HumRRO
HUMAN RESOURCES RESEARCH ORGANIZATION

2025 No. 061

Relationship of Career and Technical Education Participation and Postsecondary Outcomes

Final Report

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Executive Summary

As part of its Quality Control, Validation & Research Services contract with the Kentucky Department of Education (KDE), the Human Resources Research Organization (HumRRO) conducts research on Kentucky's Career and Technical Education (CTE) End-of-Program (EOP) assessment. The CTE EOP assessment is one measure approved for use as the postsecondary readiness indicator in Kentucky's accountability model. Students who have completed at least two credits within a career pathway that aligns with a CTE EOP assessment (i.e., "concentrator") may participate in a CTE EOP assessment for articulated credit and accountability purposes.

This study examined the relation among CTE participation types (Concentrator, Completer, Preparatory, Exploratory, and Non-Participator), CTE EOP assessment performance (Pass, Fail, Non-Attempt), and postsecondary outcomes (any postsecondary higher education enrollment, any postsecondary technical training, postsecondary educational completion, postsecondary educational achievement and credits in higher education, and post-secondary readiness and graduation indicator rates). For different outcomes, analyses were conducted both at student- and school-level.

HumRRO included three cohorts (seniors in academic years 2021-2022, 2022-2023 and 2023-2024), and analyzed data for matched student samples of CTE Students (those with participation type Concentrator, Completer, and Preparatory) and Non-CTE Students (Exploratory and Non-Participator). This allowed us to compare the average performance of CTE students to non-CTE students in terms of their post-secondary success indicators, after controlling their achievement scores and demographic factors. In addition, we also focused on CTE students only to examine how different predictor variables, such as work-based learning experience, CTE status, CTE dual credits, industry certifications, and end-of-year program assessments, influenced student postsecondary success indicators.

Key Findings

Overall, this study found that CTE participation provides clear benefits for students' post-high school success. These benefits include:

1. **Higher Enrollment Rates:** CTE students enrolled in college and technical training at significantly higher rates than non-CTE students, even when accounting for demographics and high school academic performance.

2. **Academic Performance:** While CTE and non-CTE students ultimately earned similar college credits and GPAs, CTE students showed slightly lower performance in their first two semesters. This likely reflects adjustment challenges when transitioning to traditional academic environments.

3. **Work-Based Learning Benefits:** CTE students with work-based learning experience consistently outperformed other CTE students in enrollment rates, completion rates, credit accumulation, and GPAs. However, very few students participated in these programs, limiting our analysis.

4. **Dual Credit Advantage:** CTE students who took dual credit courses significantly outperformed their peers across all measures, including higher enrollment and completion rates, better GPAs, and more college credits earned.

5. **Industry Certifications:** Students who earned industry certifications showed consistently better outcomes, including higher enrollment rates, completion rates, and academic performance.
6. **School-Level Impact:** Schools with CTE programs showed slightly lower graduation and post-secondary readiness rates than schools without CTE programs, but these differences were not statistically significant.

Based on the study findings, we draw the following conclusions:

1. **CTE programs benefit students** by improving their chances of post-high school success.

2. **Early challenges don't predict long-term outcomes.** While CTE students may struggle initially in college, their higher completion rates suggest they develop valuable persistence and practical skills that contribute to long-term success.

3. **Enhanced CTE experiences matter.** Work-based learning, dual credit courses, and industry certifications all amplify the benefits of CTE participation.

4. **CTE programs don't set back schools.** Having CTE programs does not negatively impact school accountability measures.

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Background

As part of its Quality Control, Validation & Research Services contract with the Kentucky Department of Education (KDE), the Human Resources Research Organization (HumRRO) conducts research on Kentucky's Career and Technical Education (CTE) End-of-Program (EOP) assessment. The CTE EOP assessment is one measure approved for use as the postsecondary readiness indicator in Kentucky's accountability model. Students who have completed at least two credits within a career pathway that aligns with a CTE EOP assessment (i.e., "concentrator") may participate in a CTE EOP assessment for articulated credit and accountability purposes.

KDE currently offers over 135 state-approved career pathways in 13 CTE program areas. A major goal of the CTE program is to ensure "a seamless transition into the workforce or postsecondary programs for our graduates.[1] Thus, demonstrating that CTE program participation and CTE EOP assessment performance are predictive of postsecondary outcomes is a key piece of validity evidence for the CTE program and the CTE EOP assessments.

This study examined the relation among CTE participation types, CTE EOP assessment performance, and postsecondary outcomes. Specifically, we seek to address two types of research questions: those that can be addressed using student-level data and those that can be addressed using school-level data. The Research Questions (RQs) are as follows:

Student-Level:

- RQ1. How do CTE students, on average, compare to non-CTE students in terms of post-secondary success indicators, after controlling for achievement scores and other student factors?
- RQ2. Among CTE students, is completing a work-based learning experience associated with increased postsecondary success?
- RQ3. Among CTE students, is reaching concentrator and completer status associated with increased postsecondary success?
- RQ4. Among CTE students, is earning CTE dual credit status associated with increased postsecondary success?
- RQ5. Among CTE students, is earning an industry certification or passing an end-of-program assessment associated with increased post-secondary success?

[1] https://www.education.ky.gov/CTE/Pages/default.aspx

School-Level

- RQ6. Is school participation in CTE programs associated with increased accountability indicators (postsecondary readiness and graduation rate indicator)?

Methods

For this study, we had data available from multiple academic years, specifically 2017 through 2025. Considering that the previous study by Wiley et al. (2021) focused on those earlier academic years, specifically on the graduating classes of 2016-2018, and Mulolli et al. (2024) focused on the graduating cohorts after the COVID-19 pandemic in 2021 and 2022, in this report, we included graduating cohorts of 2021-2022 until 2023-2024 as those would enable us to answer the research questions posed.

We also noticed that around 60% of ACT scores were missing for the cohorts we examined. Part of the reason for this missing data could be attributed to a 4% drop in the number of high school graduates taking the ACT in 2022 (ACT, n.d.) and a policy change that some universities no longer require students to submit ACT/SAT scores for admission. Therefore, despite the strength of the relationship between the ACT and different postsecondary outcomes (Wiley et al., 2021), we had to exclude the ACT scores from our models due to the data missingness.

We utilized the Kentucky Longitudinal Data System (KLDS) to inform our core research questions and identify the postsecondary educational outcomes. The KLDS integrates data from the Kentucky Department of Education (KDE), the Council on Postsecondary Education (CPE), the Education Professional Standards Board (EPSB), the Kentucky Higher Education Assistance Authority (KHEAA), and the Kentucky Education and Workforce Development Cabinet. We requested and received these de-identified student data from the Kentucky Center for Statistics (KYSTATS).

Our approach was to identify high school graduate cohorts that graduated in 2021-2022, 2022-2023, and 2023-2024 and match their records to their respective postsecondary educational outcomes. Table 1 provides an overview of the key variables used from each data source. Our operational definitions of the outcomes, control, and predictor variables are based on various filtering and prioritization rules specific to each research question. As such, we provide the data source and names of each source variable in Table 1 so that the origin of each analytic data set is apparent. Definitions of each key variable from each data source are provided in Appendix A.

To answer the school-level research questions, we also obtained two additional datasets that are publicly available. One dataset came from KYStats, under the CTE Employer Connector link (hereinafter: CTE_SS_PAF[2]). This dataset lists all the schools in Kentucky that offer CTE Programs, including the career pathways they offer. For analytical purposes at a later stage, we excluded technical schools or academies where students can only take CTE courses but not regular high school subjects. The second dataset, Accountability_Profile[3], came from Kentucky's historical school report card datasets. We downloaded academic years corresponding to our 2022-2023 and 2023-2024 cohorts; the 2021-2022 data was unavailable. We merged both datasets together and created a variable called CTE_Schools, where all the schools in CTE_SS_PAF received a 1, whereas the

[2] https://kystats.ky.gov/Reports/Tableau/CTESearchSystem
[3] https://rb.gy/yom15d

schools in Accountability_Profile that did not have a match in CTE_SS_PAF, received a 0. We used this variable to tell apart CTE from non-CTE schools.

Table 1. KYSTATS Data Sources

Data Source	Data Source Description	Key Variables
IC_AnnualPerson:	Infinite Campus database of student categories	AcadYr, DiplomaDate, IC_Grade, IC_FinalGPA, IC_FreeReducedLunch, IC_Gifted, IC_Mentorship, SchNo
KPEDS_CourseEnrollment:	Kentucky Postsecondary Education Data System database of course enrollment	AcadYr, KPEDS_CourseCreditHours, KPEDS_Standardized_Letter_Grade, KPEDS_Standardized_Numeric_Grade, KPEDS_Dual_Credit
KPEDS_Degree:	Kentucky Postsecondary Education Data System database of degree achievement	KPEDS_Credit_Hrs_Earned, KPEDS_DegreeYear, DegreeGroup, DegreeRank
KPEDS_Enrollment:	Kentucky Postsecondary Education Data System database of general enrollment	KPEDS_CreditBearingHours
KPEDS_ReadinessFollowUp:	Kentucky Postsecondary Education Data System database of college coursework	KPEDS_First_Sem_Tot_GPA, KPEDS_Second_Sem_Tot_GPA,
TEDS_Enrollment:	Technical Education Database System database of CTE pathway enrollment	AcadYr, TEDS_CareerPathwayName, TEDS_CIPCodes, TEDS_ProgramLevel, TEDS_StudentObjective, TEDS_TerminationStatus
TEDS_IndustryCerts:	Technical Education Database System database of industry certifications	AcadYr, TEDS_IndustryCertificate, TEDS_IndustryValid
TEDS_KOSSA:	Technical Education Database System database of Kentucky Occupational Skill Standards Assessment outcomes	AcadYr, TEDS_PassIndicator, TEDS_SkillStandard

Analysis Models

We ran several analytic models to address relevant outcomes within each research question. Each model consisted of one or two predictor variables for group comparison, control variables to account for student- or school-level characteristics, and an outcome variable(s) used for prediction. Given the nature of the research questions, we ran nine regression models for each research question, consisting of the same nine outcome variables.

Propensity Score Analysis

We statistically matched CTE to non-CTE students using the Propensity Score Matching (PSM) technique to answer the first research question. What Works Clearinghouse (WWC) recognizes

PSM as an acceptable strategy for causal inference (WWC, 2022). In this study, we employed PSM to establish baseline equivalence between CTE and non-CTE students. For academic outcomes, baseline equivalence is often established using a pre-intervention assessment. As a result, the following achievement and student-level covariates:

- **Math Achievement Scores:** Scale scores in math for the assessment students took in 8th grade, using summative assessment scores.
- **Reading Achievement Scores:** Scale scores in reading for the assessment students took in 8th grade, using summative assessment scores.
- **White:** Student identifying as White (e.g., 1= White vs 0 = Non-White).
- **Hispanic:** Student identifying as Hispanic (e.g., 1= Hispanic vs 0 = Non-Hispanic).
- **Female:** Female students (e.g., 1= Female vs 0 = Male).
- **FRL:** Student eligible for free or reduced lunch (e.g., 1= FRL Eligible vs 0 = Non-FRL Eligible).
- **IC_EL:** English Language Learner (ELL) student (e.g., 1 = English Learner vs. 0 = Not English Learner).
- **IC_SpecialEducation:** Student enrolled in special education as proxy for students with disabilities (e.g., 1= Student with Disabilities vs 0 = Not Student with Disabilities).

We employed 1:1 nearest neighbor matching without replacement with a caliper width of 0.02 on the propensity score scale, meaning that potential matches were only considered valid if the absolute difference in propensity scores between CTE and non-CTE students was no greater than 0.02, thus discarding poor matches that exceeded this threshold.

