,507) = 219.92, p < .001, \phi = -.09$). Likewise, CTE completers initially entered a 4-year institution at a significantly lower rate (47.5%) than students who did not complete their program (58.4%), although the association between variables was small ($\chi^2(1, N = 28,507) = 324.88, p < .001, \phi = -.11$). Both CTE concentration and CTE completion appear to be somewhat associated with lower rates of 4-year institution entry for CTE participants according to these results.

FIGURE 16: Institution Type by CTE Concentration and Completion Status

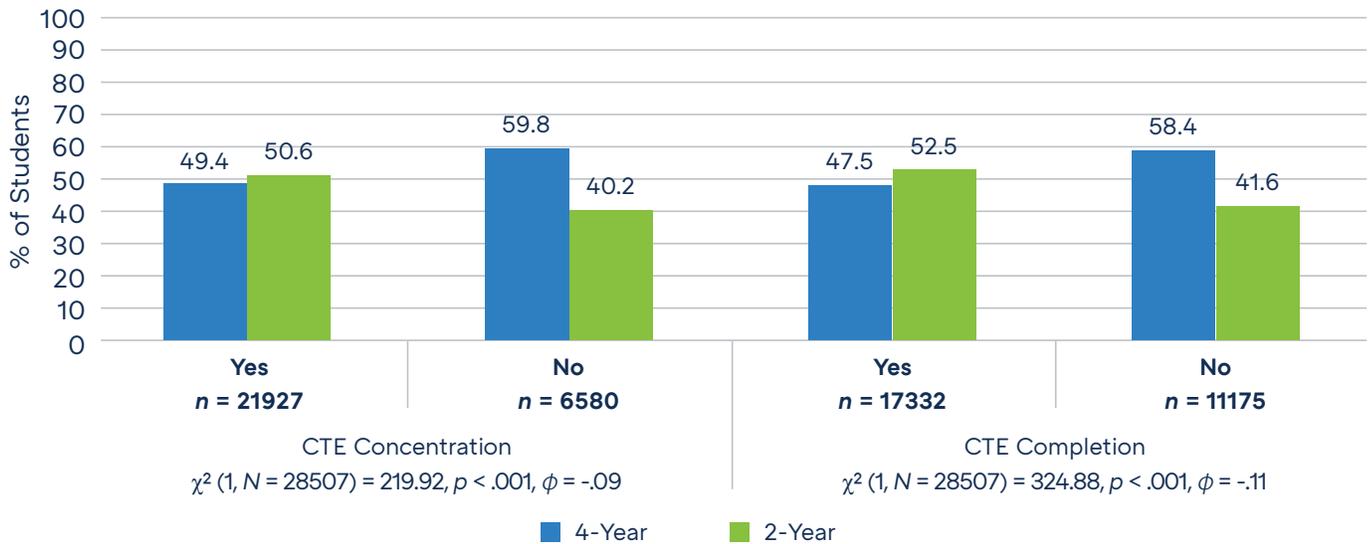


Table 8 shows that students who participated in at least one program characteristic during their high school CTE experience entered a 4-year institution at a slightly higher rate (54.9%) than students without experience in any program characteristics (50.6%), although the association between variables was minimal (χ^2 (1, N = 28,507) = 40.98, p < .001, ϕ = .04). All but one variable of interest (Cooperative Work Experience) were found to be significantly associated with the rate of initial entry at a 4-year institution for CTE participants who graduated high school on-time and entered postsecondary any time thereafter. Students who participated in each significant program characteristic of interest had a higher rate of initial enrollment in a 4-year institution than students who did not.

TABLE 8. Initial Entry to 4-year Institution by Individual CTE Program Characteristics

	% Initial Enrollment at 4-year Institution	N	df	χ^2	p	ϕ
Participated in at Least 1 Program Characteristic						
Yes	54.9	28507	1	40.98	< .001	.04
No	50.6					
Internship						
Yes	54.8	28507	1	7.19	.01	.02
No	51.6					
Cooperative Work Experience*						
Yes	51.3	28507	1	0.21	.65	-.003
No	51.8					
Job Exploration						
Yes	55.4	28507	1	18.94	< .001	.03
No	51.3					
WBE						
Yes	60.5	28507	1	33.96	< .001	.04
No	51.4					
Earned Postsecondary Credit						
Yes	58.1	28507	1	39.77	< .001	.04
No	51.2					

Persistence and Retention to Year Two

Persistence to Year Two. Figure 17 shows how the rate of persistence to year two of postsecondary differed for on-time high school graduates who entered postsecondary in the fall (after high school), by their program intensity. CTE concentrators persisted to year two at a slightly lower rate (69.5%) than non-concentrators (72.4%), although the association was minimal ($\chi^2 (1, N = 22,522) = 15.98, p < .001, \phi = -.03$). Similarly, CTE completers persisted to year two at a slightly lower rate (69.3%) than non-completers (71.6%), with a likewise small association ($\chi^2 (1, N = 22,522) = 13.77, p < .001, \phi = -.03$). These results suggest that both CTE concentration and CTE completion are associated with a slightly lower rate of persistence to year two of postsecondary for CTE participants.

FIGURE 17: Persistence to Year 2 by CTE Concentration and Completion Status

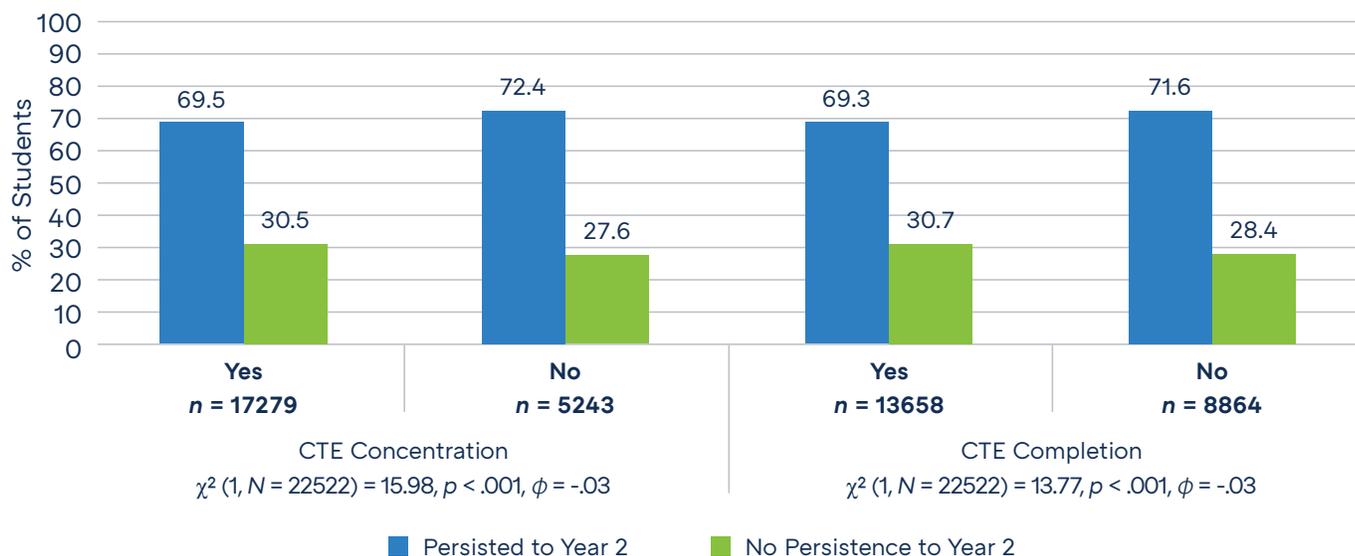


Table 9 displays the rate of persistence to year two of postsecondary education by CTE student participation in the program characteristics of interest. Students who participated in at least one program characteristic during their high school CTE experience persisted to year two at a slightly higher rate (73.2%) than students who participated in no characteristics (69.0%), with a small association ($\chi^2 (1, N = 22,522) = 38.14, p < .001, \phi = .04$). Only two specific variables of interest (Job Exploration and Earned Postsecondary Credit) were found to be significantly associated with the rate of persistence to year two. Chi-square analyses reveal that students who participated in either significant program characteristic of interest persisted at a higher rate than students who did not.

TABLE 9. Persistence to Year 2 by Individual CTE Program Characteristics

		% Persisted to Year 2	N	df	χ^2	p	ϕ
Participated in at Least 1 Program Characteristic							
	Yes	73.2	22522	1	38.14	< .001	.04
	No	69.0					
Internship*							
	Yes	72.2	22522	1	3.17	.08	.01
	No	70.0					
Cooperative Work Experience*							
	Yes	69.1	22522	1	0.96	.33	-.007
	No	70.3					
Job Exploration							
	Yes	72.8	22522	1	9.18	.002	.02
	No	69.9					
WBE*							
	Yes	71.9	22522	1	1.27	.26	.008
	No	70.1					
Earned Postsecondary Credit							
	Yes	78.7	22522	1	71.63	< .001	.06
	No	69.4					

Retention to Year Two. Figure 18 shows how the rate of retention to year two differed for on-time high school graduated, fall-entry college students by the percentage of the program they completed. Although significant with minimal effects, there was not a large difference in the percentage of students who remained at the same college to year two based on CTE concentration (62.2% versus 64.5%) or CTE completion (62.2% versus 63.5%). As such, CTE concentration and CTE completion appear to be associated with slightly lower rates of retention to year two for CTE participants, albeit to a minimal degree.

FIGURE 18: Retention to Year 2 by CTE Concentration and Completion Status

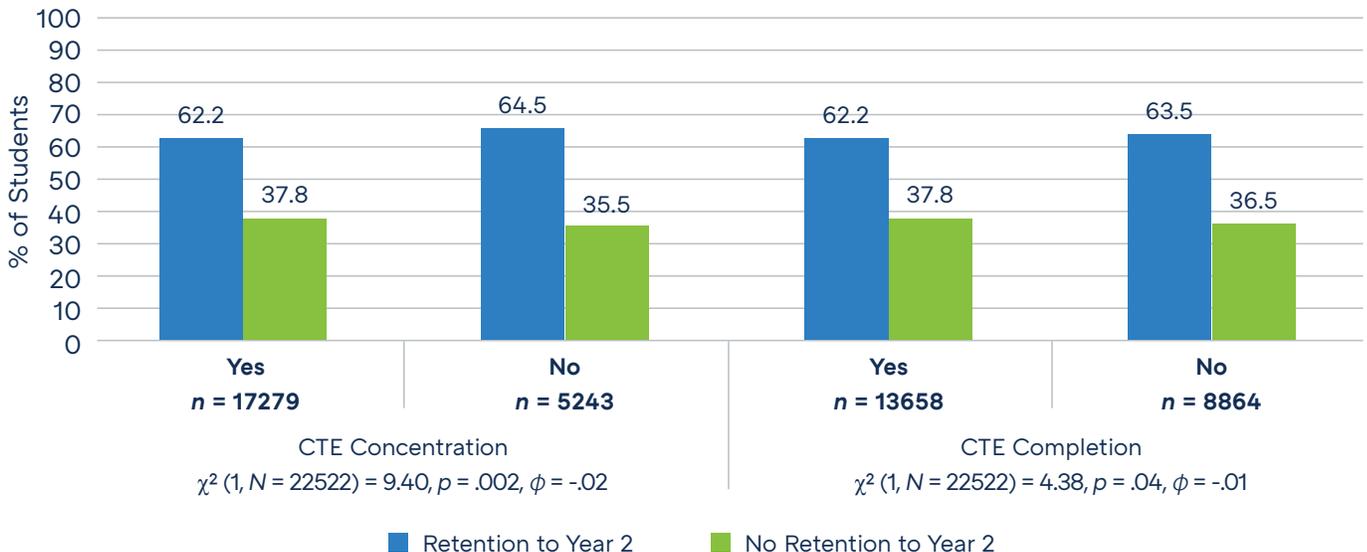


Table 10 shows that students who participated in at least one program characteristic during their high school CTE experience returned to the same college for year two at a slightly higher rate of 65.8%, compared to the 61.5% of students who did not participate in any program characteristics ($\chi^2(1, N = 22,522) = 36.33, p < .001, \phi = .04$). All but two variables of interest (Cooperative Work Experience and WBE) were found to significantly differ from their respective comparison groups in rates of retention to year two. Chi-square results show that students who participated in each significant program characteristic of interest had a slightly higher rate of retention to year two of postsecondary than students who did not, but again these differences were minimal.

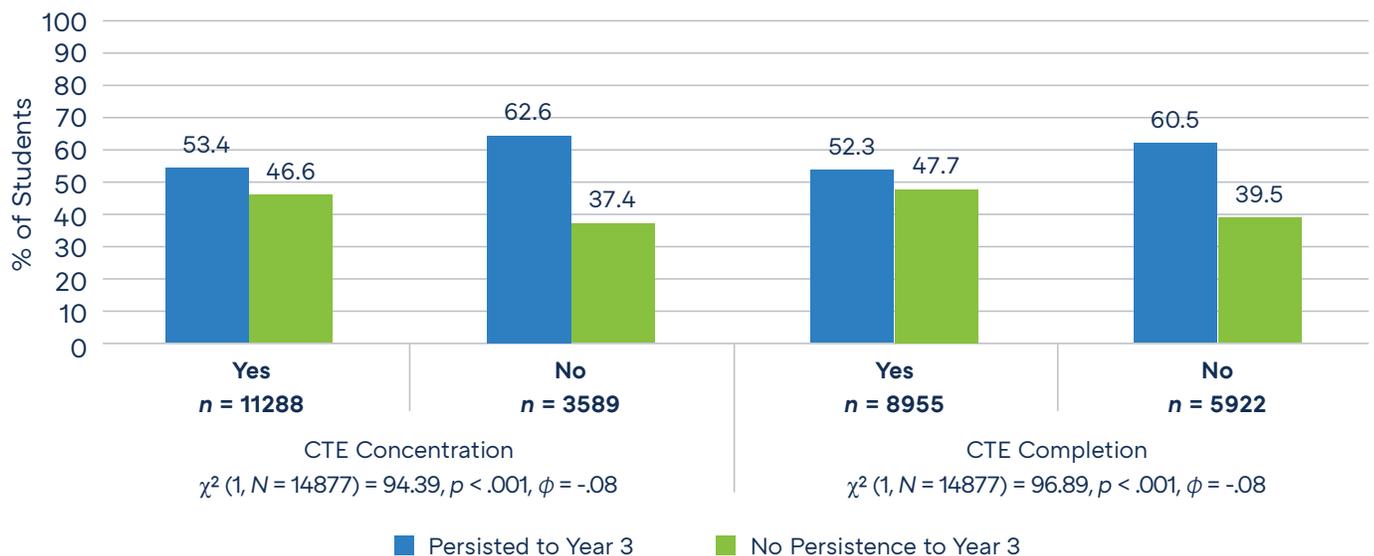
TABLE 10. Retention to Year 2 by Individual CTE Program Characteristics

		% Retention to Year 2	<i>N</i>	<i>df</i>	χ^2	<i>p</i>	ϕ
Participated in at Least 1 Program Characteristic							
	Yes	65.8	22522	1	36.33	< .001	.04
	No	61.5					
Internship							
	Yes	65.3	22522	1	4.75	.03	.02
	No	62.5					
Cooperative Work Experience*							
	Yes	61.8	22522	1	0.56	.45	-.005
	No	62.8					
Job Exploration							
	Yes	65.4	22522	1	9.02	.003	.02
	No	62.4					
WBE*							
	Yes	65.4	22522	1	2.73	.10	.01
	No	62.6					
Earned Postsecondary Credit							
	Yes	70.6	22522	1	54.62	< .001	.05
	No	62.0					

Persistence and Retention to Year Three

Persistence to Year Three. Figure 19 shows how the rate of persistence to year three differed for students in the 2010-11 and 2011-12 Grade 9 cohorts who graduated high school on-time and entered college by the fall after high school, by the percentage of the CTE program they completed. CTE concentrators persisted to year three of postsecondary at a lower rate (53.4%) than non-concentrators (62.6%), although the association between variables was small ($\chi^2(1, N = 14,877) = 94.39, p < .001, \phi = -.08$). Similarly, CTE completers persisted at a lower rate of 52.3%, compared to the 60.5% of students who did not complete their program ($\chi^2(1, N = 14,877) = 96.89, p < .001, \phi = -.08$). These findings indicate that both CTE concentration and CTE completion are associated with slightly lower rates of persistence to year three of postsecondary for CTE participants.

FIGURE 19: Persistence to Year 3 by CTE Concentration and Completion Status



*Note: 2010-11 and 2011-12 Cohorts only

Table 11 displays how participation in all individual CTE program characteristics of interest was associated with rates of persistence to year three, in different ways. Students who participated in at least one program characteristic during their high school CTE experience persisted at a slightly higher rate of 59.5%, compared to the 54.1% of students without experience in any program characteristics ($\chi^2(1, N = 14,877) = 36.36, p < .001, \phi = .05$). While participation in a cooperative work experience specifically was associated with a lower rate of persistence to year three, all other characteristics were associated with slightly higher rates of persistence to year three.

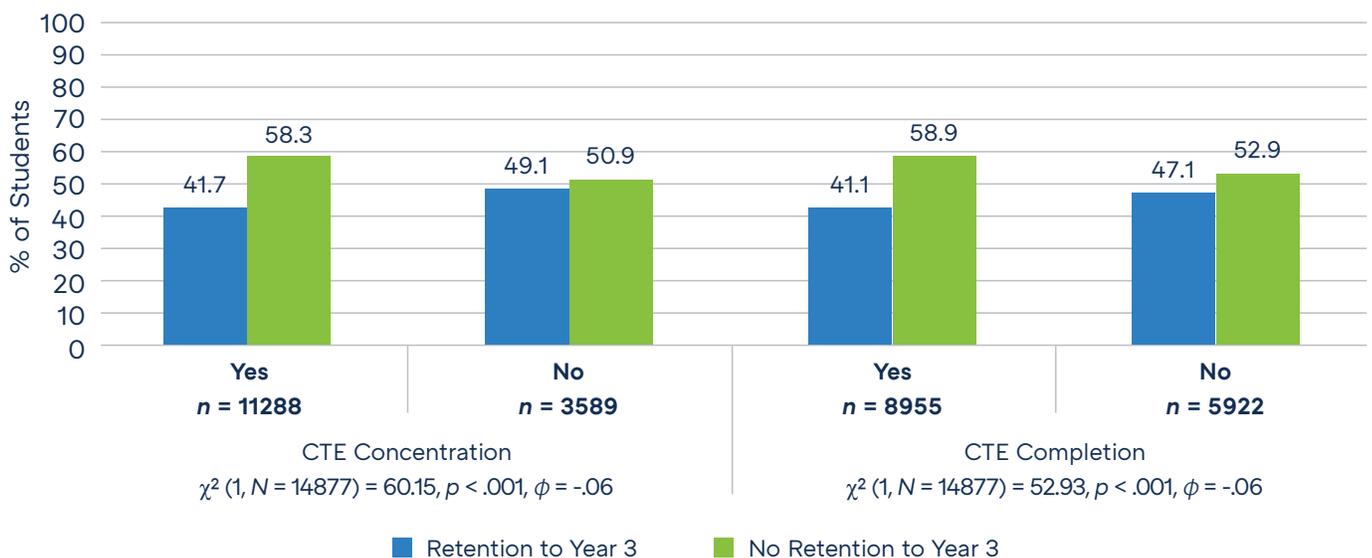
TABLE 11. Persistence to Year 3 by Individual CTE Program Characteristics

	% Persisted to Year 3	N	df	χ^2	p	ϕ
Participated in at Least 1 Program Characteristic						
Yes	59.5	14877	1	36.36	< .001	.05
No	54.1					
Internship						
Yes	61.1	14877	1	13.73	< .001	.03
No	55.2					

		% Persisted to Year 3	N	df	χ^2	p	ϕ
Cooperative Work Experience							
	Yes	49.4	14877	1	15.77	< .001	-.03
	No	56.0					
Job Exploration							
	Yes	58.7	14877	1	7.15	.007	.02
	No	55.2					
WBE							
	Yes	61.3	14877	1	8.03	.005	.02
	No	55.4					
Earned Postsecondary Credit							
	Yes	65.4	14877	1	56.76	< .001	.06
	No	54.6					

Retention to Year Three. Figure 20 shows how the rate of retention to year three differed for students in the 2010-11 and 2011-12 cohorts who graduated high school on-time and entered college the following fall, by the percentage of the program they completed. CTE concentrators returned to the same college for year three at a lower rate (41.7%) than non-concentrators (49.1%), with a small association between variables ($\chi^2 (1, N = 14,877) = 60.15, p < .001, \phi = -.06$). Likewise, CTE completers returned to the same college at a lower rate of 41.1%, compared to the 47.1% of non-completers ($\chi^2 (1, N = 14,877) = 52.93, p < .001, \phi = -.06$). Both CTE concentration and CTE completion appear linked to significantly lower rates of retention to year three for CTE participants according to these results, although the effects were minimal.

FIGURE 20: Retention to Year 3 by CTE Concentration and Completion Status



*Note: 2010-11 and 2011-12 Cohorts only

Table 12 shows that participation in all individual CTE program characteristics of interest was associated with rates of retention to year three, but in different ways. Students who participated in at least one program characteristic during their high school CTE experience returned to the same college at a slightly higher rate of 48.0%, compared to the 41.7% of students without any program characteristics ($\chi^2(1, N = 14,877) = 47.03, p < .001, \phi = .06$). While participation in a cooperative work experience was associated with a lower rate of retention to year three ($\phi = -.02$), all other characteristics were associated with higher rates of retention to year three, with minimal effects ($\phi = .03 - .06$).

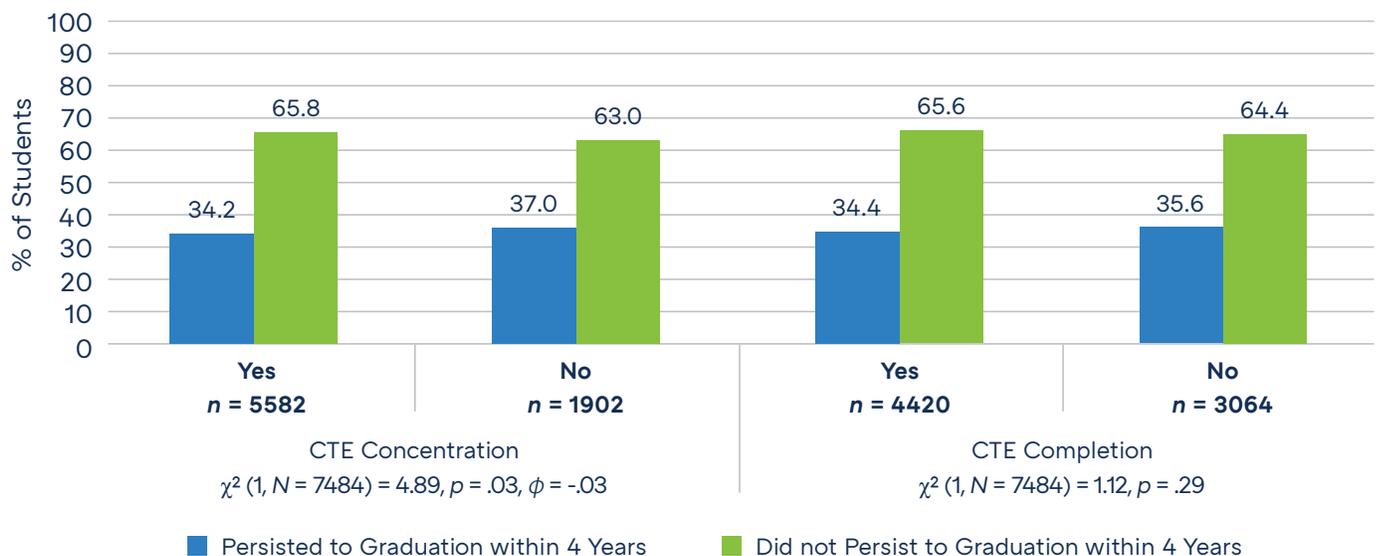
TABLE 12. Retention to Year 3 by Individual CTE Program Characteristics

		% Retention to Year 3	<i>N</i>	<i>df</i>	χ^2	<i>p</i>	ϕ
Participated in at Least 1 Program Characteristic							
	Yes	48.0	14877	1	47.03	< .001	.06
	No	41.7					
Internship							
	Yes	48.7	14877	1	12.22	< .001	.03
	No	43.1					
Cooperative Work Experience							
	Yes	39.8	14877	1	5.54	.02	-.02
	No	43.7					
Job Exploration							
	Yes	47.6	14877	1	12.41	< .001	.03
	No	43.0					
WBE							
	Yes	50.3	14877	1	11.66	.001	.03
	No	43.2					
Earned Postsecondary Credit							
	Yes	53.4	14877	1	58.04	< .001	.06
	No	42.5					

Postsecondary Graduation/Degree Completion

Persistence and Retention to Graduation. Chi-square analysis found no significant differences in the rate of retention to graduation based on CTE concentration or CTE completion. However, Figure 21 shows how the rate of persistence to graduation differed for students in the 2010-11 cohort who graduated high school on-time and entered college the next fall, by the percentage of the program completed. CTE concentrators graduated from postsecondary within four years of high school graduation at a slightly lower rate (34.2%) than non-concentrators (37.0%), although the association between variables was minimal ($\chi^2(1, N = 7,484) = 4.89, p = .03, \phi = -.03$). In contrast, CTE completers graduated at a statistically similar rate (34.4%) to non-completers (35.6%). These results suggest that despite slightly lower rates of college graduation for CTE concentrators, there is no difference in the rate of persistence to graduation based on CTE completion status alone.

FIGURE 21: Persistence to Graduation by CTE Concentration and Completion Status



*Note: 2010-11 Cohort only

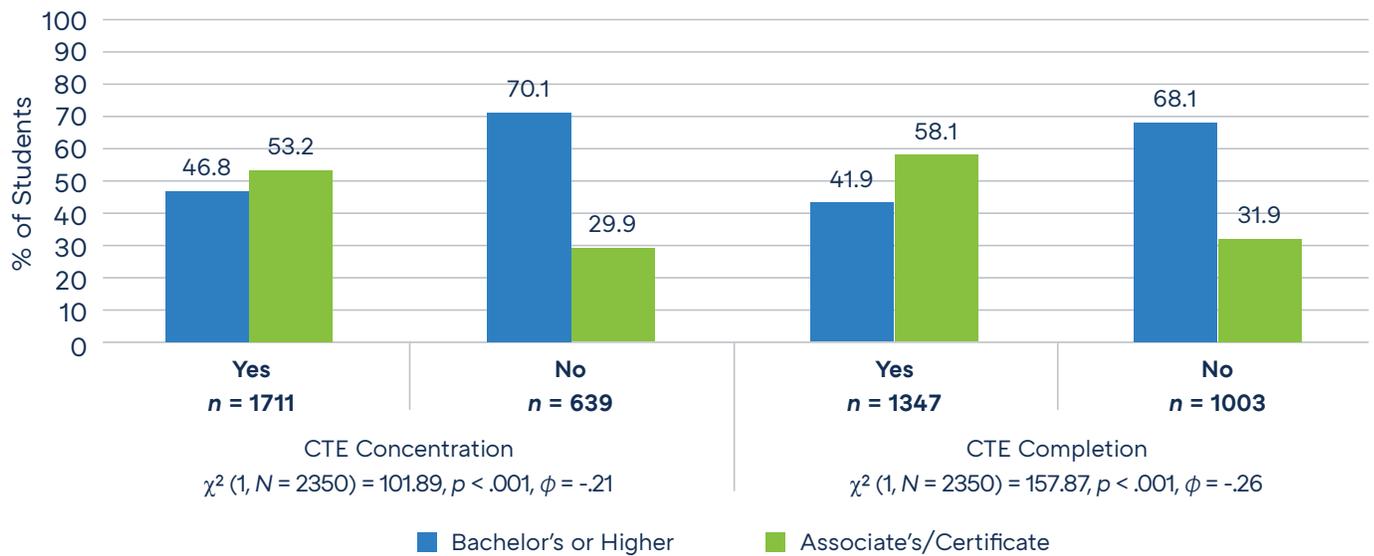
Table 13 displays the proportion of CTE participants who persisted to postsecondary graduation by their participation in the various program characteristics of interest during high school. Students who participated in at least one program characteristic graduated within four years of high school at a higher rate of 39.4%, compared to the 33.1% of students who had no such experience ($\chi^2(1, N = 7,484) = 25.74, p < .001, \phi = .06$). All but two individual variables of interest (Job Exploration and WBE) were found to be significantly associated with persistence to graduation within four years. Although students who participated in an internship graduated within four years at a lower rate (26.9%) than students who did not (35.5%), Cooperative Work Experience and Earned Postsecondary Credit were associated with significantly higher rates of postsecondary graduation, although with small effects ($\phi = .05$ and $\phi = .11$, respectively).