Our matching procedure balanced all covariates between CTE and non-CTE students. Before matching, all cohorts showed some imbalances, with cohort 2023-2024 displaying the largest initial differences with Cohen's d values of 0.137 for math scores, 0.110 for reading scores, and 0.151 for White student representation. Cohort 2022-2023 showed similar patterns with Cohen's d values of 0.095 for math scores, 0.068 for reading scores, and 0.122 for White student representation, while the overall sample also exhibited moderate effect sizes for White student representation (d = 0.120) and math scores (d = 0.088).

After matching, all standardized mean differences were substantially reduced, with Cohen's d values ranging between -0.036 and 0.039 across all cohorts, well below the conventional 0.1 threshold for acceptable balance. The negative Cohen's d values simply indicate that the direction of the difference has reversed after matching (where the control group mean slightly exceeds the treatment group mean), but the magnitude remains very small. For example, in cohort 2023-2024, reading scores showed a Cohen's d of -0.036, meaning the non-CTE students' average was slightly higher than CTE students', but this difference is negligible for practical purposes.

The most improvements were seen in cohort 2023-2024, where the largest initial effect sizes were reduced to negligible values (Math: d = -0.012, Reading: d = -0.036, White: d = -0.016). Cohort 2022-2023 showed similar improvements with post-matching Cohen's d values of 0.010 for math scores, -0.009 for reading scores, and 0.001 for White student representation. Cohort

2021-2022 maintained excellent balance with minimal effect sizes (Math: d = 0.003, Reading: d = -0.007, White: d = -0.017). This consistent improvement in covariate balance across all three cohorts creates comparable treatment and control groups, minimizing selection bias and strengthening the validity of our subsequent analyses of CTE program impacts. Tables 2 through 4 present baseline equivalence results after matching for all three cohorts.

Table 2. Baseline Equivalence for Proficiency Scores and Student Characteristics After Matching – Cohort 2021-2022

Variables	CTE N	CTE Mean	CTE SD	Non-CTE N	Non-CTE Mean	Non-CTE SD	Mean Difference	Cohen's d
Math Achievement	15,181	212.360	22.917	15,181	212.421	19.120	0.061	0.003
Reading Achievement	15,181	213.002	20.211	15,181	212.866	16.204	-0.136	-0.007
White	15,181	0.814	0.389	15,181	0.807	0.394	-0.007	-0.017
Hispanic	15,181	0.061	0.240	15,181	0.070	0.256	0.009	0.036
Female	15,181	0.484	0.500	15,181	0.475	0.499	-0.009	-0.018
FRL	15,181	0.507	0.500	15,181	0.506	0.500	-0.001	-0.001
IC_EL	15,181	0.010	0.098	15,181	0.011	0.102	0.001	0.010
IC_SpecialEducation	15,181	0.074	0.262	15,181	0.083	0.276	0.009	0.032

Table 3. Baseline Equivalence for Proficiency Scores and Student Characteristics After Matching – Cohort 2022-2023

Variables	CTE N	CTE Mean	CTE SD	Non-CTE N	Non-CTE Mean	Non-CTE SD	Mean Difference	Cohen's d
Math Achievement	15,371	210.973	19.142	15,371	211.156	17.709	0.183	0.010
Reading Achievement	15,371	215.257	16.945	15,371	215.108	15.708	-0.150	-0.009
White	15,371	0.796	0.403	15,371	0.797	0.403	0.000	0.001
Hispanic	15,371	0.065	0.247	15,371	0.070	0.254	0.005	0.018
Female	15,371	0.474	0.499	15,371	0.472	0.499	-0.002	-0.004
FRL	15,371	0.510	0.500	15,371	0.499	0.500	-0.010	-0.021
IC_EL	15,371	0.013	0.114	15,371	0.015	0.120	0.001	0.012
IC_SpecialEducation	15,371	0.074	0.261	15,371	0.084	0.277	0.010	0.039

Table 4. Baseline Equivalence for Proficiency Scores and Student Characteristics After Matching – Cohort 2023-2024

Variables	CTE N	CTE Mean	CTE SD	Non-CTE N	Non-CTE Mean	Non-CTE SD	Mean Difference	Cohen's d
Math Achievement	15,951	211.633	18.929	15,951	211.406	17.762	-0.227	-0.012
Reading Achievement	15,951	216.159	16.654	15,951	215.578	15.624	-0.581	-0.036
White	15,951	0.801	0.400	15,951	0.794	0.404	-0.006	-0.016
Hispanic	15,951	0.065	0.246	15,951	0.072	0.259	0.008	0.030
Female	15,951	0.478	0.500	15,951	0.463	0.499	-0.015	-0.030
FRL	15,951	0.498	0.500	15,951	0.491	0.500	-0.008	-0.015
IC_EL	15,951	0.012	0.109	15,951	0.013	0.112	0.001	0.005
IC_SpecialEducation	15,951	0.071	0.256	15,951	0.079	0.270	0.008	0.032

Predictor Variables

The first research question examines differences between CTE and non-CTE in relation to the outcomes of interest. Questions two through five focus only on CTE students (students with a preparatory, completer, or concentrator CTE classification). Research questions six and seven pertain to the school-level, focusing on schools with CTE programs and their performance on outcomes of interest. Below, we describe each of the predictor variables. In parentheses, we include the data sources used to generate these predictors in bolded text.

- *CTE classification* (**TEDS_Enrollment**): Each student's single high-level CTE classification. Students can enroll in multiple pathways, but may not achieve the same classification across the various pathways. For example, a student takes 4 credits in the Civil Engineering pathway and is a completer, but the student takes only 1 credit in Aerospace Engineering and is classified as an exploratory student. The CTE classification predictor represents a student's highest CTE classification across all the pathways the student attempted, prioritizing a completer classification, then preparatory, then exploratory. The student from our example would be classified as a completer overall, based on their coursework in Civil Engineering.
  - Concentrator: A student who has completed 2 courses in a single program of study (career pathway).
  - Completer: A student who has completed 4 credits in a Kentucky Department of Education-approved career pathway.
  - Preparatory[4]: No completer classification for any pathway and has a preparatory classification (completed at least 3 credits) in at least one pathway.
  - Exploratory: No completer or preparatory classification for any pathway, and has an exploratory status (completed fewer than 2 credits) in at least one pathway.
  - Non-CTE: A student who has not completed courses in a Kentucky Department of Education-approved career pathway.

[4] Note: Preparatory status is no longer used in KDE system, but because the data used in this study included cohort year 2021-2022, there were a small number of students labeled as preparatory.

- *EOP_status* (**TEDS_KOSSA)**: Pass or fail indicator for the EOP assessment
  - Pass: Passed the EOP assessment for a pathway.
  - Fail: Failed the EOP assessment for a pathway.
  - Non-attempt: Did not attempt the EOP assessment for a pathway.

- *CTE-EOP classification* (**TEDS_Enrollment**, **TEDS_KOSSA**): CTE classification is based on the EOP status of each student's unique CTE classification. That is, across all pathways for which a student attempted an EOP assessment, a student may receive a single classification for concentrator, a single classification for completer, and a single classification for preparatory if they achieved a completer or concentrator classification in one pathway and a preparatory classification in a different pathway and attempted EOP assessments for both pathways. So, while the student's *CTE classification* would be a concentrator or completer because we prioritize those two statuses over a preparatory status, their *CTE-EOP classification* would be a concentrator or completer and preparatory for relevant analyses.
  - Concentrator: Concentrator classification for at least one pathway, and attempted an EOP assessment for that pathway.
  - Completer: Completer classification for at least one pathway, and attempted an EOP assessment for that pathway.
  - Preparatory: Preparatory classification for at least one pathway, and attempted an EOP assessment for that pathway.

- *CTE_Treat* (**TEDS_Enrollment**): Indicator for participating in CTE
  - Participant: High-level CTE status is a concentrator, completer, or preparatory.
  - Non-participant: High-level CTE status is exploratory or non-CTE.

- *CC_C_Status* (**TEDS_Enrollment):** Indicator for reaching Concentrator or Completer Status in CTE
  - Concentrator or Completer: A student who achieved a concentrator or completer classification for at least one pathway.
  - Non-Concentrator or Completer: A student who has not been classified as a concentrator or completer for any pathway.

- *Ind_Certified* (**TEDS_IndustryCerts):** Industry certificates are credentials for which the student must pass a test validated/approved by the business or industry.
  - We dichotomized this variable. If a student had an industry certificate, we classified them as 1, and if it was blank, we classified them as 0.

- Work-based learning experience using *IC_Mentorship* as a proxy (**IC_Gifted)**
  - If a student completed specialized studies, such as an internship with an adult mentor in the community and under the direction of an educator knowledgeable in gifted education, it was classified as 1. Otherwise, it was classified as 0. While this measure of the work-based learning experience was not ideal, it was still useful in providing additional information on the role of CTE in students' postsecondary success.

- *CTE dual credit status* (**KPEDS_CourseEnrollment):** Students earn high school and college credit upon course completion.
  - If a student takes a dual credit course, it is classified as 1. Otherwise, it is classified as 0.
- *CTE_School* (**CTE_SS_PAF**): This is a school-level-only variable. It is an indicator of participation in CTE programs. Any school not listed as a regular school was excluded.

Control Variables

Prior research indicates some key factors associated with postsecondary educational outcomes (Princiotta et al., 2014); we used these as control variables in each model. By including control variables in the models, we can better isolate the relationship of the key predictor variable (e.g., EOP assessment status) to the outcome variable by mathematically accounting for the influence of other factors. Controlling for these variables clarifies the relationship between CTE EOP Assessment-related factors and postsecondary educational outcomes.

We included the following control variables in our models:

- *FRL:* Dichotomous variable indicating whether the student qualifies for free or reduced lunch as of their senior year.
- *HS_GPA:* Student's cumulative high school Grade Point Average (GPA) taken after their senior year.
- *White*: Dichotomous variable representing whether a student's race is White or non-White.
- *Hispanic*: Dichotomous variable representing whether a student's ethnicity is Hispanic or non-Hispanic.
- *Female:* Dichotomous variable indicating whether the student's gender is female.

Outcome Variables

All the research questions include references to postsecondary educational outcomes for their analysis. We operationally define these outcomes to include:

Postsecondary Educational Enrollment

- *Any postsecondary enrollment in higher education or technical training*: dichotomous variable indicating whether the student had any *postsecondary higher education enrollment* or *postsecondary technical training* (as defined in the following two bullets).
  - *Any postsecondary higher education enrollment*: Dichotomous variable indicating whether the student had any *postsecondary higher education enrollment* in four-year postsecondary education institutions only (**KPEDS_Enrollments**).
  - *Any postsecondary technical training*: Dichotomous variable indicating whether a student earned an industry certification (**TEDS_IndustryCerts**) after they graduated from high school or had any postsecondary technical training (**TEDS_Enrollment).** This includes data from two-year community and technical colleges as well as four-year postsecondary programs.

Postsecondary Educational Completion

- *Postsecondary educational completion – degree or certification earned*: Dichotomous variable indicating whether the student earned a degree or certification/diploma (as defined in the following two bullets).
  - *Postsecondary educational completion – degree earned*: Dichotomous variable indicating whether the student earned an AA, BA, or MA (**KPEDS_Degree**).
  - *Postsecondary educational completion – certification earned*: Dichotomous variable indicating whether the student earned a certificate (e.g., Undergraduate Certificate 1 - 2 Years) or diploma (**KPEDS_Degree**).