TABLE 13. Persistence to Graduation by Individual CTE Program Characteristics

	% Persisted to Graduation	<i>N</i>	<i>df</i>	χ^2	<i>p</i>	ϕ
Participated in at Least 1 Program Characteristic						
Yes	39.4	7484	1	25.74	< .001	.06
No	33.1					
Internship						
Yes	26.9	7484	1	16.12	< .001	-.05
No	35.5					
Cooperative Work Experience						
Yes	44.5	7484	1	20.52	< .001	.05
No	34.2					
Job Exploration*						
Yes	32.9	7484	1	1.51	.22	-.01
No	35.1					
WBE*						
Yes	36.9	7484	1	0.57	.45	.01
No	34.8					
Earned Postsecondary Credit						
Yes	50.7	7484	1	81.87	< .001	.11
No	33.3					

Highest Degree Earned. Figure 22 shows how the proportion of CTE participants who earned at least a bachelor’s degree upon postsecondary graduation differed for students in the 2010-11 cohort who graduated high school on-time and entered college the next fall, by their program intensity. CTE concentrators earned a bachelor’s degree or higher at a significantly lower rate (46.8%) than non-concentrators, who did so at a rate of 70.1% ($\chi^2 (1, N = 2,350) = 101.89, p < .001, \phi = -.21$). Likewise, CTE completers earned a bachelor’s degree or higher at a lower rate (41.9% versus 68.1%) than non-completers ($\chi^2 (1, N = 2,350) = 157.87, p < .001, \phi = -.26$). This suggests both CTE concentration and CTE completion are moderately associated with lower bachelor’s degree completion within four years, suggesting a meaningful link between intensity and degree attainment.

FIGURE 22: Highest Degree Earned by CTE Concentration and Completion Status



**Note: 2010-11 Cohort only*

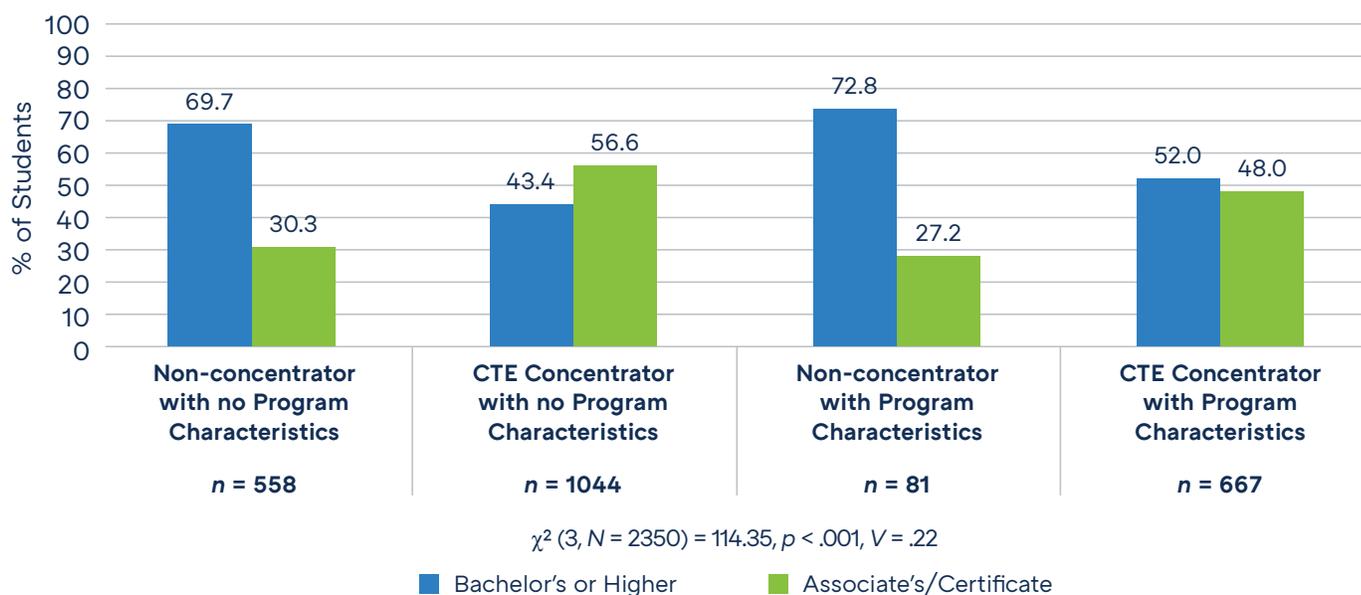
Table 14 shows the proportion of CTE participants who attained a bachelor’s degree within four years of postsecondary entry, based on their participation in the program characteristics of interest. Students who participated in at least one program characteristic during their high school CTE experience earned a bachelor’s degree or higher at rate similar to CTE participants without any program characteristic experience (54.3% versus 52.6%). All but two individual variables of interest (Internship and Job Exploration) were found to significantly differ in rates of bachelor’s degree attainment. While participation in a cooperative work experience was associated with a lower rate of bachelor’s degree completion, participation in the other significant program characteristics of interest (WBE and Earned Postsecondary Credit) was associated with slightly higher rates of bachelor’s degree attainment.

TABLE 14. Bachelor’s as Highest Degree Earned by Individual CTE Program Characteristics

	% Bachelor’s as Highest Degree	<i>N</i>	<i>df</i>	χ^2	<i>p</i>	ϕ
Participated in at Least 1 Program Characteristic*						
Yes	54.3	2350	1	0.61	.44	.02
No	52.6					
Internship*						
Yes	53.5	2350	1	0.01	.92	.002
No	53.1					
Cooperative Work Experience						
Yes	40.0	2350	1	14.67	< .001	-.08
No	54.3					
Job Exploration*						
Yes	53.6	2350	1	0.02	.88	.003
No	53.1					
WBE						
Yes	64.6	2350	1	5.53	.02	.05
No	52.6					
Earned Postsecondary Credit						
Yes	61.2	2350	1	9.38	.002	.06
No	51.9					

Figure 23 displays the results of the chi-square analysis comparing the highest degree earned by CTE participants by CTE concentration status and participation in at least one program characteristic. In this case, CTE concentrators who did not participate in any characteristics during high school earned a bachelor’s degree or higher at the lowest rate (43.4%), followed by CTE concentrators with characteristics (52.0%), and non-concentrators with no program characteristics (69.7%). Non-concentrators who participated in at least one program characteristic earned at least a bachelor’s degree at the highest rate (72.8%). Chi-square results indicate this difference in proportions was significant ($\chi^2 (3, N = 2,350) = 114.35, p < .001$) with a moderate association ($V = .22$), supporting the conclusion that program concentration is significantly associated with the rate of bachelor’s degree attainment for this cohort of students.

FIGURE 23: Highest Degree Earned by CTE Concentration vs. Program Characteristics



*Note: 2010-11 Cohort only

Logistic Regression Analyses

This phase of analysis utilized binary logistic regression to examine the effects of CTE program characteristics and intensity on high school graduation within four years, as well as postsecondary outcomes such as enrollment, persistence, retention, and degree attainment within four years of high school graduation. Logistic regression was used because all outcomes were binary.

The authors decided against modeling the association between program variables and Keystone assessment performance. Keystone exams are “best of eleventh grade”, meaning that students can take the Keystone subject tests sooner than their junior year. Due to data limitations, it was not possible to determine the point in time in which students participated in CTE or Keystone exams. This made it ambiguous to classify Keystone performance as an academic outcome influenced by CTE experiences. Keystone performance was therefore excluded from this phase of analysis.

Appendix C details the independent variables and covariates that were tested individually for significance. Analyses were exploratory in nature, which allowed for the examination of individual variables related to CTE program experiences and their association with secondary and postsecondary outcomes. The individual independent variables were examined in isolation, and then in the context of additional explanatory variables. The following section discusses the significant variables associated with each academic outcome in the final models. For a comprehensive list detailing how participation in the various program characteristics of interest was associated with each outcome, see Table B5 in Appendix B.

Analyses were exploratory in nature, which allowed for the examination of individual variables related to CTE program experiences and their association with secondary and postsecondary outcomes.

On-time High School Graduation

Appendix C, Table C1 displays the individual variables that were significantly associated with on-time high school graduation, as well as those that remained significant in the final model. The odds ratio ($\text{Exp}(\beta)$) indicates the likelihood of each outcome occurring depending on each variable status. Most notably, after controlling for other variables in the final model, the odds ratio based on CTE completion indicates that CTE completers had 5.214 times higher odds of graduating on-time than non-completers. This is equivalent to a 421.4% increase in odds of on-time high school graduation. Although the odds were also higher for CTE concentrators ($\text{Exp}(\beta) = 1.526$, or a 52.6% increase in odds), the increase in odds ($\text{Exp}(\beta) = 5.214$) based on CTE completion status suggests particular benefit to high school graduation rates for students who persist along their CTE program sequence past 50%, to completion.

Participation in all program characteristics of interest was individually associated with slightly increased odds of on-time high school graduation. Of these program characteristics, students who participated in an internship had the highest relative increase in odds of high school graduation ($\text{Exp}(\beta) = 2.323$, or a 132.3% increase in odds). The odds of a student graduating on-time from high school were between 1.33 and 1.744 times higher (a 33% to 74.4% increase in odds) if the

The increase in odds ($\text{Exp}(\beta) = 5.214$) based on CTE completion status suggests particular benefit to high school graduation rates for students who persist along their CTE program sequence past 50%, to completion.

student participated in a cooperative work experience, job exploration, or earned postsecondary credit in high school. Differences based on work-based experience, however, lost significance in context with other variables in the final model and dropped out. This indicates that apparent benefits to high school graduation rates based on work-based experience are not meaningful when contextualized with other program variables and demographic covariates.

Postsecondary Enrollment

Postsecondary Entry. The logistic regression identified a different relationship between program intensity variables (CTE Concentrator and CTE Completer) and outcomes in postsecondary education (Table C2). Individually, non-concentrators and non-completers had significantly higher odds of enrolling in postsecondary education than students who reached these program milestones. Even in the context of other program-level variables, odds ratios ($\text{Exp}(\beta)$) in the final model indicate that non-concentrators had slightly higher odds ($\text{Exp}(\beta) = 1.217$) of enrolling in postsecondary than CTE concentrators, while CTE non-completers had slightly higher odds ($\text{Exp}(\beta) = 1.113$) of enrolling than CTE completers. This is equivalent to a 21.7% and 11.3% increase in odds of postsecondary enrollment if a student was a non-concentrator or non-completer.

All program characteristics of interest maintained their significance in the final model. Students who did not participate in a cooperative work experience had 1.474 times higher odds (47.4% increase in odds) of entering postsecondary education than students who participated in this program experience. In contrast, students who participated in the remaining program characteristics had higher odds of postsecondary entry than non-participants. Students who participated in an internship, work-based experience, job exploration, or who earned postsecondary credit had between 1.160 and 1.538 times higher odds of postsecondary entry than students without these experiences, equivalent to a 16% to 53.8% increase in odds.

Full-time Enrollment and Four-year Institution Entry. The only program-level variable associated with the rate of full-time enrollment upon postsecondary entry was CTE Concentrator (Table C3). In the final model, non-concentrators had 1.244 times higher odds (a 24.4% increase in odds) of entering postsecondary at full-time status than CTE concentrators.

Table C4 shows the differential associations of program-level variables with 4-year institution entry. The odds of a student entering a 4-year institution were 1.139 times higher if the student was a non-concentrator (a 13.9% increase in odds) and 1.462 times higher if the students was a non-completer (a 46.2% increase in odds). In contrast, participation in all but one program characteristic of interest (cooperative work experience) was associated with slightly higher odds of 4-year institution entry, ($\text{Exp}(\beta)$) ranging from 1.150 to 1.432). This translates to a 15% to 43.2% increase in odds of 4-year institution entry. The absence of Cooperative Work Experience in the final model, and as an individual variable, indicates that 4-year institution entry was not associated with students' cooperative work experience.

Persistence and Retention

Tables C5 and C6 display the logistic regression statistics for program-level variables which were found to be significantly associated with persistence and retention to year two of postsecondary. Persistence and retention to year two were not associated with either variable of intensity. This indicates that the slight chi-square differences in the rate of persistence and retention to year two by CTE concentration

or CTE completion status are likely not meaningful. In contrast, CTE concentration and CTE completion were significantly associated with persistence and retention to year three (Tables C7 and C8). The odds of a student persisting to year three of postsecondary were 1.259 times higher if the student was a non-concentrator (a 25.9% increase in odds) and 1.203 times higher if the student was a non-completer (a 20.3% increase in odds). The odds of retention to year three were 1.226 times higher if the student was a non-concentrator (a 22.6% increase in odds) and 1.122 times higher if a non-completer (a 12.2% increase in odds).