Postsecondary educational achievement and credits in higher education

- *Postsecondary GPA*: Average course GPA from courses in which the student received a letter grade of A, B, C, D, or I (**KPEDS_CourseEnrollment**)[5].
- *First Semester GPA: GPA* based on all courses in the student's first semester (**KPEDS_ReadinessFollowUp)**.
- *Second Semester GPA: GPA* based on all courses in the student's second semester (**KPEDS_ReadinessFollowUp)**.
- *Postsecondary educational completion – total number of credits earned*: Total credits the student earned, regardless of whether the student earned a degree (**KPEDS_Enrollments**).

School-level outcomes

- *Postsecondary Readiness Indicator Rate:* One of the six state indicators included in Kentucky's Accountability System. To demonstrate postsecondary readiness, high school students must earn a regular or alternative high school diploma or be classified as a grade 12 non-graduate and meet either academic or career readiness (KDE, 2025).
- Graduation Indicator Rate: One of the six state indicators included in Kentucky's Accountability System. It represents the percentage of students completing the requirements for a Kentucky high school diploma compared to a cohort of students beginning in grade nine (KDE, 2025).

While our analysis included three cohorts (seniors in academic years 2021-2022, 2022-2023, and 2023-2024), it is important to highlight one caveat related to using these cohorts: postsecondary completion (earning a college degree), which typically takes at least 4 years after high school graduation. Therefore, we advise exercising caution when interpreting the model's results for postsecondary educational completion, as it is most likely still in progress for the students of our selected cohorts.

[5] Analyses using *Postsecondary GPA* only included students who earned at least 12 course credits (approximately one semester).

We only used cohorts 2022-2023 and 2023-2024 for the school-level analysis due to the missing accountability data for cohort 2021-2022.

Depending on the outcome variable, we used different analysis models:

- Hierarchical linear regression – continuous outcome. Analyses examined the predicted regression coefficient for the model's predictor variable for two-level models with students nested in schools and random intercepts for schools.
- Logistic regression – binary outcome variable (e.g., postsecondary educational completion with values of 0 or 1 depending on whether a student earned a certificate and/or degree).
  - Due to the difficulty of interpreting log odds estimated by logistic regression, we compute the Average Marginal Effect (AME) to describe the model results in more traditional terms. The AME is the effect on the probability of an outcome from a unit change in the given predictor. For example, the AME for postsecondary degree completion associated with participating in CTE versus not participating would indicate the average change in the probability of earning a degree associated with changing CTE status from non-participation to participation.

To facilitate interpretation of the analyses, the control variable *HS_GPA* was recentered by subtracting 3 from each value (i.e., *HS_GPA_centered* = *HS_GPA* – 3). This transformation shifts the reference point of the variable so that a value of zero on the new variable corresponds to a GPA of 3. This recentering preserves the original ordering, spacing, and variance of the variable and does not alter the distribution or meaning of the variable. The model interpretation guide below details how this transformation eases the interpretation of the analyses.

As was previously mentioned, *HS_GPA* is included as a control variable in the models to enable the examination of individual factors (e.g., *CTE Participation*) while accounting for differences in academic performance. If the relationship between GPA and the outcomes is not linear but is modeled as if it were, then the estimated differences between groups may be biased and misleading. Thus, the relationship was modeled in a more flexible way using a statistical technique called a cubic spline, which allows for the relationship between GPA and the outcome to bend and curve naturally to better fit the data. The use of a cubic spline ensures unbiased estimation of group mean differences while adjusting for effects of linear and non-linear control variables (Little et al., 2000).

In the results section, we present each model with a description of the operational definitions for each analytic data file, followed by the analysis results.

Results

Descriptive Statistics

As described earlier, the data used for this study originated from various sources. We determined the analytic sample for each research question primarily based on the decision rules we applied to the predictor, control, and outcome variables (described above). Because each research question addresses multiple outcomes, requiring multiple analytic models, providing descriptive statistics and cross-tabulations for each predictor group, covariate, and outcome becomes unwieldy. Table 5 provides an overview of the underlying data on which each analytic model is based. Approximately 48% of high school graduates between 2021-2022 and 2023-

2024 completed at least one pathway, thus achieving concentrator status in at least one pathway, and 11.4% passed at least one pathway. Across all cohorts, approximately 92% of graduates enroll in at least one pathway with an available EOP assessment. Percentages and counts based on certain subsets of the data are presented with the results from each research question (e.g., percentage of students who passed out of the number of students who attempted an EOP assessment).

Table 5. CTE Status and EOP Status Frequencies and Percentages for Each High School Graduation Cohort

CTE Status/Variable	All Graduates *N (%)*	2021-2022 *N (%)*	2022-2023 *N (%)*	2023-2024 *N (%)*
Total N	93,006 (100)	30,363 (32.65)	30,743 (33.05)	31,903 (34.30)
CTE Status				
Concentrator (CC)	44,486 (47.83)	15,165 (49.95)	13,370 (43.49)	15,951 (50.00)
Completer (C)	7 (0.008)	6 (0.02)	1 (.00)	0 (.00)
Preparatory (P)	10 (0.011)	10 (0.03)	0 (.00)	0 (.00)
Exploratory (E)	40,58 (43.64)	13,012 (42.85)	13,499 (43.91)	14,075 (44.12)
Non-Participator (N)	5,916 (6.36)	2,169 (7.14)	1,872 (6.09)	1,875 (5.88)
EOP Attempt Status				
Passed at least one EOP assessment[1]	10,601 (11.40)	3,283 (10.81)	3,338 (10.86)	3,980 (12.48)
Failed all EOP assessments[2]	5,623 (6.05)	1,639 (5.40)	2,090 (6.80)	1,894 (5.94)
Non-attempt	30,279 (32.55)	10,259 (33.79)	9,943 (32.34)	10,077 (31.59)
NA	46,503 (50.00)	15,181 (50.00)	15,371 (50.00)	15,951 (50.00)
Work-Based Learning Experience				
CTE students who had work-based learning experience	128 (0.14)	36 (0.12)	42 (0.14)	50 (0.16)
CTE students who had no work-based learning experience	46,375 (49.86)	15,145 (49.88)	15,329 (49.86)	15,901 (49.84)
Earning CTE Dual Credit				
CTE students who earned dual credit	24,372 (26.20)	8.928 (29.40)	5,275 (17.16)	10,169 (31.87)
CTE students who did not earn dual credit	3,832 (4.12)	1,252 (4.12)	1,334 (4.34)	1,246 (3.91)

[1]Student who passed an EOP assessment for at least one pathway, even if they have another failed attempt.

[2]Student who did not pass an EOP assessment for any pathway.

Because student-level research questions investigate the same postsecondary educational outcomes, and the only difference is the predictors, we ran the same regression models with different predictors for each research question. Table 6 summarizes the nine analysis models for our first five research questions. Some models are drawn on different analytic samples. Specifically, Models i-v include all CTE participant and non-CTE participant students from each of the three cohorts, Models vi-viii examine students from each cohort who enrolled in a postsecondary institution and earned 12 or more credits, and Model ix includes each cohort's students who enrolled in a postsecondary institution. The descriptive statistics tables will be reported separately based on their analytic sample in the following discussion.

Table 6. Analysis Model for Research Questions 1-5

Model	Outcome	Regression Model
1-5 – i	Any postsecondary higher education enrollment	Logistic
1-5 – ii	Any postsecondary enrollment in higher education or technical training	Logistic
1-5 – iii	Postsecondary educational completion – degree or certification earned	Logistic
1-5 – iv	Postsecondary educational completion – degree earned	Logistic
1-5 – v	Postsecondary educational completion –certification earned	Logistic
1-5 – vi	Postsecondary GPA (at least 12 credits)	2-level HLM
1-5 – vii	Postsecondary first semester GPA	2-level HLM
1-5 – viii	Postsecondary second semester GPA	2-level HLM
1-5 – ix	Postsecondary educational completion – total number of credits earned	2-level HLM

Note: HLM = Hierarchical Linear Modeling.

Table 7 shows outcome variables for school-level research questions.

Table 7. Analysis Model for Research Questions 6

Model	Outcome	Regression Model
6	Accountability Indicators (Postsecondary Readiness Rate and Graduation Rate)	Linear

Research Question 1

RQ1: How do CTE students, on average, compare to non-CTE students, on average, in terms of ***postsecondary success indicators?***

RQ 1 examines whether CTE participation (regardless of EOP assessment attempt) predicts postsecondary educational outcomes while controlling for student-level characteristics. The generic model is given below, where CTE_Treat is 1 for the CTE classification of the concentrator, completer, or preparatory and 0 for exploratory and non-participant.

OUTCOME ~ CTE_Treat + FRL + HS_GPA + White + Hispanic + Female

$$OUTCOME_{ij} \sim CTE\_Treat_{ij} + FRL_{ij} + HS\_GPA_{ij} + White_{ij} + Hispanic_{ij} + Female_{ij}$$

Tables 8a-c provide the descriptive statistics for RQ1 models that examine different predictive relationships between CTE participants and non-participant students. Table 8a shows that CTE participants tended to enroll more in higher education or technical training than non-participants (see the first and second rows of Table 8a). However, technical training enrollment numbers are low in both groups. In terms of the proportions of earning postsecondary degrees and certifications, CTE students earned postsecondary degrees or certifications at higher rates than

non-participants (see the third row in Table 8a). Table 8b shows that CTE participants had comparable postsecondary total GPAs (Table 8b, row 1) but slightly lower first-semester GPAs (Table 8b, row 2) and second-semester GPAs (Table 8b, row 3) than non-participants. Table 8c shows that CTE and non-CTE students tended to earn comparable numbers of postsecondary credits.

Table 8a. Comparison of Postsecondary Educational Outcomes: CTE and Non-CTE Participants

		2021-2022	2021-2022	2022-2023	2022-2023	2023-2024	2023-2024
		CTE (N = 15,179)	Non-CTE (N = 15,181)	CTE (N = 15,371)	Non-CTE (N = 15,371)	CTE (N = 15,951)	Non-CTE (N = 15,951)
Model	Model Outcome	*N (%)*	*N (%)*	*N (%)*	*N (%)*	*N (%)*	*N (%)*
1-i	Higher education enrollment	10,723 *(70.63)*	9,876 *(65.06)*	11,152 *(72.55)*	9,568 *(62.25)*	11,951 *(74.92)*	10,131 *(63.51)*
1-ii	Technical training enrollment	6 *(0.040)*	1 *(0.0066)*	28 *(0.18)*	13 *(0.085)*	13 *(0.082)*	11 *(0.069)*
1-iii	Degree or certification earned	2,413 *(15.89)*	1,263 *(8.32)*	2,302 *(14.98)*	1,091 *(7.10)*	1,984 *(12.44)*	855 *(5.36)*
1-iv	Degree earned	1,166 (7.68)	608 *(4.01)*	701 *(4.56)*	368 *(2.39)*	304 *(1.91)*	192 *(1.20)*
1-v	Certificatio n earned	1,812 *(11.94)*	903 *(5.95)*	1,948 *(12.67)*	865 *(5.63)*	1,756 *(11.01)*	721 *(4.52)*

Table 8b. Comparison of Postsecondary Educational Outcomes: CTE and Non-CTE Participants

		2021-2022	2021-2022	2022-2023	2022-2023	2023-2024	2023-2024
		CTE (N = 6,672)	Non-CTE (N= 6,070)	CTE (N = 7,026)	Non-CTE (N= 5,860)	CTE (N = 7,380)	Non-CTE (N= 6,183)
Model	Model Outcome	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*
1-vi	Total GPA	3.00 (0.78)	3.03 (0.79)	3.04 (0.77)	3.06 (0.76)	3.12 (0.74)	3.16 (0.74)
1-vii	First semester GPA	2.42 (1.41)	2.47 (1.42)	2.50 (1.38)	2.58 (1.35)	2.34 (1.45)	2.47 (1.44)
1-viii	Second semester GPA	2.08 (1.54)	2.15 (1.55)	2.18 (1.52)	2.31 (1.49)	2.16 (1.53)	2.25 (1.53)

Table 8c. Comparison of Total Number of Postsecondary Credits Earned: CTE and Non-CTE Participant

		2021-2022	2021-2022	2022-2023	2022-2023	2023-2024	2023-2024
		CTE (N = 10,723)	Non-CTE (N= 9,876)	CTE (N = 11,152)	Non-CTE (N= 9,568)	CTE (N = 11,951)	Non-CTE (N= 10,131)
Model	Model Outcome	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*
1-ix	Total number of credits earned	55.86 (41.28)	56.83 (41.06)	44.60 (30.19)	44.59 (29.93)	29.96 (19.56)	30.18 (19.68)

Table 9 reports the results from the logistic regression models examining the impact of CTE participation on enrollment in higher education. For example, we present a discussion of the logistic regression table and the AME table (Table 9); for subsequent models, we will only present the AME tables in the main results section (all regression models are presented in Appendices B-E).

As noted above, logistic regression coefficients are reported in terms of log odds. Thus, within the 2021-2022 cohort, being a CTE student is associated with a 0.106 unit increase in the log odds of enrolling in higher education (or an odds ratio equal to 1.11). Given that the odds ratio is greater than 1 (indicating increased likelihood) and the CTE_Treat coefficient is significant, the results suggest that CTE participation has a positive relation to higher education.

In practice, however, it is difficult to interpret a change in the log odds of a dichotomous outcome. Thus, we include a table for each research question section below, reporting the AMEs for each model in the research question. Table 10 presents the estimated AMEs for each model for RQ1 based on the logistic regression models reported in Appendix B. The first row shows the AME resulting from the models reported in Table 9 (Model 1-i). It can be interpreted to mean that, in the 2021-2022, 2022-2023, and 2023-2024 cohorts, CTE participation was associated with an increase of 1.71%, 4.01%, and 5.29%, respectively, in the probability of enrolling in higher education. This kind of interpretation is more accessible to the way that dichotomous outcomes are typically thought about. Additionally, the p-value is reported and interpreted similarly to traditional interpretations. Thus, each of the increases in the probability of enrolling in higher education is statistically significant.

Table 9. Logistic Regression Model for Enrollment in Higher Education

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	1.367***	0.052	1.150***	0.049	1.204***	0.049
Parametric	CTE_Treat	0.106***	0.030	0.244***	0.029	0.332***	0.029
Parametric	FRL	-0.400***	0.031	-0.333***	0.031	-0.322***	0.031
Parametric	White	-0.547***	0.046	-0.512***	0.043	-0.457***	0.043
Parametric	Hispanic	-0.199**	0.070	-0.169*	0.067	-0.262***	0.066
Parametric	Female	0.392***	0.030	0.427***	0.030	0.335***	0.030
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_Final GPA_m3)	5.370***	6.764	5.530***	6.971	3.833***	4.846

Note. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05

Additionally, Table 10 includes AMEs for Model 1-vi to Model 1-ix, which examine a continuous outcome (including GPA and the number of postsecondary credits earned) using Hierarchical Linear Modeling (HLM). An AME for a linear or logistic regression model is the change in the outcome variable associated with a unit change in the predictor variable, where logistic regression outcomes can be thought of as the probability of a binary outcome, and linear regression outcomes can be thought of as the amount of the continuous outcome.

Table 10. AME for RQ1

Model	Outcome	2021-2022 AME	2022-2023 AME	2023-2024 AME
1-i	Higher education enrollment	1.708%***	4.009%***	5.294%***
1-ii	Technical training enrollment	0.021%***	0.097%***	0.004%***
1-iii	Degree or certification earned	6.604%***	6.642%***	6.341%***
1-iv	Degree earned	3.086%***	1.604%***	0.412%***
1-v	Certification earned	5.317%***	6.146%***	5.998%***
1-vi	Total GPA[1]	-0.015***	-0.007***	-0.007***
1-vii	First semester GPA[1]	-0.055***	-0.073***	-0.126***
1-viii	Second semester GPA[1]	-0.060***	-0.131***	-0.078***
1-ix	Total number of credits earned[1]	-1.354***	-1.033***	-0.243***

[1]AMEs for linear regressions are interpreted the same way as a regression coefficient.

As shown in Table 10, after controlling for demographic characteristics, academic indicators, and school-level variance, CTE participation was associated with small to modest, statistically

significant increases in higher education enrollment and completion. Among students who enrolled in higher education or technical training, participation in CTE is positively associated with the probability of earning a postsecondary degree and/or certification. However, for students enrolled in higher education and who completed more than 12 credits, the results indicate that CTE participation is negatively associated with first- and second-semester total GPAs. This might be due to the large number of missing values in the first- and second-semester total GPAs.

Interpretation Guide

The following section will demonstrate how to interpret the regression models in Appendices B-E. The interpretations of logistic and HLM models differ slightly. Therefore, examples will be provided for both.

Logistic Regression Interpretation

Logistic regression models evaluate the relationships between a binary outcome variable and a set of predictor variables. Model 1-i presented above evaluates a student's enrollment in higher education (0 = not enrolled, 1 = enrolled) as a function of a student's CTE status, Free or Reduced Lunch (FRL) status, high school GPA, race, ethnicity, and gender. Logistic regression models report their results in terms of the logged odds of a student's outcome. In this example, a 1 is a student's logged odds of enrolling in higher education. Because log-odds may not be intuitive for most people, the estimates can be transformed into an Average Marginal Effect (AME) which can be interpreted in terms of probability. The AMEs are only presented for the primary predictors of interest and not for the control variables. The interpretations of the estimates from Model 1-I for the 2021-2022 cohort are as follows:

- Intercept = 1.367: The expected log-odds of enrollment in higher education for a student who is non-CTE, non-FRL, non-White, non-Hispanic, male, and who has a GPA of 3.00 is 1.367. An inverse logit transformation translates the intercept to represent a probability of .80 (i.e. $\frac{e^{1.367}}{1+e^{1.367}} \approx 0.80$).
- CTE_Treat = 0.106: The log-odds of enrollment in higher education are 0.106 higher on average for CTE students than for non-CTE students, controlling for FRL status, race, ethnicity, gender, and academic achievement. For the AME, the probability of enrollment in higher education is 1.71% higher for CTE students than for non-CTE students.
- FRL = -0.400: The log-odds of enrollment in higher education are 0.400 lower on average for FRL students than for non-FRL students, controlling for CTE status, race, ethnicity, gender, and academic achievement.
- White = -0.547: The log-odds of enrollment in higher education are 0.547 lower on average for white students than for non-white students, controlling for CTE status, FRL status, ethnicity, gender, and academic achievement.
- Hispanic = -0.199: The log-odds of enrollment in higher education are 0.199 lower on average for Hispanic students than for non-Hispanic students, controlling for CTE status, FRL status, race, gender, and academic achievement.

- Female = 0.392: The log-odds of enrollment in higher education are 0.392 lower on average for female students than for male students, controlling for CTE status, FRL status, race, ethnicity, and academic achievement.
- Spline(GPA): GPA was included in the model using a cubic spline to flexibly control for potential non-linear relationships between GPA and the likelihood of enrollment in higher education. The spline terms are not interpreted directly. Rather, they allow the model to adjust for GPA in a way that does not assume a strictly linear effect, helping to ensure more accurate estimates of the other variables.

HLM Models

The interpretation of the HLM model estimates will be very similar to the logistic regression model interpretations. Now, rather than interpreting results in terms of log odds, the interpretations will be on the scale of the outcome variable. Therefore, if the outcome variable is post-secondary GPA, then the estimates represent the expected difference or change in post-secondary student's GPA based on the predictor variable, controlling for the other variables Lastly, the HLMs used a random intercept spline to account for clustering of students within school to minimize the potential for bias in the results.

Research Question 2

RQ2: Among CTE students, is completing a work-based learning experience associated with increased postsecondary success?

While RQ1 compares the postsecondary performance of CTE to non-CTE students, RQ2 examines whether the Work-Based Learning (WBL) experience is associated with better postsecondary educational performance among CTE students only. The analytic sample includes students with a concentrator, completer, or preparatory CTE classification status in at least one pathway. Because no direct variable indicated WBL experience in the dataset, IC_Mentorships was used as a proxy for it. The generic model is given below, where IC_Mentorships is 1 for completing specialized studies, such as an internship with an adult mentor in the community and under the direction of an educator knowledgeable in gifted education, and 0 for not completing any specialized mentorship studies in gifted education.

OUTCOME ~ IC_Mentorships + FRL + HS_GPA + White + Hispanic + Female

$$OUTCOME_{ij} \sim IC\_Mentorships_{ij} + FRL_{ij} + HS\_GPA_{ij} + White_{ij} + Hispanic_{ij} + Female_{ij}$$

Tables 11a-c provide the descriptive statistics for RQ2 models that investigate the differences in postsecondary educational outcomes between CTE students who had WBL and those who did not. Table 11a shows that, across cohorts, CTE students with WBL were more likely to enroll in higher education than those without WBL experience (see the first row). In terms of technical training, both groups show a zero or minimal proportion of CTE students enrolling in technical training. Additionally, CTE students with WBL earned postsecondary degrees and/or certifications at higher rates than CTE students without WBL. Table 11b indicates that CTE students with WBL tend to obtain higher postsecondary GPAs than CTE students without WBL. Table 11c exhibits a similar pattern: CTE students with WBL earned more post-secondary educational credits than those without WBL. However, the results should be interpreted with caution, given that the number of CTE students who had WBL is very small.

Table 11a. Comparison of Postsecondary Educational Outcomes: CTE Students with and Without Work-Based Learning Experience

		2021-2022	2021-2022	2022-2023	2022-2023	2023-2024	2023-2024
		WBL (N = 36)	No WBL (N=15,145)	WBL (N = 42)	No WBL (N = 15,329)	WBL (N = 50)	No WBL (N = 15,901)
Model	Model Outcome	*N (%)*	*N (%)*	*N (%)*	*N (%)*	*N (%)*	*N (%)*
2-i	Higher education enrollment	33 (*91.67*)	10,690 (*70.58*)	39 (*92.86*)	11,113 (*72.50*)	44 (*88.00*)	11,907 (*74.88*)
2-ii	Technical training enrollment	0 (*.000*)	6 (*0.04*)	0 (*.000*)	28 (*0.18*)	0 (*.000*)	13 (*0.08*)
2-iii	Degree or certification earned	8 (*22.22*)	2,405 (*15.88*)	17 (*40.48*)	2,285 (*14.91*)	14 (*28.00*)	1,970 (*12.39*)
2-iv	Degree earned	4 (*11.11*)	1,166 (*7.67*)	11 (*26.19*)	690 (*4.50*)	5 (*10.00*)	299 (*1.88*)
2-v	Certification earned	6 (*16.67*)	1,806 (*11.92*)	9 (*21.43*)	1,939 (*12.65*)	9 (*18.00*)	1,747 (*10.99*)

Table 11b. Comparison of Postsecondary Educational Outcomes: CTE Students With and Without Work-Based Learning Experience

		2021-2022	2021-2022	2022-2023	2022-2023	2023-2024	2023-2024
		WBL (N = 22)	No WBL (N= 6,650)	WBL (N = 32)	No WBL (N= 6,994)	WBL (N = 33)	No WBL (N= 7,347)
Model	Model Outcome	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*
2-vi	Total GPA	3.20 (0.74)	3.00 (0.77)	3.47 (0.55)	3.04 (0.77)	3.43 (0.64)	3.12 (0.74)
2-vii	First semester GPA	1.89 (1.75)	2.42 (1.41)	2.61 (1.55)	2.50 (1.38)	2.45 (1.63)	2.34 (1.45)
2-viii	Second semester GPA	1.56 (1.73)	2.08 (1.54)	2.55 (1.61)	2.18 (1.52)	2.07 (1.72)	2.16 (1.53)

Table 11c. Comparison of Total Number of Postsecondary Credits Earned: CTE Students With and Without Work-Based Learning Experience

		2021-2022	2021-2022	2022-2023	2022-2023	2023-2024	2023-2024
		WBL (N = 33)	No WBL (N= 10,690)	WBL (N = 39)	No WBL (N= 11,113)	WBL (N = 44)	No WBL (N= 11,907)
Model	Model Outcome	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*
2-ix	Total number of credits earned	68.73 (45.50)	55.82 (41.27)	62.32 (39.18)	44.54 (30.14)	45.14 (25.86)	29.90 (19.51)

Across all postsecondary outcomes, WBL was associated with significant increases in higher education enrollment, postsecondary degree, and/or certification completion, after excluding the contribution of control variables. Table 12 shows the overall AMEs for each model/outcome. Generally, results indicate that WBL is associated with an increase in higher education enrollment for the first two cohorts. In contrast, for the last cohort, 2023-2024, it is associated with a decrease in higher education enrollment. Among CTE students who enrolled in higher education, WBL experience is positively associated with degree and/or certification completion and the total number of credits earned.