Only one program characteristic of interest was associated with persistence and retention to both years two *and* three of postsecondary. Students who earned postsecondary credit in high school had significantly higher odds of persistence and retention to both years than students who did not earn credit. In particular, students who earned postsecondary credit had 1.218 times higher odds of persistence to year three and 1.441 times higher odds of retention to year three, or a 21.8% and 44.1% increase in odds. Students who participated in job exploration had 1.260 times higher odds (a 26% increase in odds) of persisting to year two than students who did not; however, job exploration was not associated with persistence to year three, or retention to any year. Inversely, students with internship experience had 1.321 times higher odds of retention to year two (a 32.1% increase), 1.603 times higher odds of retention to year three (60.3% increase), and 1.341 times higher odds (34.1% increase in odds) of persistence to year three. Work-based experience was associated only with retention to year three, such that students with work-based experience had 1.314 times higher odds (a 31.4% increase in odds).

Students who earned postsecondary credit in high school had significantly higher odds of persistence and retention to both years than students who did not earn credit.

Uniquely, Cooperative Work Experience was the only program variable not associated with higher odds of persistence or retention. For students who did not participate in a cooperative work experience, the odds of persisting to year three were 1.557 times higher (a 55.7% increase in odds). Likewise, the odds of retention to year three were 1.233 times higher (or a 23.3% increase in odds) if a student did not participate in a cooperative work experience. No variables were associated with retention to graduation.

Postsecondary Graduation and Highest Degree Earned

Table C9 displays that no variables of intensity were associated with postsecondary graduation in the context of other program-level variables in the final model. Although CTE concentration was found to be individually associated with postsecondary graduation within four years of high school, it lost significance in the final model. The variables that maintained significance were Cooperative Work Experience and Earned Postsecondary Credit. Students with either program characteristic had 1.260 and 1.657 times higher odds of graduating, respectively, or a 26% and 65.7% increase in odds.

Students with either program characteristic [cooperative work experience and earned postsecondary credit] had 1.260 and 1.657 times higher odds of graduating, respectively, or a 26% and 65.7% increase in odds.

Among students who graduated, Table C10 shows the logistic regression statistics for program variables associated with bachelor's degree attainment. Although CTE concentration was individually associated with the highest degree earned by CTE students, such that odds of a student attaining a bachelor's degree were higher if the student was a non-concentrator, this variable again dropped out in

the context of the final model. Instead, CTE non-completers were found to have 2.758 times higher odds (a 175.8% increase) of bachelor’s degree attainment than CTE completers, even in the context of other moderating variables.

Likewise, only one program characteristic maintained significance in the final model. The odds of a student earning a bachelor’s degree were 1.761 times higher (a 76.1% increase in odds) if the student earned postsecondary credit in high school. Participation in this program characteristic appears to be meaningfully associated with the highest degree earned by CTE students.

Demographic Trends

Figures 24–29 visually depict the final model odds ratios for the demographic variables that explained the greatest amount of variance in the educational outcomes of interest for CTE students. For example, Figure 24 displays the racial/ethnic variables used in each outcome’s final model. It can be interpreted as follows: In the final model, white CTE students were found to have 1.142 times higher odds (a 14.2% increase) of graduating high school on-time than non-white students. For this outcome, the most variance could be explained using a dichotomous, demographic variable indicating if a student was white or non-white. For other outcomes in the figure, the greatest variance could be explained using Hispanic/non-Hispanic or Black/non-Black indicators.

Notably, the odds of a CTE student entering postsecondary were 1.618 times higher (a 61.8% increase in odds) if the student was non-white. For all other outcomes, odds were higher for the demographic category which contained white students. For example, non-Hispanic students had 2.016 times higher odds of earning a bachelor’s degree than Hispanic students, while non-Black/African American students had 2.504 times higher odds of graduating from postsecondary than Black/African American students. This is equivalent to a 101.6% to 150.4% increase in odds of attaining a bachelor’s degree and graduating from postsecondary education, respectively.

Non-Hispanic students had 2.016 times higher odds of earning a bachelor’s degree than Hispanic students, while non-Black/African American students had 2.504 times higher odds of graduating from postsecondary than Black/African American students.

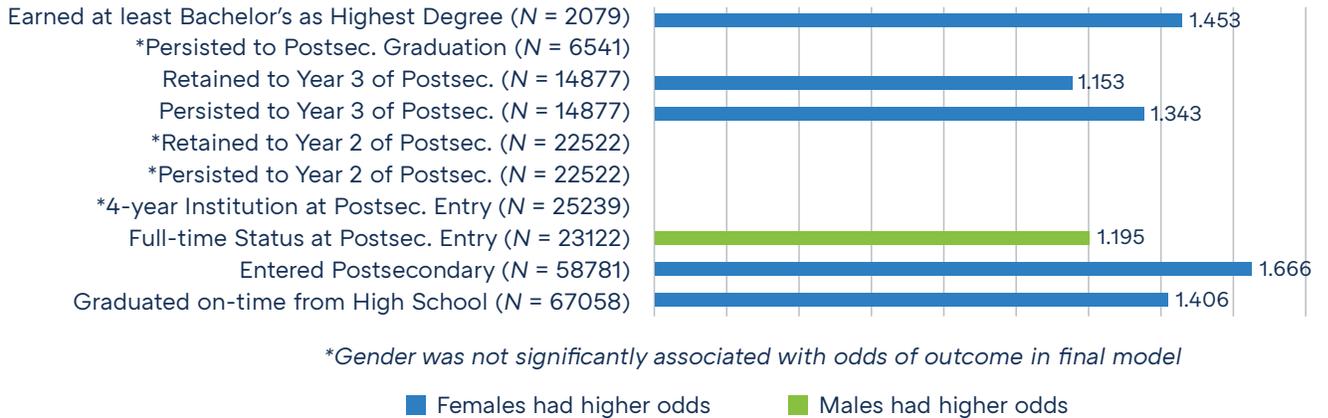
FIGURE 24: Final Model Odds Ratios (Exp(B)) for All Outcomes by CTE Participant Race/Ethnicity



■ Non-white students had higher odds ■ White students had higher odds
■ Non-Black/African American students had higher odds ■ Non-Hispanic students had higher odds

Figure 25 displays the outcomes with which gender was significantly associated in the final models. Gender was not associated with 4-year institution entry, persistence and retention to year two, or postsecondary graduation. The odds of a student enrolling in postsecondary education at full-time status were 1.195 times higher (a 19.5% increase in odds) if the student was male. For all remaining outcomes, females had between 1.153 and 1.666 times higher odds, equivalent to a 15.3% to 66.6% increase in odds relative to male students.

FIGURE 25: Final Model Odds Ratios (Exp(B)) for All Outcomes by CTE Participant Gender



As depicted in Figures 26 and 27, students who were non-economically disadvantaged or non-Special Education had higher odds of achieving each outcome. Most strikingly, the odds of a student earning a bachelor's degree were 2.006 times higher (a 100.6% increase in odds) if the student was non-economically disadvantaged and 3.008 times higher (a 200.8% increase in odds) if the student was not involved in Special Education during high school.

FIGURE 26: Final Model Odds Ratios (Exp(B)) for All Outcomes by CTE Participant Economically Disadvantaged Status

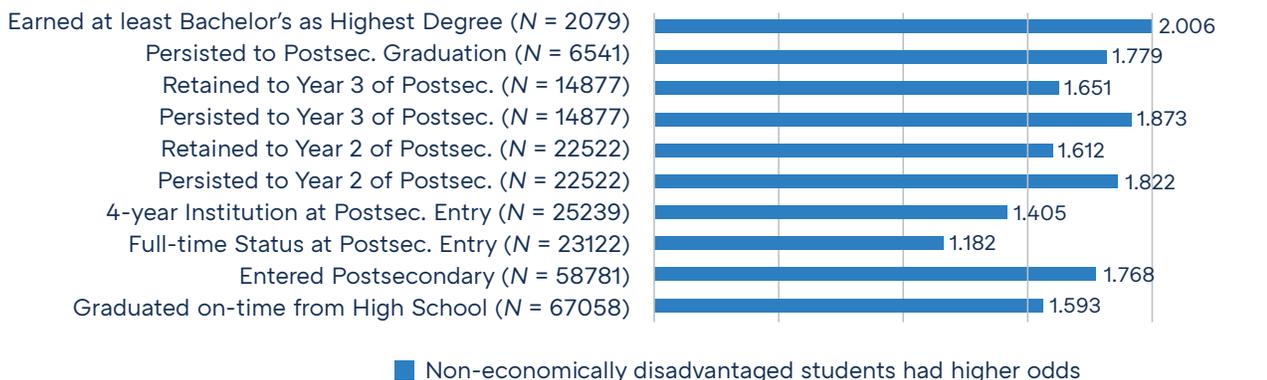


FIGURE 27: Final Model Odds Ratios (Exp(B)) for All Outcomes by CTE Participant Special Education Status

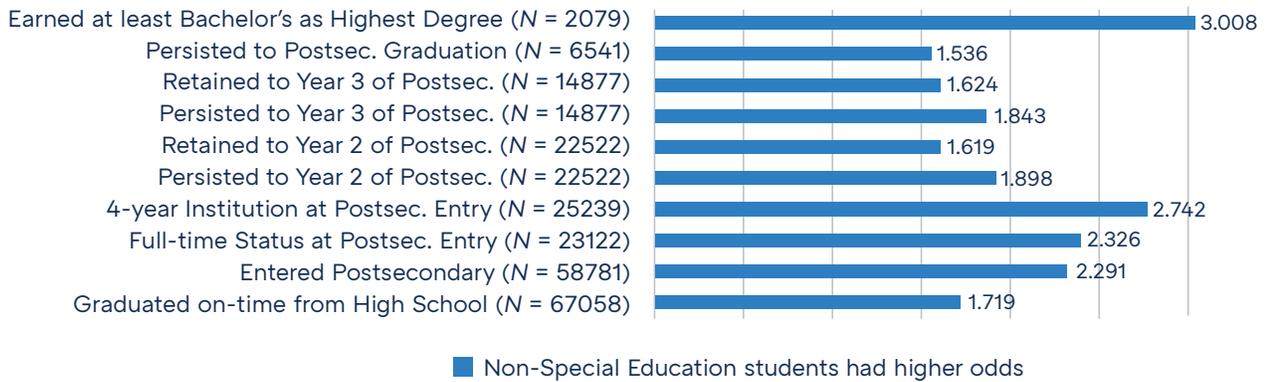
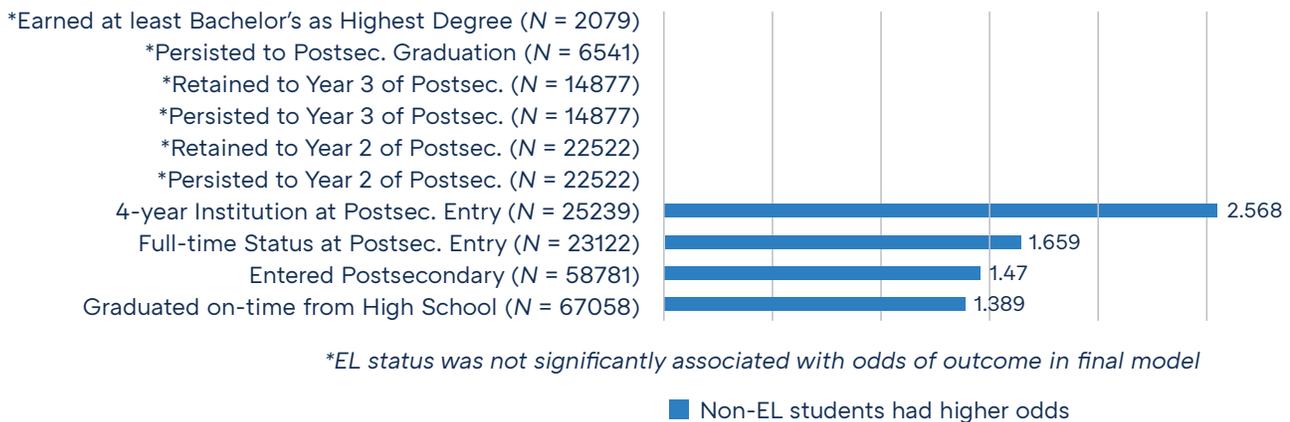


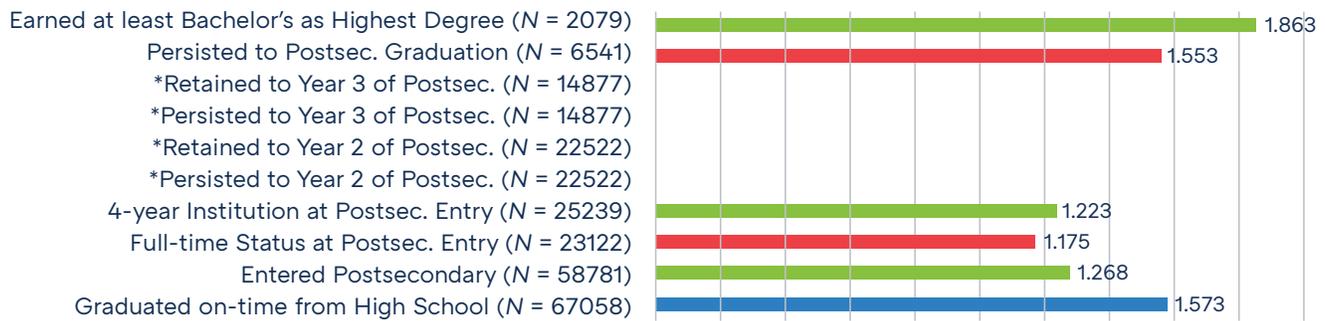
Figure 28 depicts that for all outcomes significantly associated with English Learner (EL) status, non-EL students had higher odds. Particularly, the odds of a student enrolling in a 4-year institution were 2.568 times higher (a 156.8% increase in odds) if the student was not an English Learner.