Table 12. AME for RQ2

Model	Outcome	2021-2022 AME	2022-2023 AME	2023-2024 AME
2-i	Higher education enrollment	14.980%***	6.272%***	-3.305%***
2-ii	Technical training enrollment	-0.028%***	-0.192%***	-0.080%***
2-iii	Degree or certification earned	5.571%***	17.383%***	10.049%***
2-iv	Degree earned	0.705%***	11.035%***	2.835%***
2-v	Certification earned	7.474%***	5.263%***	5.292%***
2-vi	Total GPA	-0.008***	0.194***	0.090***
2-vii	First semester GPA	-0.753***	-0.192***	-0.023***
2-viii	Second semester GPA	-0.874***	-0.008***	-0.518***
2-ix	Total number of credits earned	0.128***	5.429***	8.591***

Research Question 3

RQ3: Among CTE students, is reaching concentrator and completer status associated with increased postsecondary success?

RQ3 focuses on the first two categories of CTE status, concentrator and completer, by investigating whether achieving concentrator and completer status is associated with increased postsecondary success among CTE students. The analytic sample includes students with a concentrator, completer, or preparatory CTE classification status in at least one pathway. The generic model is

given below, where CC_C_Status is 1 for CTE students classified as concentrator or completer and 0 for CTE students classified as non-concentrator or non-completer.

OUTCOME ~ CC_C_Status + FRL + HS_GPA + White + Hispanic + Female

$$OUTCOME_{ij} \sim CC\_C\_Status_{ij} + FRL_{ij} + HS\_GPA_{ij} + White_{ij} + Hispanic_{ij} + Female_{ij}$$

Due to the dataset's characteristics, only a limited number of CTE students from the 2021-2022 cohorts were classified as preparatory (non-concentrators or non-completers). Tables Xa-c present the descriptive statistics for the RQ3 models, which compare the postsecondary educational outcomes of CTE concentrators or completers with those of CTE non-concentrators or non-completers.

Table 13a shows that the CTE students classified as concentrators or completers were highly likely to enroll in higher education. However, the percentages of those who enrolled in technical training or earned postsecondary degrees and/or certifications were rather low. It is important to remember that the cohorts we examined are likely still undergoing their postsecondary education, so it is not surprising to see such percentages. Table 13b shows means for postsecondary GPAs. It is worth noting that the mean total GPA appears to increase from one year to the other, and the mean GPAs for the first and second semesters are lower than the overall GPA. The concentrator or completer students from the earlier cohorts earned a greater number of postsecondary educational credits than those from the later cohorts (Table 13c).

Finally, the number of CTE students classified as a non-concentrator or non-completer was extremely small (n=4 for the 2021-2022 cohort, and n = 0 for the two other cohorts). Therefore, group differences could not be analyzed.

Table 13a. Comparison of Postsecondary Educational Outcomes: CTE Students Classified as Concentrator or Completer Status vs. CTE Students Classified as Non-Concentrator or Non-Completer Status

		2021-2022	2021-2022	2022-2023	2022-2023	2023-2024	2023-2024
		CC/C (N = 15,145)	Not CC/C (N=10)	CC/C (N = 15,371)	Not CC/C (N = 0)	CC/C (N = 15,951)	Not CC/C (N = 0)
Model	Model Outcome	*N (%)*	*N (%)*	*N (%)*	*N (%)*	*N (%)*	*N (%)*
2-i	Higher education enrollment	*10,719* (70.65)	*4* *(40.00)*	11,152 (*72.55*)	0 (*.000*)	11,951 (*74.92*)	0 (*.000*)
2-ii	Technical training enrollment	6 (*0.04*)	10 (100.00)	28 (*0.18*)	0 (*.000*)	13 (*0.08*)	0 (*.000*)
2-iii	Degree or certification earned	2,413 (*15.89*)	0 (*.000*)	2,302 (*14.98*)	0 (*.000*)	1,984 (*12.44*)	0 (*.000*)
2-iv	Degree earned	1,166 (*7.69*)	0 (*.000*)	701 (*4.56*)	0 (*.000*)	304 (*1.91*)	0 (*.000*)
2-v	Certification earned	1,812 (*11.94*)	0 (*.000*)	1,948 (*12.67*)	0 (*.000*)	1,756 (*11.01*)	0 (*.000*)

Table 13b. Comparison of Postsecondary Educational Outcomes: CTE Students Classified as Concentrator or Completer Status vs. CTE Students Classified as Non-Concentrator or Non-Completer Status

		2021-2022	2021-2022	2022-2023	2022-2023	2023-2024	2023-2024
		CC/C (N = 6,670)	Not CC/C (N= 2)	CC/C (N = 7,026)	Not CC/C (N= 0)	CC/C (N = 7,380)	Not CC/C (N= 0)
Model	Model Outcome	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*
2-vi	Total GPA	3.01 (0.78)	-	3.04 (0.77)	-	3.12 (0.74)	-
2-vii	First semester GPA	2.41 (1.41)	-	2.50 (1.38)	-	2.34 (1.45)	-
2-viii	Second semester GPA	2.08 (1.54)	-	2.18 (1.52)	-	2.16 (1.53)	-

Note. Means not reported due to low n or n = 0.

Table 13c. Comparison of Total Number of Postsecondary Credits Earned: CTE Students Classified as Concentrator or Completer Status vs. CTE Students Classified as Non-Concentrator or Non-Completer Status

		2021-2022	2021-2022	2022-2023	2022-2023	2023-2024	2023-2024
		CC/C (N = 10,719)	Not CC/C (N= 4)	CC/C (N = 11,152)	Not CC/C (N= 0)	CC/C (N = 11,951)	Not CC/C (N= 0)
Model	Model Outcome	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*
2-ix	Total number of credits earned	55.85 (41.28)	-	44.60 (30.19)	-	29.96 (19.56)	-

Note. Means not reported due to low n or n = 0.

Due to the significant imbalance in sample sizes between the groups and the extremely small sample sizes of CTE students classified as non-concentrators or non-completers, we decided not to proceed with the logistic regression and HLM analyses to ensure the reliability and validity of our findings.

Research Question 4

RQ4: Among CTE students, is earning CTE dual credit status associated with increased postsecondary success?

RQ4 examines the impact of earning dual credit on CTE students' postsecondary educational performance. The analytic sample includes students with a concentrator, completer, or preparatory CTE classification status in at least one pathway. The generic model is given below,

where HS_Dual_Credit is 1 for CTE students who took dual credit courses during high school and 0 for CTE students who have not.

OUTCOME ~ HS_Dual_Credit+ FRL + HS_GPA + White + Hispanic + Female

$$OUTCOME_{ij} \sim HS\_Dual\_Credit_{ij} + FRL_{ij} + HS\_GPA_{ij} + White_{ij} + Hispanic_{ij} + Female_{ij}$$

Tables 14a-c provide the descriptive statistics for the RQ4 models, which investigate the differences in educational outcomes between CTE students who earned dual credit and those who did not. The results consistently indicate that CTE students who earned dual credit outperform those without dual credit across all outcomes. Notably, as shown in Table 14a, CTE students with dual credit exhibit higher enrollment and completion rates in higher education or technical training compared to those without dual credit. Table 14b shows that CTE students with dual credit obtain higher total GPAs than those without dual credit. Table 10c shows a similar pattern: CTE students who earned dual credit tended to complete more postsecondary educational credits.

Table 14a. Comparison of Postsecondary Educational Outcomes: CTE Students Who Earned Dual Credit vs. CTE Students Who Did Not Earned Dual Credit

		2021-2022	2021-2022	2022-2023	2022-2023	2023-2024	2023-2024
		Earned Dual Credit *(N = 8,928)*	Not Earned Dual Credit *(N = 1,252)*	Earned Dual Credit *(N = 9,275)*	Not Earned Dual Credit *(N = 1,334)*	Earned Dual Credit *(N = 10,169)*	Not Earned Dual Credit *(N = 1,246)*
Model	Model Outcome	*N (%)*	*N (%)*	*N (%)*	*N (%)*	*N (%)*	*N (%)*
4-i	Higher education enrollment	8,928 (100)	1,252 (100)	9,275 (100)	1,334 (100)	10169 (100)	1,246 (100)
4-ii	Technical training enrollment	4 (0.00)	1 (0.00)	13 (0.14)	1 (0.00)	3 (0.00)	0 (0.00)
4-iii	Degree or certification earned	2,315 (25.93)	91 (7.27)	2,205 (23.77)	95 (7.12)	1,903 (18.71)	80 (6.42)
4-iv	Degree earned	1,151 (12.89)	8 (0.64)	690 (7.44)	9 (0.67)	302 (2.97)	1 (0.08)
4-v	Certification earned	1,724 (19.31)	87 (6.95)	1,840 (19.84)	94 (7.05)	1,667 (16.39)	79 (6.34)

Table 14b. Comparison of Postsecondary Educational Outcomes: CTE Students Who Earned Dual Credit vs. CTE Students Who Did Not Earned Dual Credit

		2021-2022	2021-2022	2022-2023	2022-2023	2023-2024	2023-2024
		Earning Dual Credit *(N = 6,015)*	**Not Earned Dual Credit** *(N = 657)*	**Earning Dual Credit** *(N = 6,287)*	**Not Earned Dual Credit** *(N=739)*	**Earning Dual Credit** *(N = 6,663)*	**Not Earned Dual Credit** *(N=717)*
Model	Model Outcome	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*
4-vi	Total GPA	3.02 (0.77)	2.83 (0.83)	3.06 (0.76)	2.88 (0.83)	3.14 (0.73)	2.90 (0.82)
4-vii	First semester GPA	2.39 (1.43)	2.63 (1.15)	2.47 (1.41)	2.78 (1.03)	2.30 (1.48)	2.70 (1.07)
4-viii	Second semester GPA	2.06 (1.55)	2.27 (1.39)	2.16 (1.54)	2.36 (1.32)	2.13 (1.55)	2.41 (1.28)

Table 14c. Comparison of Total Number of Postsecondary Credits Earned: CTE Students Who Earned Dual Credit vs. CTE Students Who Did Not Earned Dual Credit

		2021-2022	2021-2022	2022-2023	2022-2023	2023-2024	2023-2024
		Earning Dual Credit *(N = 8,928)*	**Not Earned Dual Credit** *(N=1,252)*	**Earning Dual Credit** *(N = 9,275)*	**Not Earned Dual Credit** *(N=1,334)*	**Earning Dual Credit** *(N = 10,169)*	**Not Earned Dual Credit** *(N=1,246)*
Model	Model Outcome	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*
4-ix	Total number of credits earned	58.53 (41.52)	43.70 (37.78)	46.90 (30.63)	34.78 (25.09)	31.71 (19.99)	21.72 (12.40)

Table 15 contains the overall AMEs for RQ4 models/outcomes. After controlling for student-level characteristics and school-level variance, earning dual credit was associated with a significant increase in earning a postsecondary degree or certification and earning a degree or certification alone across all three cohorts. Additionally, among CTE students enrolled in postsecondary higher education, earning dual credit was also related to a higher total GPA for the 2023-2024 cohort, and completing five times more postsecondary educational credits for all three cohorts.