FIGURE 28: Final Model Odds Ratios (Exp(B)) for All Outcomes by CTE Participant English Learner (EL) Status



Finally, Figure 29 shows the geographic variables which were associated with outcomes in the final models. CTE participants from rural locales had 1.573 times higher odds (a 57.3% increase) of graduating on-time from high school than non-rural students. The remaining relevant outcomes were associated with a dichotomous variable indicating if a student was from a city/non-city school. CTE students from cities had 1.223 times higher odds (a 22.3% increase in odds) of initially enrolling at a 4-year institution and 1.863 times higher odds (86.3% increase in odds) of earning a bachelor's degree upon graduation than non-city students. In contrast, non-city CTE students had 1.175 times higher odds of initially enrolling at full-time status and 1.553 times higher odds than city CTE students of graduating from postsecondary within four years. This is equivalent to a 17.5% and 55.3% increase in odds, respectively. These odds ratios depict a complicated relationship between student geographic locale and academic outcomes for CTE students.

FIGURE 29: Final Model Odds Ratios (Exp(β)) for All Outcomes by CTE Participant Geographic Locale



**Geographic locale was not significantly associated with odds of outcome in final model*

- Rural students had higher odds
- Non-City students had higher odds
- City students had higher odds

Discussion

This study tracked three cohorts of Pennsylvania high school students from Grade 9 entry in years 2010-11, 2011-12, and 2012-13 into various points in their postsecondary education by 2017-18. Using chi-square and logistic regression analyses, CTE participants were identified in contrast to the non-CTE student population in order to compare academic outcomes. Secondary analyses compared outcomes within the CTE student population, based on CTE participants' program intensity (CTE concentration and CTE completion status) and the program characteristics in which they elected to participate. In this section, the results of these analyses are interpreted.

What is the description and breakdown of the CTE student population?

Descriptive analysis showed that Pennsylvania's CTE population was majority male (57.5%). Although the majority of CTE participants in PA were white (73.3%), this was to be expected considering the relatively low proportion of the overall student population who were non-white (29.1%). Unexpectedly, white students were slightly over-represented in the CTE participant population. Research from the National Center for Education Statistics (2013) indicated national rates of enrollment in at least one CTE credit were similar for Black/African American and white students. The present study clarifies that for the time period studied, 17% and 19% of these student groups in Pennsylvania 'participated' in CTE by completing at least 10% of a CTE program, respectively.

As predicted based on results from Palmer and Gaunt (2007), the current study found that economically disadvantaged and Special Education students were overrepresented among CTE participants in PA. A majority of CTE participants (62.7%) qualified as historically underperforming, a student category which includes economically disadvantaged, Special Education, and EL students. This is notable in comparison to the overall student cohort population, who qualified as historically underperforming at a rate of 46.0%.

Finally, descriptive analysis showed that while more CTE participants were enrolled in suburban schools than any other geographic locale, suburban schools were in fact underrepresented in CTE

when compared to their representation in the overall student population. This could be related to the U.S. Department of Education's finding that nationally, students from urban areas were more likely to have access to CTE than suburban students (Arbeit et al., 2017). Instead, rural students in the present study were overrepresented among CTE students. Although the U.S. Department of Education reported that students from urban locales had higher access to career and technical education nationally (Arbeit et al., 2017), the present study found that only 17.2% of CTE participants in PA attended city schools. This may suggest a potential distinction between CTE access and enrollment. It is possible that higher availability does not necessarily correspond with higher participation in CTE. Or perhaps urban schools in PA do not have higher access, as seen nationally. Although the current study did not investigate differences in CTE access in Pennsylvania schools, this may be worth investigating in future research.

While more CTE participants were enrolled in suburban schools than any other geographic locale, suburban schools were in fact underrepresented in CTE when compared to their representation in the overall student population.

How do CTE students differ from non-CTE students in rates of Keystone exam passing, on-time high school graduation and postsecondary enrollment, persistence, retention, and degree completion?

Despite the lack of literature indicating a difference between CTE and non-CTE students on standardized state assessment performance, the present study found that non-CTE students in PA passed the Keystone Algebra, Biology, and Literature exams at a significantly higher rate than CTE participants, with moderate effects ($\phi = -.21$, $\phi = -.22$, and $\phi = -.24$). While these findings suggest a discrepancy in academic performance between the two groups, it is difficult to say whether Keystone performance should be considered an educational outcome or moderator. The researchers did not have access to student course performance data or student GPA; instead, Keystone end-of-course assessment data were available for one cohort of PA students and provided the only data point regarding student achievement. The decision to interpret Keystone exam performance as an educational outcome, rather than a moderating variable, was based on the precedent that the Keystone exams indicate student progression through school.

Interestingly, CTE participants graduated from high school on-time at a slightly higher rate (86.5%) than non-CTE students (85.0%). Even after controlling for student demographic differences, the logistic regression analysis confirmed that CTE participants in these cohorts had 31.2% higher odds than non-CTE students of graduating on-time from high school. This finding is notable as the only academic outcome for which CTE participants exhibited preferable academic outcomes to non-CTE students.

CTE participants graduated from high school on-time at a slightly higher rate (86.5%) than non-CTE students (85.0%).

Despite the higher rate of high school graduation for CTE participants, postsecondary enrollment behaviors appear to favor non-CTE students. CTE participants enrolled in postsecondary education (2-year or 4-year institutions) at a significantly lower rate than non-CTE students, with a moderate effect. The majority (75.5%) of CTE participants who enrolled in postsecondary initially did so at full-time status, although non-CTE students had a significantly higher rate of full-time enrollment (88.6%). As anticipated by research from Dietrich et al. (2016), CTE students were more likely than non-CTE students to initially enroll at a 2-year institution after high school graduation; however, they still enrolled at 4-year institutions more often than not.

While non-CTE students in PA had significantly higher rates of persistence and retention to year two of postsecondary education, differences were more pronounced in year three, when CTE students had even lower rates of persistence and retention relative to non-CTE students. All the same, the effect sizes for persistence and retention to years two *and* three were small. The rate of persistence to graduation, which effectively represents the rate of postsecondary degree completion within four years of high school graduation, did not differ as much as expected between the two groups; CTE participants graduated at a rate of 34.9% compared to 47.8% of non-CTE students. There was no statistical difference between groups in the rate of retention to graduation.

These results were confirmed by the logistic regression analyses. Even after controlling for student demographics, non-CTE students had at least double the odds of achieving each postsecondary outcome. Exceptions were retention to year two and persistence to graduation, for which non-CTE students still had significantly higher odds ($\text{Exp}(\beta) = 1.654$ and 1.372 , respectively).

Finally, although non-CTE students in Pennsylvania received at least a bachelor's degree within four years at a higher rate than CTE participants, with a moderate effect ($\phi = -.24$), CTE participants who graduated from postsecondary still earned a bachelor's degree or higher (53.1%) more often than any other degree type (46.9%). After controlling for demographic differences, non-CTE students had 389.4% higher odds of attaining a bachelor's degree than CTE participants. Still, it is important to note that industry certifications could not be included in this analysis due to limitations in data accessibility. Perhaps the inclusion of industry certification would paint a wholly different picture of postsecondary credential earning among CTE students.

To what extent do CTE student outcomes differ depending on the characteristics (i.e. participation in work-based learning experiences, internships, postsecondary credits earned, etc.) and intensity (i.e. percentage of program completed, CTE concentration/completion status) of the CTE program curriculum?

Among the 78,228 CTE participants in these three cohorts, 58,664 (75%) qualified as CTE concentrators while 45,314 (58%) qualified as CTE completers. This appears to conflict with the U.S. Department of Education's (2019) finding that the majority of CTE students are non-concentrators; however, this is likely a result of the differing standards used by states to define their CTE student populations. Nationally, 37% of CTE participants (students who earned at least one credit in CTE) qualified as CTE concentrators by earning at least two credits in a single CTE career cluster (U.S. Department of Education). In Pennsylvania, these definitions relied instead on the percentage of CTE program technical hours students completed. It is therefore difficult to compare student outcomes across states by CTE participation or concentration status.

While the majority of CTE participants in Pennsylvania were concentrators, a similar proportion (76.5%) never participated in any program characteristics of interest. The rate of participation in individual program characteristics ranged from 3.1% (work-based experience) to 8.7% (job exploration). The following section interprets student outcomes based on CTE concentration and completion status, as well as participation in the various CTE program characteristics.

Keystone Exams

Chi-square results indicate that Keystone state standardized exam performance for CTE participants differed by program intensity, or the percentage of the program completed. Both CTE concentration and CTE completion were associated with slightly higher rates of Keystone Algebra exam passage, although performance on the Keystone Biology and Literature exams did not differ by concentration status alone. Instead, CTE completers scored advanced/proficient on the Biology and Literature exams at a significantly higher rate than non-completers. While slightly higher Algebra exam achievement is seen for CTE concentrators who completed at least 50% of their program, CTE students who persisted to program completion had significantly higher rates of achievement on all Keystone subject exams than non-completers. These findings suggest a potential threshold for CTE program intensity, where significantly higher rates of Keystone exam passage are witnessed for CTE students who persisted along their course sequences to completion, but not necessarily for students who qualified as ‘concentrators’ by completing at least 50% of their program.

Participation in at least one CTE program characteristic of interest was found to be associated with slightly higher rates of Keystone Algebra, Biology, and Literature exam passage. Although students who participated in an internship or job exploration during their CTE program did not differ in their Keystone Biology performance levels, and students with cooperative work experience had similar Keystone Literature performance as students without such experience, participation in all other program characteristics was associated with higher rates of Keystone exam passage.

It is important to note, however, that Keystone exam data reflect the “best of eleventh grade”; therefore, differences in Keystone performance cannot be interpreted as direct effects of CTE concentration or completion. Keystone performance was excluded from the logistic regression modeling for this reason. Likewise, CTE students can demonstrate postsecondary readiness by other means than passing the Keystone subject tests. Namely, they can show proficiency by passing the National Occupational Competency Testing Institute (NOCTI)/National Institute for Metalworking Skills (NIMS) assessments (Pennsylvania Department of Education, n.d.-b). To allow for comparisons between CTE and non-CTE students in Research Question 1, the present study used Keystone state standardized assessment performance as the sole indicator of academic performance.

Significantly higher rates of Keystone exam passage are witnessed for CTE students who persisted along their course sequence to completion, but not necessarily for students who qualified as ‘concentrators’ by completing at least 50% of their program.

CTE students can demonstrate postsecondary readiness by other means than passing the Keystone subject tests.

On-time High School Graduation

The current study's findings support previous research by Rivera-Batiz (2003) which suggested that participation in work-based learning opportunities decreased student risk of dropout. For CTE participants in these cohorts, participation in at least one program characteristic of interest was associated with a higher rate of on-time high school graduation.

Likewise, all individual program characteristics of interest showed significant but small associations with high school graduation. Differences based on work-based experience, however, lost significance in context with other variables in the final logistic regression model and dropped out. This indicates that apparent benefits to high school graduation rates based on work-based experience are not meaningful when contextualized with other program variables and demographic covariates. Students with the remaining program experiences had between 1.33 and 2.323 times higher odds of graduating from high school relative to students without these experiences.

The percentage of the program completed by CTE participants had the largest effect on their rate of high school graduation, as both CTE concentration and CTE completion had significant moderate effects ($\phi = .26$ and $\phi = .31$). Binary logistic regression analysis found that even in the context of other significant program-level variables, CTE completers had over five times higher odds than non-completers of graduating on-time from high school. Differences based on CTE concentration were significant, but less pronounced ($\text{Exp}(\beta) = 1.526$). These findings strongly suggest that on-time high school graduation for CTE participants is associated, to some degree, with whether students elected to persist along their program sequence. Quite possibly, these results indicate an overlap between premature CTE program dropout and non-traditional high school graduation patterns (i.e., dropout or grade repetition).

Binary logistic regression analysis found that even in the context of other significant program-level variables, CTE completers had over five times higher odds than non-completers of graduating on-time from high school.

Postsecondary Enrollment

Notably, CTE concentrators and CTE completers had significantly lower rates of college entry, full-time enrollment, and initial entry at a 4-year institution when compared to students who did not persist to these program intensity thresholds. This is consistent with the results from Research Question 1, which indicate that CTE participants (who completed at least 10% of their CTE program) had lower odds than non-CTE students of enrolling in postsecondary education, while those who did enroll in college were more likely than non-CTE students to do so part-time, and at 2-year institutions. However, CTE Concentration was the only intensity variable significantly associated with the rate of full-time enrollment in the logistic regression analysis. In the final model, non-concentrators had 1.244 times higher odds of entering postsecondary at full-time status than CTE concentrators.

CTE students who participated in a cooperative work experience enrolled in postsecondary at a significantly lower rate than students who did not.

CTE participants in Pennsylvania who participated in at least one program characteristic of interest had slightly higher rates of postsecondary entry, full-time enrollment, and 4-year institution entry compared to CTE students with no such experience. Participation in individual program characteristics, however,

were differentially associated with postsecondary enrollment patterns. Although participation in all other program characteristics of interest was associated with higher rates of postsecondary entry, CTE students who participated in a cooperative work experience enrolled in postsecondary at a significantly lower rate than students who did not. In contrast, while students who earned postsecondary credit in high school initially enrolled in postsecondary at full-time status at a higher rate than those who did not, this difference was not significant in the context of the final logistic regression model. The rate of full-time enrollment was not significantly associated with participation in the remaining program experiences. Finally, participation in a cooperative work experience was not significantly associated with the rate of initial entry in a 4-year institution; however, participation in the remaining characteristics was associated with increased odds of 4-year institution entry.

Persistence and Retention

Students who participated in at least one program characteristic persisted to years two, three, and on-time college graduation at slightly higher rates than students who did not. The logistic regression models found that only two individual program characteristics (Job Exploration and Earned Postsecondary Credit) were significantly associated with higher rates of persistence to year two of postsecondary. In fact, postsecondary credit earning during high school CTE was the only variable associated with persistence and retention to years two *and* three, as well as persistence to graduation. While students who participated in job exploration had higher odds ($\text{Exp}(\beta) = 1.260$) of persisting to year two than students who did not, Job Exploration was not significantly associated with persistence to year three, or retention to any year. Inversely, students with internship experience had higher odds of retention to years two and three, as well as persistence to year three. Work-based Experience was associated only with retention to year three, such that students with work-based experience had 1.314 times higher odds.

Uniquely, Cooperative Work Experience was the only program variable not associated with higher odds of persistence or retention to any year of postsecondary education. Students who did not participate in a cooperative work experience had higher odds of persistence and retention to a third year. However, students who *did* participate in a cooperative work experience had higher odds of graduating from college within four years of high school. At first glance, this is an odd finding. Persistence to graduation effectively indicates whether a student graduated from postsecondary within four years of high school; however, it is not an indication of whether the student persisted through postsecondary education *across consecutive years*. Students with cooperative work experience had higher odds of graduating within four years, but lower odds of persistence and retention to a third year, consecutively. Again, these results highlight a distinction in outcomes within the CTE population. They suggest that students who participate in specific program characteristics of interest may have more favorable outcomes in postsecondary education.

Although CTE concentrators and CTE completers had lower rates of persistence and retention to year two than students who did not reach these thresholds, neither CTE Concentration nor CTE Completion were significant variables in the final logistic regression models after controlling for other explanatory variables. They were, however, significantly associated with persistence and retention to year three, such that non-concentrators and non-completers had 1.259 and 1.203 times higher odds

The percentage of the program that CTE students complete is associated with persistence and retention to a third year only, such that CTE concentrators and CTE completers had lower odds of continuing to a third consecutive year.

of persistence to a third year. Likewise, although CTE concentration appeared to be associated with a lower rate of persistence to graduation according to the chi-square analysis, neither variable of intensity was significant in the final logistic regression model after controlling for other explanatory variables. Among the students who graduated from postsecondary education, there was no difference in the rate of retention to graduation based on CTE concentration or CTE completion. These findings suggest that the percentage of the program that CTE students complete is associated with persistence and retention to a third year of postsecondary education only, such that CTE concentrators and CTE completers had lower odds of continuing to a third consecutive year.

This could be due in part to the proportion of CTE concentrators and CTE completers who initially enrolled at 2-year postsecondary institutions, and the proportion of those students who graduated with an associate degree/certificate within four years. Over half of CTE concentrators (50.6%) and CTE completers (52.5%) initially enrolled in 2-year institutions, which is significantly greater than the 2-year institution rate for non-concentrators (40.2%) and non-completers (41.6%). CTE concentrators (53.2%) and CTE completers (58.1%) likewise graduated with an associate degree/certificate at a significantly higher rate than other CTE students (29.9% of non-concentrators, and 31.9% of non-completers). Given that a significantly higher percentage of non-concentrators and non-completers continued to a third year of postsecondary education, this could indicate that the postsecondary path for CTE concentrators and CTE completers tends to end after attaining an associate degree, certificate, or other pre-baccalaureate credential.

Highest Degree Earned

The effect of CTE Concentration was moderate ($\phi = -.21$); in fact, students who did not complete at least 50% of their program had a significantly higher rate of bachelor's degree completion (70.1%) than those who did (46.8%). However, when contextualized with other variables in the final logistic regression model, CTE concentration lost significance. Instead, non-completers were found to have 2.758 times higher odds of bachelor's degree attainment than CTE completers, even in the context of other moderating variables. These results suggest that CTE Completion is a more meaningful threshold of intensity when considering the highest degree earned by CTE participants. Combined with the moderate effect of CTE Completion found in the chi-square analysis ($\phi = -.26$), this is an indication that students who progress further along their CTE program sequence are significantly less likely to earn a bachelor's degree in postsecondary education. Again, this finding suggests that students who commit to more CTE in high school likely prioritize earlier workforce entry, more often earning an associate/certificate than any other postsecondary degree type.

Despite the small but significant effects of various program characteristics on highest degree earned seen in the chi-square analyses, only one program characteristic was significant in the context of the final logistic regression model when controlling for other explanatory variables. The odds of a CTE student earning a bachelor's degree were 1.761 times higher (a 76% increase in odds) if the student earned postsecondary credit in high school. Participation in this program characteristic appears to be meaningfully associated with the highest degree earned by CTE students. This is consistent with previous literature suggesting a potential benefit of postsecondary credit earning in high school (South Dakota Board of Regents, 2013), finding that a significantly greater proportion of dual enrolled students

The odds of a CTE student earning a bachelor's degree were 1.761 times higher (a 76% increase in odds) if the student earned postsecondary credit in high school.

graduated with a bachelor's degree in four years compared to other students. The results of the present study suggest that this benefit is likewise applicable to the CTE student population.

These results highlight the significant effects of CTE program intensity and characteristics on the highest degree earned by college graduated CTE participants. While one program characteristic was associated with higher odds of bachelor's degree completion, general participation in program characteristics had no effect. The percentage of the program completed was most relevant to student degree attainment, as CTE concentrators and CTE completers earned bachelor's degrees at a significantly higher rate.

The PIMS data used to determine high school academic achievement did not include information on student performance or GPA.

Limitations and Suggestions for Future Study

The present study faced several limitations. First, the authors were not able to request data on industry certifications earned in high school. The analyses described in this report would be strengthened by including industry certification as an additional academic outcome. Although the current study demonstrates the differing academic outcomes of CTE students to some degree, future studies should utilize industry certification data in order to paint a more complete picture of Pennsylvania students and their educational trajectories.

Second, the PIMS data used to determine high school academic achievement did not include information on student performance or GPA. These student-level factors could have been used as moderating variables to create a more robust illustration of CTE student outcomes. Although Keystone performance could have been used as a proxy for high school performance, the researchers instead interpreted Keystone performance as its own educational outcome when possible. The inclusion of academic performance data would be a beneficial addition to future research.

Finally, this report does not distinguish CTE student outcomes by industry or subject field of study. Due to limitations in data access, the researchers did not compare academic outcomes within the CTE population depending on the primary industry associated with students' CTE programs. As it is likely that CTE participants across different industries experience distinct outcomes in postsecondary education, this may be a potential direction for future studies in the Commonwealth.

Conclusions

Career and technical education (CTE) in Pennsylvania offers extant educational opportunities for students interested in fast-tracking their careers. Understandably, it follows that CTE students pursue unique educational trajectories following secondary education. The findings presented herein indicate that students who participate in CTE programs pursue different educational opportunities than non-CTE students in Pennsylvania. Additionally, outcomes were found to vary depending on CTE program intensity, such that students who persist along their program sequences are often less involved in traditional 4-year degree seeking opportunities. Finally, CTE students who take advantage of the various program characteristics (work-based experiences, internships, postsecondary credit-earning, etc.) available to them often have higher odds of reaching various postsecondary milestones. Pennsylvania students would likely benefit from schools offering as many CTE programs, and program characteristic opportunities, as feasible.

CTE students who take advantage of the various program characteristics (work-based experiences, internships, postsecondary credit-earning, etc.) available to them often have higher odds of reaching various postsecondary milestones.

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Appendix A

Definitions

Cooperative Work Experience: the CTE Student Fact template of PIMS defines a cooperative work experience as a “CTE program-related learning component providing on-the-job experience in a career and technical education program. Through written arrangement between the school and employer, the student received instruction, including required academic courses and related career and technical instruction, by alternation of study in school with a job related to the career and technical education instruction.”

CTE Completion: variable status indicating that a student participated in and ultimately completed a CTE program in high school, according to the *CTE Status Type Code* in the CTE Student Fact template of PIMS

CTE Completers: this term describes any student who met the definition for **CTE Completion** according to their *CTE Status Type Code* in the Pennsylvania Information Management System (PIMS)

CTE Concentration: variable status indicating that a student participated in and ultimately completed at least 50% of a CTE program in high school, as determined by the *Percentage of Program Complete* indicator in the CTE Student Fact template of PIMS

CTE Concentrator: this term describes any student who met the definition for **CTE Concentration** by completing at least 50% of their CTE program, according to the *Percentage of Program Complete* variable in the CTE Student Fact Template of PIMS

CTE Participant: any student present in the CTE Student Fact template (excluding Adult Affidavit Program students) who completed at least 10% of their program, according to the *Percentage of Program Complete* indicator in PIMS

CTE program: any PDE-approved secondary program (Occupational, Tech Prep, or Program of Study) that has a technical component and requires the student to complete and sign an “Annual Educational Occupational Objectives for Students Enrolled in a PDE Approved CTE Program” form (PDE-408) or similar form. Student enrollment in a CTE program is indicated by their presence in CTE Student Fact template of PIMS. *Note: the current study excludes students in the Adult Affidavit Program (AAP), although they were present in the CTE Student Fact template.

Earned Postsecondary Credit: variable status indicating that a student enrolled in and ultimately received postsecondary credit through a CTE program in high school. This status relies on the Cumulative Postsecondary Credits Earned indicator from the CTE Student Fact template of PIMS, where LEAs report only “earned credits awarded and documented on an official postsecondary institution transcript.”

Historically underperforming: status indicating student is either a Special Education, English Learner, or economically disadvantaged student.

Intensity: term used by the researchers to describe the percentage of the CTE program that CTE participants completed. The present study compared CTE participant outcomes by identifying whether students reached two different intensity milestones during the course of their programs. Thresholds of intensity include **CTE concentration** and **CTE completion**

Internship: the CTE Student Fact template of PIMS defines an internship as a “CTE program-related learning component that provides planned, supervised experiential learning with rotation periods of work observation and work exploration in a variety of employment situations ordinarily for short periods of time. Students are usually not paid for their experience; however, they do receive school credit. These experiences are primarily intended to develop career awareness rather than occupational competence.”

Job Exploration: the CTE Student Fact template of PIMS define job exploration as a “CTE program-related learning component providing off-campus, credit-bearing exploratory learning activities occurring in the community with the specific intent to provide realistic career exploration experiences for students.”

Non-completers: term used throughout report to describe CTE participants who did not complete their CTE program; opposite of **CTE completer**

Non-concentrator: describes CTE participants who did not meet the criteria for **CTE concentration** by completing at least 50% of their program; opposite of **CTE concentrator**

Persistence: term indicating whether a student who enrolled in postsecondary continued their education in the following, consecutive years. Outcomes of interest include student persistence to a second or third year of postsecondary education, or on-time graduation within four years of high school completion.

Program Characteristics: variable indicating if a CTE participant participated in any of the following learning components during their program: Internship, Cooperative Work Experience, Job Exploration, Work-based Experience (WBE), or Earned Postsecondary Credit. Students were labeled as having participated in at least one program characteristic or not during their respective programs.

Retention: term indicating whether a student who enrolled in postsecondary returned to the same institution in the following, consecutive years. Outcomes of interest include student retention to a second, third, or fourth year of postsecondary education.

Work-based Experience (WBE): the CTE Student Fact template of PIMS defines a work-based experience as a “CTE program-related learning component providing off-campus learning gained through training and instruction. Work-based experiences refer to technical skills occurring in a work setting. This learning component primarily is implemented and used within Job Seeking/Changing Skills, Diversified Occupations, programs (CIP 32.0105).

Appendix B

TABLE B1. Overall Student Population Demographics by 9th Grade Cohort

	All Cohorts (N = 418341) % (n)	2010–11 Cohort (N = 140299) % (n)	2011–12 Cohort (N = 139071) % (n)	2012–13 Cohort (N = 138971) % (n)
Gender				
Male	51.2 (214012)	51.4 (72115)	50.8 (70672)	51.3 (71225)
Female	48.8 (204329)	48.6 (68184)	49.2 (68399)	48.7 (67746)
Race/Ethnicity				
American Indian/Alaskan Native	0.1 (605)	0.1 (202)	0.1 (191)	0.2 (212)
Black/African American	15.2 (63716)	15.1 (21147)	15.4 (21379)	15.2 (21190)
Hispanic	8.7 (36508)	8.2 (11501)	8.8 (12171)	9.2 (12836)
White	70.9 (296574)	72.0 (100986)	70.7 (98310)	70.0 (97278)
Multi-Racial	1.5 (6471)	1.3 (1825)	1.5 (2150)	1.8 (2496)
Asian	3.4 (14176)	3.2 (4543)	3.4 (4765)	3.5 (4868)
Native Hawaiian or other Pacific Islander	*	*	*	*
Historically Underperforming				
Yes	46.0 (192406)	44.8 (62833)	46.4 (64558)	46.6 (65015)
No	54.0 (225935)	55.2 (77466)	53.6 (74513)	53.2 (73956)
Special Education				
Yes	14.9 (62286)	14.3 (20059)	15.0 (20871)	15.4 (21356)
No	85.1 (356055)	85.7 (120240)	85.0 (118200)	84.6 (117615)
English Learner (EL)				
Yes	2.2 (9382)	2.1 (3003)	2.2 (3071)	2.4 (3308)
No	97.8 (408959)	97.9 (137296)	97.8 (136000)	97.6 (135663)
Economically Disadvantaged				
Yes	38.9 (162584)	37.7 (52836)	39.3 (54696)	39.6 (55052)
No	61.1 (255757)	62.3 (87463)	60.7 (84375)	60.4 (83919)
Geographic Locale				
Rural	16.2 (67876)	16.5 (23144)	15.9 (22121)	16.3 (22611)
Town	11.1 (46638)	11.3 (15915)	11.0 (15284)	11.1 (15439)
Suburban	42.0 (175612)	41.8 (58636)	42.2 (58676)	42.0 (58300)
City	16.2 (67965)	16.2 (22708)	16.4 (22845)	16.1 (22412)
Missing	14.4 (60250)	14.2 (19896)	14.5 (20145)	14.5 (20209)

*Note: Cell size excluded because it does not meet minimum reporting requirements.