Table 15. AME for RQ4

Model	Outcome	2021-2022 AME	2022-2023 AME	2023-2024 AME
4-i	Higher education enrollment	0.00%	0.00%	0.00%
4-ii	Technical training enrollment	-0.05%	0.08%	0.03%
4-iii	Degree or certification earned	18.10%***	16.55%***	12.48%***
4-iv	Degree earned	11.72%***	6.08%***	2.43%***
4-v	Certification earned	12.68%***	13.53%***	10.86%***
4-vi	Total GPA	0.05	0.05	0.08***
4-vii	First semester GPA	-0.34***	-0.40***	-0.51***
4-viii	Second semester GPA	-0.31***	-0.30***	-0.41***
4-ix	Total number of credits earned	5.81***	5.34***	5.56***

Research Question 5

RQ5: Among CTE students, is earning an industry certification or passing an end-of-program assessment associated with increased postsecondary success?

RQ5 focuses on two predictor variables and examines whether earning an industry certification or passing an EOP assessment increases postsecondary educational success. The analytic sample includes students with a concentrator, completer, or preparatory CTE classification status in at least one pathway. The generic model is given below. EOP_status is 1 for CTE students who passed an EOP assessment for any pathway and 0 for CTE students who failed EOP assessment(s) for all pathways they attempted. Ind_Certified is 1 for CTE students with industrial certification and 0 for CTE students without industrial certification.

OUTCOME ~ EOP_status + Ind_Certified+ FRL + HS_GPA + White + Hispanic + Female

$$OUTCOME_{ij} \sim EOP\_status_{ij} + IND\_Certified_{ij} + FRL_{ij} + HS\_GPA_{ij} + White_{ij} + Hispanic_{ij} + Female_{ij}$$

Tables 16a-d present the descriptive statistics for the RQ5 models, which examine the differences in postsecondary educational outcomes between CTE students who earned an industrial certification or passed an EOP assessment and those who did not. A notable distinction of RQ5 is that it investigates two predictors, with one of them, Ind_Certified, sharing a data source with the outcome variable, technical training enrollment. Specifically, technical training enrollment is defined as earning an industry certification (TEDS_IndustryCerts) or enrolling in postsecondary technical training (TEDS_Enrollment) after high school graduation. Due to this overlap, Model 2, which uses technical training enrollment as the outcome, only includes EOP_Pass as the predictor to avoid redundancy. The RQ5 models are divided into three groups: models 5-i to 5-v (Tables 16a and 16b) encompass all CTE students from 2021 to 2023 cohorts but examine different groupings of that population; models 5-vi to 5-viii (Table 12c) focus on CTE students who enrolled in a postsecondary institution and earned 12 or more credits; and model 5-ix (Table 16d) includes CTE students who enrolled in a postsecondary institution, regardless of credits earned.

Tables 16a-b show that CTE students with an industrial certification or passing EOP assessment enrolled in higher education and completed a degree or certification at a higher rate than those without. Table 16b indicates that CTE students passing EOP assessment and CTE students failing EOP assessment had slightly higher probabilities of enrolling in postsecondary technical training. Among CTE students enrolled in higher education, Tables 16c and 16d show that CTE students with industrial certification or passing EOP tended to obtain higher total GPAs and earn more credits than those without certification or failing EOP assessment.

Table 16a. Comparison of Postsecondary Educational Outcomes: CTE Students With/Without Industrial Certification

		2021-2022	2021-2022	2022-2023	2022-2023	2023-2024	2023-2024
		With Industrial Certification *(N =1,207)*	Without Industrial Certification *(N=3,715)*	With Industrial Certification *(N =1,394)*	Without Industrial Certification *(N=4,034)*	With Industrial Certification *(N =1,777)*	Without Industrial Certification *(N=4,097)*
Model	Model Outcome	*N(%)*	*N(%)*	*N(%)*	*N(%)*	*N(%)*	*N(%)*
5-i	Higher education enrollment	947 (78.46)	2,637 (70.98)	1,099 (78.83)	2,881 (71.41)	1,383 (77.83)	2,968 (72.44)
5-iii	Degree or certification earned	176 (14.58)	420 (11.31)	203 (14.56)	351 (8.70)	145 (8.16)	201 (4.91)
5-iv	Degree earned	105 (8.70)	246 (6.62)	68 (4.88)	134 (3.32)	27 (1.52)	37 (0.90)
5-v	Certification earned	121 (10.02)	297 (7.99)	173 (12.41)	273 (6.77)	126 (7.06)	173 (4.22)

Table 16b. Comparison of Postsecondary Educational Outcomes: CTE Students Passing/Failing EOP Assessment

		2021-2022	2021-2022	2022-2023	2022-2023	2023-2024	2023-2024
		Passing EOP Assessment *(N =3,283)*	Failing EOP Assessment *(N=1,639)*	Passing EOP Assessment *(N =3,338)*	Failing EOP Assessment *(N=2,090)*	Passing EOP Assessment *(N =3,980)*	Failing EOP Assessment *(N=1,894)*
Model	Model Outcome	*N(%)*	*N(%)*	*N(%)*	*N(%)*	*N(%)*	*N(%)*
5-i	Higher education enrollment	2,684 (82.75)	900 (54.91)	2,769 (82.95)	1,211 (57.94)	3,287 (82.59)	1,064 (56.18)
5-ii	Technical training enrollment	0 (0.00)	0 (0.00)	2 (0.06)	2 (0.10)	3 (0.08)	0 (0.00)
5-iii	Degree or certification earned	439 (13.37)	157 (9.58)	392 (11.74)	162 (7.95)	242 (6.08)	104 (5.49)
5-iv	Degree earned	288 (8.77)	63 (3.84)	169 (5.06)	33 (1.58)	62 (1.56)	2 (0.11)
5-v	Certification earned	291 (8.86)	127 (7.75)	303 (9.07)	143 (6.84)	195 (4.90)	104 (5.49)

Table 16c. Comparison of Postsecondary Educational Outcomes: CTE Students With/Without Industrial Certification

		2021-2022	2021-2022	2022-2023	2022-2023	2023-2024	2023-2024
		With Industrial Certification *(N = 655)*	Without Industrial Certification *(N=1,640)*	With Industrial Certification *(N = 736)*	Without Industrial Certification *(N=1,785)*	With Industrial Certification *(N = 873)*	Without Industrial Certification *(N=1,821)*
Model	Model Outcome	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*
5-vi	Total GPA	3.08 (0.80)	3.01 (0.75)	3.11 (0.74)	2.99 (0.78)	3.13 (0.75)	3.08 (0.77)
5-vii	First semester GPA	2.54 (1.44)	2.52 (1.35)	2.74 (1.24)	2.59 (1.32)	2.47 (1.38)	2.45 (1.39)
5-viii	Second semester GPA	2.25 (1.55)	2.19 (1.49)	2.47 (1.43)	2.27 (1.46)	2.24 (1.50)	2.27 (1.49)

Table 16d. Comparison of Postsecondary Educational Outcomes: CTE Students Passing/Failing EOP Assessment

		2021-2022	2021-2022	2022-2023	2022-2023	2023-2024	2023-2024
		Passing EOP Assessment *(N = 1,833)*	Failing EOP Assessment *(N=462)*	Passing EOP Assessment *(N = 1,907)*	Failing EOP Assessment *(N=614)*	Passing EOP Assessment *(N = 2,198)*	Failing EOP Assessment *(N=496)*
Model	Model Outcome	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*
5-vi	Total GPA	3.11 (0.74)	2.72 (0.77)	3.11 (0.76)	2.79 (0.76)	3.17 (0.73)	2.76 (0.80)
5-vii	First semester GPA	2.58 (1.39)	2.32 (1.30)	2.73 (1.28)	2.33 (1.31)	2.51 (1.41)	2.23 (1.28)
5-viii	Second semester GPA	2.27 (1.53)	1.97 (1.41)	2.43 (1.45)	2.01 (1.42)	2.32 (1.51)	2.02 (1.40)

Table 16e. Comparison of Total Number of Postsecondary Credits Earned: CTE Students With/Without Industrial Certification

		2021-2022	2021-2022	2022-2023	2022-2023	2023-2024	2023-2024
		With Industrial Certification *(N = 947)*	Without Industrial Certification *(N=2,637)*	With Industrial Certification *(N = 1,099)*	Without Industrial Certification *(N=2,881)*	With Industrial Certification *(N = 1,383)*	Without Industrial Certification *(N=2,968)*
Model	Model Outcome	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD*	*Group Outcomes M (SD*
5-ix	Total number of credits earned	62.72 (40.14)	57.88 (40.57)	47.36 (28.84)	44.19 (28.31)	29.87 (18.39)	28.61 (17.61)

Table 16f. Comparison of Total Number of Postsecondary Credits Earned: CTE Students Passing/Failing EOP Assessment

		2021-2022	2021-2022	2022-2023	2022-2023	2023-2024	2023-2024
		Passing EOP Assessment *(N = 2,684)*	Failing EOP Assessment *(N=900)*	Passing EOP Assessment *(N = 2,769)*	Failing EOP Assessment *(N=1,211)*	Passing EOP Assessment *(N = 3,287)*	Failing EOP Assessment *(N=1,064)*
Model	Model Outcome	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD*	*Group Outcomes M (SD*
5-ix	Total number of credits earned	64.26 (40.88)	43.94 (35.25)	49.27 (28.52)	35.45 (25.99)	31.30 (18.08)	21.94 (15.15)

Table 17 summarizes the overall AMEs for RQ5 models. In terms of EOP_Pass, after controlling for demographics, academic characteristics, and school-level variance, passing the EOP assessment was significantly associated with higher rates of enrollment in higher education, as well as increases in GPA during the first and second semesters of postsecondary study. However, passing the EOP assessment was also related to a small but significant decrease in the rate of earning a postsecondary degree or certification. With regard to IND_Certified, after excluding the influence of control variables, earning an industrial certification at high school was associated with significant increases in higher education enrollment, postsecondary degree or certification completion, and postsecondary certification completion.

Table 17. AME for RQ5

Model	Outcome	Predictor	2021-2022 AME	2022-2023 AME	2023-2024 AME
5-i	Higher education enrollment				
		EOP_Pass	2.99%***	4.60%***	2.94%***
		IND_Certified	2.56%***	1.31%	2.30%***
5-ii	Technical training enrollment				
		EOP_Pass	-0.03%	-0.09%	0.03%
5-iii	Degree or certification earned				
		EOP_Pass	-6.46%***	-5.84%***	-8.86%***
		IND_Certified	0.77%	2.10%***	2.47%***
5-iv	Degree earned				
		EOP_Pass	-1.85%***	-1.38%***	-1.15%***
		IND_Certified	-0.74%	-1.15%***	-1.50%***
5-v	Certification earned				
		EOP_Pass	-5.17%***	-5.16%***	-8.09%***
		IND_Certified	1.53%**	3.14%***	3.86%***
5-vi	Total GPA				
		EOP_Pass	-0.02	-0.03	-0.04
		IND_Certified	-0.03	0.03	0.01
5-vii	First semester GPA				
		EOP_Pass	0.11**	0.23***	0.19***
		IND_Certified	-0.01	0.04	0.04
5-viii	Second semester GPA				
		EOP_Pass	0.10*	0.25***	0.12**
		IND_Certified	-0.02	0.07	0.01
5-ix	Total number of credits earned				
		EOP_Pass	2.04*	0.46	-1.62***
		IND_Certified	-1.81*	-1.57**	-1.64***

Research Question 6

RQ6: Is school participation in CTE programs associated with increased accountability indicator rates (postsecondary readiness and graduation)?

RQ6 examines whether participating in a CTE program increases schools' accountability indicator rates. The analytic sample includes all CTE and non-CTE students with accountability indicator rates. The analytical model is presented below, where CTE_School is 1 for schools that offer one or more CTE pathway, and 0 for schools that do not offer any.

OUTCOME ~ CTE_School + FRL_pct + White_pct + Female_pct

As can be noticed in the regression models above, for the school-level research questions, demographic variables were expressed as percentages after aggregating the student-level data to school-level. However, to improve the interpretability of the coefficient estimates, we converted percentages to proportions in the regression models. For example, the graduation rate is the outcome variable. When variables are expressed as percentages (0-100), the coefficients represent the change in graduation rate for each percentage point increase in the predictor variable, but when converted to proportions (0-1), the coefficients represent the change in graduation rate for a complete shift from 0% to 100% of the predictor variable. This transformation makes the coefficients more meaningful and easier to interpret, as they reflect the full range of impact of each demographic or program variable on graduation outcomes.

Table 18. Comparison of Outcomes: CTE and Non-CTE Schools

		2022-2023	2022-2023	2023-2024	2023-2024
		CTE School *(N =74)*	**Non-CTE School** *(N=140)*	**CTE School** *(N =74)*	**Non-CTE School** *(N=140)*
Model	Model Outcome	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*	*Group Outcomes M (SD)*
6, 6i	Postsecondary Readiness Indicator Rate	95.08 (16.60)	96.70 (13.97)	91.37 (15.34)	94.79 (12/63)
6, 6i	Graduation Indicator Rate	93.89 (4.10)	94.89 (3.80)	95.22 (4.08)	95.55 (3.36)

Findings outlined in Table 19 revealed that CTE schools showed lower postsecondary readiness rates and graduation rates compared to non-CTE schools in both years, with these negative effects growing larger from 2022-2023 to 2023-2024 (from -0.645 to -2.113 for postsecondary readiness, and from -0.294 to -2.113 for graduation rates). However, these differences were not statistically significant, meaning we cannot conclude that having a CTE program negatively impacts the high school accountability indicators.

Table 19. Comparison of Outcomes: CTE and Non-CTE Schools

	2022-2023	2023-2024	2022-2023	2023-2024
	Postsecondary Readiness Indicator Estimate (SE)	Postsecondary Readiness Indicator Estimate (SE)	Graduation Rate Indicator Estimate (SE)	Graduation Rate Indicator Estimate (SE)
(Intercept)	77.060 (12.388)	101.397 (11.669)	91.216 (3.092)	101.397 (11.669)
CTE_School	-0.645 (2.039)	-2.113 (1.946)	-0.294 (0.509)	-2.113 (1.946)
FRL_pct	-0.645 (6.039)	-9.495 (5.847)	-8.436*** (1.507)	-9.495 (5.847)
White_pct	16.781* (6.657)	10.964 (6.633)	3.129 (1.661)	10.964 (6.633)
Hispanic_pct	-53.684* (21.159)	-14.783 (22.272)	-6.997 (5.281)	-14.783 (22.272)
Female_pct	20.154 (17.954)	-19.275 (17.146)	11.931** (4.481)	-19.275 (17.146)

*Significance levels: 0 <= '***' < 0.001 < '**' < 0.01 < '*' < 0.05*

Discussion

This study found that CTE participation, on average, offers positive postsecondary benefits for students. CTE students consistently demonstrated higher rates of enrollment in higher education and technical training compared to their non-CTE peers, and this advantage remained significant even after accounting for important background factors such as demographics, socioeconomic status, and high school academic performance. This suggests that CTE participation provides benefits that go beyond what can be explained by student characteristics alone. The descriptive analysis reinforces this positive trend, showing that CTE participants not only enrolled in postsecondary education at higher rates but also completed degrees and certifications more frequently than their counterparts, indicating that the advantages of CTE extend from initial access through actual credential attainment. However, it is essential to note that the student cohorts in this study graduated from high school 2 to 3 years ago, which is less than the time typically needed to complete a traditional 4-year degree. It is possible that CTE students more frequently complete a less-than-4-year degree or that CTE students who earn college credits in high school are able to complete their degree earlier.

The academic performance results, however, present a more nuanced picture that requires careful consideration. While CTE and non-CTE students earned similar numbers of postsecondary credits and maintained comparable overall grade point averages, CTE participants showed somewhat lower performance in their first and second semesters. This initial academic adjustment may reflect the transition challenges that CTE students face when moving to traditional postsecondary academic environments. However, it is important to note that substantial missing data in the early semester grades make this finding less definitive. It is possible that students who participated in CTE took fewer college preparatory classes during high school, contributing to lower performance levels in the first year of higher education. Another possibility is that CTE students, on average, tend to perform lower than their non-CTE counterparts. Prior research shows that low-performing students are tracked into CTE classes more often (Plank, 2001) and high school GPA decreased with increased CTE credit taking (Aliaga et al., 2014). However, after matching

students' academic performance, some studies found that CTE students scored higher than their matched non-CTE counterparts on the ACT exam (Lekes et al., 2007).

Despite these early academic performance differences, the fact that CTE students ultimately achieve higher completion rates suggests they successfully overcome any initial challenges. This could potentially indicate that CTE programs develop valuable persistence and practical skills that contribute to long-term educational success beyond what traditional academic metrics capture.

This study is particularly interested in how CTE students' specific CTE-related experiences relate to their postsecondary outcomes. The remaining discussion focuses on the impacts of the various CTE options.

Work-Based Learning (WBL) experiences are generally associated with improved postsecondary outcomes among CTE students. However, the results should be interpreted cautiously due to the very small number of CTE students who participated in WBL programs. CTE students with work-based learning experience consistently demonstrated higher rates of higher education enrollment, degree and certification completion, and credit accumulation compared to their CTE peers without such experience. They also maintained higher postsecondary GPAs across all measures examined. However, the relationship with higher education enrollment showed some inconsistency, with work-based learning positively associated with enrollment in the earlier cohorts but negatively associated in the most recent cohort. Despite this variation in enrollment patterns, work-based learning participants who did enroll in postsecondary education showed stronger performance in terms of credential completion and credit earning. These findings suggest that work-based learning may provide CTE students with valuable skills, connections, or motivation that enhance their postsecondary success. However, the small sample size of work-based learning participants limits the generalizability of these conclusions and calls for further research with larger samples to confirm these preliminary positive associations.

Earning dual high school credit showed a consistently positive relationship with post-secondary success among CTE students. CTE students who participated in dual credit programs significantly outperformed their peers without dual credit experience across all measured outcomes, including higher rates of postsecondary enrollment and degree completion, better academic performance as measured by GPA, and substantially greater credit accumulation in postsecondary education. CTE students who earned industry certifications demonstrated consistently positive postsecondary outcomes, with significant increases in higher education enrollment, degree and certification completion rates, and overall academic performance. In contrast, the results for passing EOP assessments present a more mixed picture. While students who passed EOP assessments showed higher rates of higher education enrollment and better first and second semester GPAs, they exhibited lower rates of completing post-secondary degrees or certifications. However, as mentioned above, we don't have a clear picture of whether those students graduated from college, given that they are still underway.

The school-level analysis revealed a complex relationship between school-level CTE participation and accountability measures. Schools offering CTE programs showed lower postsecondary readiness and graduation rates compared to non-CTE schools, though these differences were not statistically significant. Thus, the analysis suggests that the presence of CTE programs alone does not negatively impact school accountability measures.

These findings suggest that while individual CTE participation, particularly when combined with dual credit opportunities and industry certifications, can enhance postsecondary success, the broader

implementation and structure of CTE programs at the school level may require further refinement to maximize their potential benefits for both students and institutional outcomes.

Limitations

While we examined different postsecondary success indicators, our options were limited to only those available in the data we received from KYSTATS. For example, we used IC_Mentorships variable as a proxy for work-based learning experience since we did not have an exclusive variable for student internship completion. We acknowledge that this approach primarily captures internship experiences and may not fully represent the broader spectrum of work-based learning opportunities available to CTE students. As more comprehensive work-based learning data becomes available for CTE programs, future research should incorporate these expanded measures to provide a more complete picture of student experiences. Furthermore, we did not have data available regarding student employment outcomes after graduation, such as their role, mean wages, career prospects, etc. The availability of such data would have allowed us to examine the role of CTE in students after they graduated from college and potentially further support our findings on the difference that the CTE program makes.

Small sample sizes and missing data are also limitations of this study, as small numbers of students participated in some of the CTE options. We recommend that these results be interpreted with caution and that this line of research be repeated in the future as participation in CTE-related educational experiences increases and better-quality postsecondary data are available.

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Appendix A: Data Source and Key Variables Information

Table A-1. KYSTATS Relevant Variable Data Dictionary

Data Source	Variable Name	Short Description
IC_AnnualPerson	AcadYr	4-digit year associated with the ending year of the academic calendar. This column is the KLDS source for the academic year and is used for reporting purposes.
IC_AnnualPerson	DistNo	A unique number or alphanumeric code assigned to a local education agency by a school system, a state, or other agency or entity. This is the KLDS source for reporting purposes.
IC_AnnualPerson	SchNo	A unique number or alphanumeric code assigned to an institution by a school, school system, state, or other agency or entity. This is the KLDS source for reporting purposes.
IC_AnnualPerson	IC_Grade	The grade level or primary instructional level at which a student enters and receives services in a school or an educational institution during a given academic session. This is the KLDS source for reporting purposes.
IC_AnnualPerson	IC_Diploma_Date	The month and year on which the diploma/credential is awarded to a student in recognition of his/her completion of the curricular requirements. This is the KLDS source for reporting purposes.
IC_AnnualPerson	IC_FinalGPA	Grade point average for the academic year for the public P12 academic record. This column is the KLDS source for a person's final GPA and is used for reporting purposes.
IC_AnnualPerson	IC_FreeReducedLunch	An indication of a student's level of eligibility to participate in the National School Lunch Program for breakfast, lunch, snack, supper, and milk programs. This is the KLDS source for reporting purposes and is derived from the higher of Free, Reduced, Paid (Assume null = Paid and transform) for all enrollments that year.
IC_AnnualPerson	IC_Gifted	KYStats Derived indicator based on a qualifying record in the Gifted table for that year. If the person is ever gifted, he or she has the IC_Gifted indicator. This column is the KLDS source for the gifted indicator of a person and is used for reporting purposes.
IC_AnnualPerson	IC_EL	English Learner Indicator. KYStats Derived indicator based on a qualifying record in the EL table for that year.