TABLE B2. CTE Student Population Demographics by Cohort

	All Cohorts (N = 78228) % (n)	2010–11 Cohort (N = 26215) % (n)	2011–12 Cohort (N = 25733) % (n)	2012–13 Cohort (N = 26280) % (n)
Gender				
Male	57.5 (45013)	57.7 (15119)	57.6 (14833)	57.3 (15061)
Female	42.5 (33215)	42.3 (11096)	42.4 (10900)	42.7 (11219)
Race/Ethnicity				
American Indian/Alaskan Native	0.2 (129)	0.1 (39)	0.2 (44)	0.2 (46)
Black/African American	13.7 (10733)	13.8 (3619)	14.1 (3628)	13.3 (3486)
Hispanic	10.0 (7802)	9.7 (2533)	9.6 (2479)	10.6 (2790)
White	73.3 (57359)	73.9 (19368)	73.3 (18868)	72.8 (19123)
Multi-Racial	1.5 (1148)	1.2 (315)	1.4 (365)	1.8 (468)
Asian	1.3 (1031)	1.3 (331)	1.3 (338)	1.4 (362)
Native Hawaiian or other Pacific Islander	*	*	*	*
Historically Underperforming				
Yes	62.7 (49012)	61.4 (16090)	63.3 (16278)	63.3 (16644)
No	37.3 (29216)	38.6 (10125)	36.7 (9455)	36.7 (9636)
Special Education				
Yes	25.6 (20039)	24.7 (6463)	26.2 (6750)	26.0 (6826)
No	74.4 (58189)	75.3 (19752)	73.8 (18983)	74.0 (19454)
English Learner (EL)				
Yes	1.9 (1468)	1.9 (492)	1.8 (461)	2.0 (515)
No	98.1 (76760)	98.1 (25723)	98.2 (25272)	98.0 (25765)
Economically Disadvantaged				
Yes	51.4 (40203)	50.2 (13149)	51.8 (13341)	52.2 (13713)
No	48.6 (38025)	49.8 (13066)	48.2 (12392)	47.8 (12567)
Geographic Locale				
Rural	22.6 (17666)	22.5 (5889)	22.1 (5694)	23.1 (6083)
Town	13.7 (10713)	13.8 (3607)	13.5 (3473)	13.8 (3633)
Suburban	32.4 (25320)	31.7 (8305)	33.0 (8501)	32.4 (8514)
City	17.2 (13438)	17.4 (4551)	17.0 (4387)	17.1 (4500)
Missing	14.2 (11091)	14.7 (3863)	14.3 (3678)	13.5 (3550)

*Note: Cell size excluded because it does not meet minimum reporting requirements.

TABLE B3. CTE Student Demographics by CTE Concentration and CTE Completion Status

	Never CTE Concentrator or CTE Completer (N = 19564) % (n)	CTE Concentrators (N = 58664) % (n)	CTE Completers (N = 45314) % (n)
Gender			
Male	56.3 (11010)	58.0 (34003)	57.9 (26246)
Female	43.7 (8554)	42.0 (24661)	42.1 (19068)
Race/Ethnicity			
American Indian/Alaskan Native	0.2 (41)	0.2 (88)	0.2 (69)
Black/African American	16.8 (3296)	12.7 (7437)	11.2 (5096)
Hispanic	10.3 (2007)	9.9 (5795)	9.7 (4414)
White	69.6 (13614)	74.6 (43745)	76.4 (34618)
Multi-Racial	1.8 (350)	1.4 (798)	1.2 (566)
Asian	1.3 (249)	1.3 (782)	1.2 (540)
Native Hawaiian or other Pacific Islander	*	*	*
Historically Underperforming			
Yes	63.1 (12347)	62.5 (36665)	61.9 (28048)
No	36.9 (7217)	37.5 (21999)	38.1 (17266)
Special Education			
Yes	25.3 (4954)	25.7 (15085)	25.9 (11714)
No	74.7 (14610)	74.3 (43579)	74.1 (33600)
English Learner (EL)			
Yes	2.1 (412)	1.8 (1056)	1.6 (713)
No	97.9 (19152)	98.2 (57608)	98.4 (44601)
Economically Disadvantaged			
Yes	53.0 (10371)	50.9 (29832)	49.9 (22608)
No	47.0 (9193)	49.1 (28832)	50.1 (22706)
Geographic Locale			
Rural	22.6 (4414)	22.6 (13252)	23.2 (10524)
Town	15.8 (3085)	13.0 (7628)	12.2 (5526)
Suburban	27.1 (5293)	34.1 (20027)	36.2 (16393)
City	17.7 (3462)	17.0 (9976)	15.2 (6879)
Missing	16.9 (3310)	13.3 (7781)	13.2 (5992)

*Note: Cell size excluded because it does not meet minimum reporting requirements.

TABLE B4. CTE Student Demographics by Participation in CTE Program Characteristics

	Never Participated in Any Program Characteristics (N = 59818) % (n)	Internship (N = 3211) % (n)	Cooperative Work Experience (N = 6093) % (n)	Job Exploration (N = 6778) % (n)	Work-based Experience (WBE) (N = 2390) % (n)	Earned Postsecondary Credit (N = 4791) % (n)
Gender						
Male	57.9 (34664)	32.8 (1052)	74.0 (4507)	50.8 (3445)	50.6 (1210)	51.3 (2457)
Female	42.1 (25154)	67.2 (2159)	26.0 (1586)	49.2 (3333)	49.4 (1180)	48.7 (2334)
Race/Ethnicity						
American Indian/ Alaskan Native	0.2 (104)	*	*	*	*	*
Black/African American	15.1 (9047)	24.3 (779)	2.8 (169)	16.3 (1104)	6.4 (153)	7.1 (341)
Hispanic	10.3 (6150)	17.2 (553)	6.0 (368)	8.8 (595)	14.7 (352)	7.5 (357)
White	71.7 (42898)	51.8 (1664)	89.5 (5454)	70.3 (4762)	77.0 (1840)	81.6 (3911)
Multi-Racial	1.5 (893)	1.7 (54)	0.8 (46)	1.9 (126)	1.2 (28)	1.6 (76)
Asian	1.2 (706)	4.9 (156)	0.7 (45)	2.6 (179)	0.5 (13)	2.0 (96)
Native Hawaiian or other Pacific Islander	0.01 (20)	*	*	*	*	*
Historically Underperforming						
Yes	64.8 (38765)	68.3 (2193)	49.0 (2983)	63.4 (4295)	53.2 (1271)	49.3 (2363)
No	35.2 (21053)	31.7 (1018)	51.0 (3110)	36.6 (2483)	46.8 (1119)	50.7 (2428)
Special Education						
Yes	27.0 (16135)	15.5 (499)	23.0 (1403)	22.0 (1494)	17.6 (420)	18.5 (884)
No	73.0 (43683)	84.5 (2712)	77.0 (4690)	78.0 (5284)	82.4 (1970)	81.5 (3907)
English Learner (EL)						
Yes	2.0 (1197)	3.3 (105)	0.9 (57)	1.9 (130)	2.2 (52)	1.0 (48)
No	98.0 (58621)	96.7 (3106)	99.1 (6036)	98.1 (6648)	97.8 (2338)	99.0 (4743)
Economically Disadvantaged						
Yes	53.4 (31951)	61.4 (1972)	35.0 (2134)	53.5 (3623)	44.9 (1072)	40.2 (1928)
No	46.6 (27867)	38.6 (1239)	65.0 (3959)	46.5 (3155)	55.1 (1318)	59.8 (2863)
Geographic Locale						
Rural	22.8 (13641)	11.3 (364)	28.8 (1756)	15.0 (1015)	7.8 (187)	28.3 (1357)
Town	14.2 (8485)	8.4 (270)	13.2 (806)	10.9 (742)	6.8 (163)	13.2 (633)
Suburban	31.2 (18693)	26.5 (852)	36.2 (2205)	34.1 (2309)	29.7 (710)	41.2 (1974)
City	17.3 (10335)	44.6 (1433)	9.0 (550)	28.7 (1944)	28.7 (686)	7.0 (334)
Missing	14.5 (8664)	9.1 (292)	12.7 (776)	11.3 (768)	26.9 (644)	10.3 (493)

*Note: Cell size excluded because it does not meet minimum reporting requirements.

TABLE B5. Relative Odds of All Academic Outcomes based on CTE Student Participation in each CTE Program Characteristic: Significant Associations from Logistic Regression (Appendix C)

<i>Participated in...</i>	Internship	Cooperative Work Experience	Job Exploration	WBE	Earned Postsecondary Credit
Outcome					
On-time High School Graduation	↑	↑	↑		↑
Postsecondary Entry	↑	↓	↑	↑	↑
Full-time Enrollment status					
4-year Institution type	↑		↑	↑	↑
Persistence to Year 2			↑		↑
Retention to Year 2	↑				↑
Persistence to Year 3	↑	↓			↑
Retention to Year 3	↑	↓		↑	↑
Persistence to Grad		↑			↑
Bachelor's as Highest Degree earned					↑

↑ = participation in program characteristic is associated with higher odds of achieving outcome

↓ = participation in program characteristic is associated with lower odds of achieving outcome

□ = participation in program characteristic was not associated with this outcome, according to the logistic regression

Appendix C

Logistic Regression Analysis Tables

To interpret the direction of model coefficients, the coding of variables used in the logistic regression analyses are listed below:

CTE Completer (0 = Did not complete CTE program; 1 = Completed CTE program)

CTE Concentrator (0 = Did not complete at least 50% of program; 1 = Completed at least 50%)

Any Program Characteristics (0 = Did not participate in any characteristics; 1 = Participated in at least one program characteristic)

Internship (0 = Did not participate in internship; 1 = Participated in internship)

Cooperative Work Experience (0 = Did not participate in Cooperative Work Experience; 1 = Participated in Cooperative Work Experience)

Job Exploration (0 = Did not participate in Job Exploration; 1 = Participated in Job Exploration)

Work-Based Experience (0 = Did not participate in work-based experience; 1 = Participated in work-based experience)

Earned Postsecondary Credit (0 = Did not earn postsecondary credit; 1 = Earned postsecondary credit)

Gender (0 = Female; 1 = Male)

Race/Ethnicity – White (0 = Not white; 1 = White)

Race/Ethnicity – Black/African American (0 = Not Black/African American; 1 = Black/African American)

Race/Ethnicity – Hispanic (0 = Not of Hispanic origin; 1 = Hispanic)

Special Education (0 = Not Special Education; 1 = Special Education)

Economically Disadvantaged (0 = Not economically disadvantaged; 1 = Economically disadvantaged)

English Learner (0 = Not EL; 1 = EL)

Geographic Locale – Rural (0 = Not rural; 1 = Rural)

Geographic Locale – City (0 = Not city; 1 = City)

TABLE C1. Logistic Regression Analysis of On-time High School Graduation by CTE Participants' Program Experiences

Individual Independent Variables	β	Se β	Wald's χ^2	df	p	Exp(β) Odds Ratio	Model χ^2 (p)	n
CTE Completer ¹	2.006	.026	5976.470	1	.001	7.433	7650.211 (.001)	78,149
CTE Concentrator ¹	1.512	.022	4842.107	1	.001	4.538	4769.167 (.001)	78,149
Any Program Characteristics ¹	1.085	.033	1072.863	1	.001	2.959	1354.390 (.001)	78,149
Internship ¹	1.628	.103	251.552	1	.001	5.093	427.764 (.001)	78,149
Cooperative Work Experience ¹	1.592	.073	482.168	1	.001	4.915	791.892 (.001)	78,149
Job Exploration ¹	.889	.051	304.596	1	.001	2.432	385.377 (.001)	78,149
Work-Based Experience ¹	.489	.073	45.037	1	.001	1.631	51.215 (.001)	78,149
Earned Postsecondary Credit ¹	.946	.062	229.705	1	.001	2.576	299.202 (.001)	78,149
Final Model*							7790.490 (.001)	67,058
Constant	-.284	.076	13.839	1	.001	.753		
CTE Completer ¹	1.651	.036	2160.282	1	.001	5.214		
CTE Concentrator ¹	.423	.030	193.920	1	.001	1.526		
Gender ²	.341	.026	167.819	1	.001	1.406		
Race/Ethnicity - White ¹	.133	.030	19.273	1	.001	1.142		
Special Education ²	.542	.027	389.052	1	.001	1.719		
English Learner ²	.329	.075	19.172	1	.001	1.389		
Economically Disadvantaged ²	.466	.027	291.194	1	.001	1.593		
Geographic Locale - Rural ¹	.453	.033	188.817	1	.001	1.573		
Cooperative Work Experience ¹	.556	.083	45.393	1	.001	1.744		
Internship ¹	.843	.120	49.203	1	.001	2.323		
Job Exploration ¹	.285	.063	20.374	1	.001	1.330		
Earned Postsecondary Credit ¹	.373	.073	26.230	1	.001	1.452		

*Final Models include all independent variables that were significant when tested individually and remained significant.

¹First is reference in logistic regression model; ²Last is reference in logistic regression model.

TABLE C2. Logistic Regression Analysis of Postsecondary Entry by CTE Participants' Program Experiences

Individual Independent Variables	β	Se β	Wald's χ^2	df	p	Exp(β) Odds Ratio	Model χ^2 (p)	n
CTE Completer ²	.247	.016	228.549	1	.001	1.280	228.409 (.001)	66,255
CTE Concentrator ²	.284	.019	215.750	1	.001	1.329	215.302 (.001)	66,255
Any Program Characteristics ¹	.152	.018	72.016	1	.001	1.164	71.876 (.001)	66,255
Internship ¹	.768	.038	409.693	1	.001	2.156	423.700 (.001)	66,255
Cooperative Work Experience ²	.480	.029	270.173	1	.001	1.615	280.860 (.001)	66,255
Job Exploration ¹	.317	.027	142.964	1	.001	1.373	142.709 (.001)	66,255
Work-Based Experience ¹	.308	.044	49.291	1	.001	1.361	49.207 (.001)	66,255
Earned Postsecondary Credit ¹	.425	.032	181.569	1	.001	1.529	182.008 (.001)	66,255
Final Model*							5319.033 (.001)	58,781
Constant	-2.487	.077	1030.514	1	.001	.083		
CTE Completer ²	.107	.025	18.944	1	.001	1.113		
CTE Concentrator ²	.196	.029	45.412	1	.001	1.217		
Internship ¹	.430	.045	93.230	1	.001	1.538		
Cooperative Work Experience ²	.388	.033	138.940	1	.001	1.474		
Job Exploration ¹	.148	.032	21.740	1	.001	1.160		
Work-Based Experience ¹	.412	.055	56.776	1	.001	1.510		
Earned Postsecondary Credit ¹	.427	.035	152.475	1	.001	1.533		
Race/Ethnicity – White ²	.481	.025	380.087	1	.001	1.618		
Gender ²	.510	.018	823.637	1	.001	1.666		
Special Education ²	.829	.022	1405.419	1	.001	2.291		
English Learner ²	.385	.067	32.578	1	.001	1.470		
Economically Disadvantaged ²	.570	.019	892.589	1	.001	1.768		
Geographic Locale – City ¹	.238	.027	79.766	1	.001	1.268		

*Final Models include all independent variables that were significant when tested individually and remained significant.

¹First is reference in logistic regression model; ²Last is reference in logistic regression model.

TABLE C3. Logistic Regression Analysis of Full-time Enrollment Status at Postsecondary Entry by CTE Participants' Program Experiences

Individual Independent Variables	β	Se β	Wald's χ^2	df	p	Exp(β) Odds Ratio	Model χ^2 (p)	n
CTE Concentrator ²	.276	.036	59.115	1	.001	1.318	60.972 (.001)	26,121
Final Model*							954.796 (.001)	23,122
Constant	-.741	.112	43.582	1	.001	.476		
CTE Concentrator ²	.219	.039	31.122	1	.001	1.244		
Gender ¹	.178	.032	31.421	1	.001	1.195		
Race/Ethnicity – White ¹	.502	.040	155.946	1	.001	1.653		
Special Education ²	.844	.041	420.673	1	.001	2.326		
English Learner ²	.506	.107	22.271	1	.001	1.659		
Economically Disadvantaged ²	.167	.035	22.836	1	.001	1.182		
Geographic Locale – City ²	.161	.042	14.599	1	.001	1.175		

TABLE C4. Logistic Regression Analysis of Four-year Institution Entry by CTE Participants' Program Experiences

Individual Independent Variables	β	Se β	Wald's χ^2	df	p	Exp(β) Odds Ratio	Model χ^2 (p)	n
CTE Completer ²	.440	.024	323.366	1	.001	1.553	326.000 (.001)	28,507
CTE Concentrator ²	.422	.029	218.370	1	.001	1.525	221.273 (.001)	28,507
Internship ¹	.128	.048	7.181	1	.007	1.137	7.203 (.007)	28,507
Job Exploration ¹	.165	.038	18.912	1	.001	1.179	18.986 (.001)	28,507
Work-Based Experience ¹	.367	.063	33.620	1	.001	1.443	34.262 (.001)	28,507
Earned Postsecondary Credit ¹	.277	.044	39.575	1	.001	1.319	39.982 (.001)	28,507
Work-Based Experience ¹	.308	.044	49.291	1	.001	1.361	49.207 (.001)	66,255
Earned Postsecondary Credit ¹	.425	.032	181.569	1	.001	1.529	182.008 (.001)	66,255
Final Model*							1675.258 (.001)	25,239
Constant	-2.451	.123	396.742	1	.001	.086		
CTE Concentrator ²	.130	.043	9.301	1	.002	1.139		
CTE Completer ²	.380	.036	108.751	1	.001	1.462		
Internship ¹	.140	.060	5.468	1	.019	1.150		
Job Exploration ¹	.236	.047	24.909	1	.001	1.266		
Work-Based Experience ¹	.359	.075	23.077	1	.001	1.432		
Earned Postsecondary Credit ¹	.225	.047	22.394	1	.001	1.252		
Race/Ethnicity – White ¹	.357	.035	103.319	1	.001	1.429		
Special Education ²	1.009	.040	649.731	1	.001	2.742		
English Learner ²	.943	.116	65.638	1	.001	2.568		
Economically Disadvantaged ²	.340	.029	137.088	1	.001	1.405		
Geographic Locale – City ¹	.202	.038	27.876	1	.001	1.223		
Economically Disadvantaged ²	.570	.019	892.589	1	.001	1.768		
Geographic Locale – City ¹	.238	.027	79.766	1	.001	1.268		

*Final Models include all independent variables that were significant when tested individually and remained significant.

¹First is reference in logistic regression model; ²Last is reference in logistic regression model.

TABLE C5. Logistic Regression Analysis of Persistence to Year Two by CTE Participants' Program Experiences

Individual Independent Variables	β	Se β	Wald's χ^2	df	p	Exp(β) Odds Ratio	Model χ^2 (p)	n
Job Exploration ¹	.142	.047	9.171	1	.002	1.153	9.323 (.002)	22,522
Earned Postsecondary Credit ¹	.490	.058	70.441	1	.001	1.632	76.021 (.001)	22,522
Final Model*							873.243 (.001)	22,522
Constant	-.278	.050	30.381	1	.001	.758		
Job Exploration ¹	.231	.048	23.152	1	.001	1.260		
Earned Postsecondary Credit ¹	.364	.059	37.659	1	.001	1.439		
Race/Ethnicity – Black/African American ²	.255	.041	39.290	1	.001	1.290		
Special Education ²	.641	.040	251.722	1	.001	1.898		
Economically Disadvantaged ²	.600	.031	372.276	1	.001	1.822		

TABLE C6. Logistic Regression Analysis of Retention to Year Two by CTE Participants' Program Experiences

Individual Independent Variables	β	Se β	Wald's χ^2	df	p	Exp(β) Odds Ratio	Model χ^2 (p)	n
Internship ¹	.120	.055	4.747	1	.029	1.128	4.796 (.029)	22,522
Earned Postsecondary Credit ¹	.387	.053	54.076	1	.001	1.472	56.355 (.001)	22,522
Final Model*							668.218 (.001)	22,522
Constant	-.479	.049	94.372	1	.001	.619		
Earned Postsecondary Credit ¹	.275	.053	26.532	1	.001	1.317		
Internship ¹	.278	.057	24.025	1	.001	1.321		
Special Education ²	.482	.040	148.319	1	.001	1.619		
Economically Disadvantaged ²	.477	.029	262.542	1	.001	1.612		
Race/Ethnicity – Black/African American ²	.334	.039	72.031	1	.001	1.397		

*Final Models include all independent variables that were significant when tested individually and remained significant.

¹First is reference in logistic regression model; ²Last is reference in logistic regression model.

TABLE C7. Logistic Regression Analysis of Persistence to Year Three by CTE Participants' Program Experiences

Individual Independent Variables	β	Se β	Wald's χ^2	df	p	Exp(β) Odds Ratio	Model χ^2 (p)	n
CTE Concentrator ²	.381	.039	93.851	1	.001	1.464	95.340 (.001)	14,877
CTE Completer ²	.334	.034	96.628	1	.001	1.397	97.271 (.001)	14,877
Any Program Characteristics ¹	.224	.037	36.297	1	.001	1.250	36.524 (.001)	14,877
Internship ¹	.245	.066	13.678	1	.001	1.277	13.869 (.001)	14,877
Cooperative Work Experience ²	.265	.067	15.649	1	.001	1.303	15.672 (.001)	14,877
Earned Postsecondary Credit ¹	.453	.061	56.010	1	.001	1.573	57.902 (.001)	14,877
Final Model*							873.056 (.001)	14,877
Constant	-1.617	.106	233.790	1	.001	.198		
CTE Concentrator ²	.231	.056	16.994	1	.001	1.259		
CTE Completer ²	.185	.049	14.454	1	.001	1.203		
Internship ¹	.294	.083	12.511	1	.001	1.341		
Cooperative Work Experience ²	.443	.082	29.286	1	.001	1.557		
Earned Postsecondary Credit ¹	.197	.077	6.493	1	.011	1.218		
Gender ²	.295	.034	73.968	1	.001	1.343		
Special Education ²	.612	.051	146.585	1	.001	1.843		
Economically Disadvantaged ²	.628	.036	299.436	1	.001	1.873		
Any Program Characteristics ¹	.244	.061	16.197	1	.001	1.276		
Race/Ethnicity – Black/African American ²	.189	.049	15.093	1	.001	1.208		

*Final Models include all independent variables that were significant when tested individually and remained significant.

¹First is reference in logistic regression model; ²Last is reference in logistic regression model.

TABLE C8. Logistic Regression Analysis of Retention to Year Three by CTE Participants' Program Experiences

Individual Independent Variables	β	Se β	Wald's χ^2	df	p	Exp(β) Odds Ratio	Model χ^2 (p)	n
CTE Concentrator ²	.298	.038	59.948	1	.001	1.347	59.846 (.001)	14,877
CTE Completer ²	.245	.034	52.850	1	.001	1.278	52.850 (.001)	14,877
Any Program Characteristics ¹	.252	.037	46.931	1	.001	1.286	46.853 (.001)	14,877
Internship ¹	.226	.065	12.176	1	.001	1.253	12.135 (.001)	14,877
Cooperative Work Experience ²	.160	.068	5.527	1	.019	1.174	5.575 (.018)	14,877
Job Exploration ¹	.185	.053	12.382	1	.001	1.203	12.341 (.001)	14,877
Work-Based Experience ¹	.288	.084	11.590	1	.001	1.333	11.562 (.001)	14,877
Earned Postsecondary Credit ¹	.439	.058	57.344	1	.001	1.551	57.484 (.001)	14,877
Final Model*							610.792 (.001)	14,877
Constant	-1.706	.097	310.169	1	.001	.182		
CTE Concentrator ²	.204	.055	13.891	1	.001	1.226		
CTE Completer ²	.115	.048	5.685	1	.017	1.122		
Internship ¹	.472	.068	48.045	1	.001	1.603		
Cooperative Work Experience ²	.209	.071	8.712	1	.003	1.233		
Work-Based Experience ¹	.273	.087	9.905	1	.002	1.314		
Earned Postsecondary Credit ¹	.365	.060	37.541	1	.001	1.441		
Gender ²	.142	.034	17.343	1	.001	1.153		
Race/Ethnicity – Black/African American ²	.335	.050	44.448	1	.001	1.398		
Special Education ²	.485	.052	85.575	1	.001	1.624		
Economically Disadvantaged ²	.502	.036	190.195	1	.001	1.651		

*Final Models include all independent variables that were significant when tested individually and remained significant.

¹First is reference in logistic regression model; ²Last is reference in logistic regression model.

TABLE C9. Logistic Regression Analysis of Persistence to Graduation by CTE Participants' Program Experiences

Individual Independent Variables	β	Se β	Wald's χ^2	df	p	Exp(β) Odds Ratio	Model χ^2 (p)	n
CTE Concentrator ²	.122	.055	4.886	1	.027	1.130	4.861 (.027)	7,484
Any Program Characteristics ¹	.271	.053	25.670	1	.001	1.311	25.460 (.001)	7,484
Internship ²	.403	.101	15.935	1	.001	1.496	16.757 (.001)	7,484
Cooperative Work Experience ¹	.432	.096	20.254	1	.001	1.540	19.861 (.001)	7,484
Earned Postsecondary Credit ¹	.724	.081	79.249	1	.001	2.063	78.294 (.001)	7,484
Final Model*							525.554 (.001)	6,541
Constant	-2.561	.125	418.060	1	.001	.077		
Cooperative Work Experience ¹	.231	.105	4.848	1	.028	1.260		
Earned Postsecondary Credit ¹	.505	.087	33.860	1	.001	1.657		
Race/Ethnicity – Black/African American ²	.918	.099	85.280	1	.001	2.504		
Special Education ²	.429	.086	25.166	1	.001	1.536		
Economically Disadvantaged ²	.576	.059	93.818	1	.001	1.779		
Geographic Locale – City ²	.440	.077	33.126	1	.001	1.553		

TABLE C10. Logistic Regression Analysis of Bachelor's Degree Attainment as Highest Degree Earned by CTE Participants' Program Experiences

Individual Independent Variables	β	Se β	Wald's χ^2	df	p	Exp(β) Odds Ratio	Model χ^2 (p)	n
CTE Concentrator ²	.982	.099	98.336	1	.001	2.671	104.477 (.001)	2,350
CTE Completer ²	1.083	.087	153.621	1	.001	2.954	160.439 (.001)	2,350
Cooperative Work Experience ²	.578	.152	14.356	1	.001	1.782	14.678 (.001)	2,350
Earned Postsecondary Credit ¹	.382	.125	9.300	1	.002	1.465	9.468 (.002)	2,350
Final Model*							281.418 (.001)	2,079
Constant	-2.854	.293	94.786	1	.001	.058		
CTE Completer ²	1.014	.098	107.648	1	.001	2.758		
Earned Postsecondary Credit ¹	.566	.139	16.516	1	.001	1.761		
Gender ²	.374	.095	15.589	1	.001	1.453		
Special Education ²	1.101	.181	36.841	1	.001	3.008		
Economically Disadvantaged ²	.696	.113	38.241	1	.001	2.006		
Geographic Locale – City ¹	.622	.148	17.608	1	.001	1.863		
Race/Ethnicity – Hispanic ²	.701	.224	9.792	1	.002	2.016		

*Final Models include all independent variables that were significant when tested individually and remained significant.

¹First is reference in logistic regression model; ²Last is reference in logistic regression model.

POL PK-20 Policy

ECE Early Childhood

K12 Education K-12 Education

PSE Postsecondary Education

WRK Workforce

LIB Public Libraries

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The mission of the Department of Education is to ensure that every learner has access to a world-class education system that academically prepares children and adults to succeed as productive citizens. Further, the Department seeks to establish a culture that is committed to improving opportunities throughout the commonwealth by ensuring that technical support, resources, and optimal learning environments are available for all students, whether children or adults.