Table A-1. (Continued)

Data Source	Variable Name	Short Description
IC_Assessment_Scores	AcadYr	Academic Year- 4-digit year associated with the ending year of the academic calendar (IE 2008-2009 school year = AcadYr 2009)
IC_Assessment_Scores	AssessmentDesc	Description of Assessment code given for that particular student
IC_Assessment_Scores	DistNo	State-assigned district number in which the student is attending the school
IC_Assessment_Scores	Grade	Grade in which the student is enrolled. This column is the KLDS source for the student's grade when assessed and is used for reporting purposes.
IC_Assessment_Scores	Scale_Score	Assessment score.
IC_Assessment_Scores	SchNo	State-assigned school number in which the student is attending the school
KPEDS_CourseEnrollment	AcadYr	Calendar years are associated with a summer, fall, and spring sequence of terms.
KPEDS_CourseEnrollment	KPEDS_CourseCreditHours	Number of credits attempted upon successful completion of the class.
KPEDS_CourseEnrollment	KPEDS_Standardized_Letter_Grade	Standardized grade indicating the level of proficiency/achievement in a particular class.
KPEDS_CourseEnrollment	KPEDS_Standardized_Numeric_Grade	Numeric equivalent of the standardized letter grade. This column is the KLDS source for the course grade and is used for reporting purposes.
KPEDS_CourseEnrollment	KPEDS_Dual_Credit	Students earn both high school and college credit upon completion of the course.
KPEDS_Degree	KPEDS_Credit_Hrs_Earned	The total number of credit hours earned for first-time degree recipients is shown in this column. This column is the KLDS source for the credit hours earned by a person and is used for reporting purposes.
KPEDS_Degree	DegreeRank	This is a KYStats derived rank degrees based on the KPEDS_DegreeLevelShortDescription. This column is the KLDS source for the degree rank and is used for reporting purposes.
KPEDS_Degree	KPEDS_Degree_Year	Calendar years are associated with a summer, fall, and spring sequence of terms. This column is the KLDS source for a person's degree year and is used for reporting purposes.

Table A-1. (Continued)

Data Source	Variable Name	Short Description
KPEDS_Enrollments	AcadYr	The calendar year is associated with a summer, fall, and spring sequence of terms. This column is the KLDS source for the academic year of enrollment and is used for reporting purposes.
KPEDS_Enrollments	KPEDS_CreditBearingHours	Total semester hours for academic credit. This column is the KLDS source for the credit hours completed by a person and is used for reporting purposes.
KPEDS_ReadinessFollowUp	KPEDS_Second_Sem_Tot_GPA	Grade Point Average based on all courses in the student's Second semester.
KPEDS_ReadinessFollowUp	KPEDS_First_Sem_Tot_GPA	Grade Point Average based on all courses in the student's first semester.
TEDS_Enrollment	TEDS_CareerPathwayName	This is the official name of the pathway that is represented by the CIP Code. This column is the KLDS source for the career pathway name and is used for reporting purposes.
TEDS_Enrollment	TEDS_CIPCodes	Seven-digit field derived from NCES.
TEDS_Enrollment	DistNo	District Number.
TEDS_Enrollment	TEDS_ProgramLevel	The education or curriculum level of the program. This field is a selection criteria in some reports used for Federal reporting.
TEDS_Enrollment	SchNo	School Number.
TEDS_Enrollment	TEDS_EducationLevel	The education level of the course.
TEDS_Enrollment	TEDS_StudentObjective	Indicates if the student is preparatory or exploring in a pathway. This column is the KLDS source for the student objective and is used for reporting purposes.
TEDS_Enrollment	TEDS_TerminationStatus	Schools are accountable for the outcome for all students who enroll in a technical program until the “normal amount of time has passed for the student to complete or graduate.”
TEDS_IndustryCerts	AcadYr	Academic year that corresponds with the record.
TEDS_IndustryCerts	TEDS_IndustryCertificate	Industry certificates are those credentials for which the student must pass a test that has been validated/approved by the business or industry.
TEDS_KOSSA	AcadYr	Academic year that corresponds with the record.
TEDS_KOSSA	TEDS_PassIndicator	This element indicates if the student passed the KOSSA test or not.
TEDS_KOSSA	TEDS_SkillStandard	Name of the KOSSA test the student attempted.

Appendix B: Research Question 1 Regression Models

Table B-1. RQ1-i – Logistic Regression Model for Any Postsecondary Higher Education Enrollment

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	1.367***	0.052	1.150***	0.049	1.204***	0.049
Parametric	CTE_Treat	0.106***	0.030	0.244***	0.029	0.332***	0.029
Parametric	FRL	-0.400***	0.031	-0.333***	0.031	-0.322***	0.031
Parametric	White	-0.547***	0.046	-0.512***	0.043	-0.457***	0.043
Parametric	Hispanic	-0.199**	0.070	-0.169*	0.067	-0.262***	0.066
Parametric	Female	0.392***	0.030	0.427***	0.030	0.335***	0.030
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_FinalGPA_m3)	5.370***	6.764	5.530***	6.971	3.833***	4.846

Note. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05

Table B-2. RQ1-ii – Logistic Regression Model for Any Postsecondary Technical Training Enrollment

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	-9.001***	1.100	-7.025***	0.352	-7.224***	0.423
Parametric	CTE_Treat	1.404	1.121	0.725*	0.339	0.023	0.421
Parametric	FRL	-1.612	1.150	0.250	0.329	-0.257	0.434
Parametric	Female	-0.071	0.950	-0.265	0.327	-0.009	0.430
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_Final GPA_m3)	1.043	1.085	1.195	1.366	3.667	4.645

Note. The variables White and Hispanic were excluded from analysis RQ1-ii due to a lack of variability with the outcome. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05

Table B-3. RQ1-iii – Logistic Regression Model for Any Postsecondary Degree or Certification Earned

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	-2.942***	0.076	-2.896***	0.075	-3.327***	0.084
Parametric	CTE_Treat	0.664***	0.038	0.731***	0.041	0.844***	0.045
Parametric	FRL	-0.127**	0.039	-0.164***	0.041	-0.074	0.044
Parametric	White	0.505***	0.068	0.342***	0.065	0.495***	0.074
Parametric	Hispanic	0.464***	0.097	0.383***	0.095	0.498***	0.104
Parametric	Female	0.064	0.038	-0.022	0.039	-0.012	0.042
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_Final GPA_m3)	3.492***	4.408	10.353***	12.945	3.038***	3.841

Note. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05

Table B-4. RQ1-iv – Logistic Regression Model for Any Postsecondary Degree Earned

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	-4.500***	0.201	-4.722***	0.171	-6.480***	0.559
Parametric	CTE_Treat	0.624***	0.055	0.548***	0.071	0.318**	0.103
Parametric	FRL	-0.206***	0.056	-0.296***	0.074	-0.302**	0.113
Parametric	White	0.458***	0.099	0.361**	0.125	0.012	0.166
Parametric	Hispanic	0.203	0.150	0.401*	0.181	-0.068	0.275
Parametric	Female	0.082	0.054	-0.078	0.069	0.436***	0.107
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_Final GPA_m3)	8.766***	10.981	8.853***	11.089	4.574***	5.785

Note. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05

Table B-5. RQ1-v – Logistic Regression Model for Any Postsecondary Certification Earned

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	-3.195***	0.087	-3.023***	0.079	-3.521***	0.090
Parametric	CTE_Treat	0.682***	0.044	0.783***	0.044	0.888***	0.047
Parametric	FRL	-0.085	0.044	-0.126**	0.043	-0.052	0.046
Parametric	White	0.560***	0.079	0.329***	0.069	0.586***	0.080
Parametric	Hispanic	0.515***	0.110	0.341***	0.102	0.579***	0.110
Parametric	Female	-0.143***	0.043	-0.143***	0.042	-0.080	0.045
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_Final GPA_m3)	4.394***	5.538	8.573***	10.786	3.099***	3.919

Note. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05

Table B-6. RQ1-vi – HLM for Postsecondary Total GPA

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	2.972***	0.021	2.950***	0.020	3.067***	0.019
Parametric	CTE_Treat	-0.015	0.012	-0.007	0.012	-0.007	0.011
Parametric	FRL	-0.120***	0.013	-0.058***	0.013	-0.056***	0.012
Parametric	White	0.090***	0.019	0.108***	0.018	0.035*	0.017
Parametric	Hispanic	0.081**	0.029	0.106***	0.028	0.045	0.027
Parametric	Female	-0.102***	0.012	-0.090***	0.012	-0.037**	0.011
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_Final GPA_m3)	7.458***	9.287	7.185***	8.927	7.508***	9.314
Smooth	s(SCHOOL_ID)	0.001	1.000	0.001	1.000	0.002	1.000

Note. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05

Table B-7. RQ1-vii – HLM for Postsecondary First Semester GPA

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	2.469***	0.044	2.495***	0.042	2.399***	0.044
Parametric	CTE_Treat	-0.055*	0.025	-0.073**	0.024	-0.126***	0.025
Parametric	FRL	-0.002	0.027	0.020	0.026	-0.042	0.027
Parametric	White	-0.007	0.039	0.041	0.037	-0.003	0.039
Parametric	Hispanic	0.096	0.061	0.042	0.058	0.188**	0.061
Parametric	Female	-0.079**	0.026	-0.035	0.025	-0.012	0.026
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_Final GPA_m3)	4.461***	5.618	4.158***	5.249	4.651***	5.854
Smooth	s(SCHOOL_ID)	0.002	1.000	0.339	1.000	0.885**	1.000

Note. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05

Table B-8. RQ1-viii – HLM for Postsecondary Second Semester GPA

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	2.271***	0.047	2.338***	0.046	2.272***	0.046
Parametric	CTE_Treat	-0.060*	0.027	-0.131***	0.027	-0.078**	0.027
Parametric	FRL	-0.079**	0.029	-0.025	0.029	-0.081**	0.029
Parametric	White	-0.130**	0.042	-0.084*	0.040	-0.117**	0.040
Parametric	Hispanic	0.011	0.065	-0.007	0.063	0.014	0.064
Parametric	Female	-0.103***	0.028	-0.068*	0.027	0.003	0.027
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_Final GPA_m3)	4.961***	6.237	4.318***	5.447	5.063***	6.359
Smooth	s(SCHOOL_ID)	0.004	1.000	0.795*	1.000	0.873**	1.000

Note. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05

Table B-9. RQ1-ix – HLM for Postsecondary Total Credits Earned

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	63.244***	0.850	47.369***	0.619	30.661***	0.405
Parametric	CTE_Treat	-1.354**	0.501	-1.033**	0.369	-0.243	0.240
Parametric	FRL	-8.631***	0.527	-5.042***	0.391	-2.941***	0.254
Parametric	White	-6.255***	0.756	-3.386***	0.539	-1.503***	0.355
Parametric	Hispanic	-2.081	1.183	-0.225	0.848	-0.241	0.561
Parametric	Female	0.742	0.513	1.559***	0.375	1.834***	0.244
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_Final GPA_m3)	5.561***	6.988	5.315***	6.676	5.601***	7.029
Smooth	s(SCHOOL_ID)	0.008	1.000	0.607	1.000	0.607	1.000

Note. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05

Appendix C: Research Question 2 Regression Models

Table C-1. RQ2-i – Logistic Regression Model for Any Postsecondary Higher Education Enrollment

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	1.568***	0.071	1.568***	0.069	1.676***	0.069
Parametric	IC_Mentorships	1.109	0.669	0.424	0.617	-0.208	0.468
Parametric	FRL	-0.411***	0.043	-0.402***	0.044	-0.285***	0.043
Parametric	White	-0.597***	0.066	-0.564***	0.063	-0.530***	0.064
Parametric	Hispanic	-0.189	0.099	-0.136	0.097	-0.320***	0.095
Parametric	Female	0.509***	0.044	0.593***	0.044	0.472***	0.044
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_Final GPA_m3)	3.776***	4.774	3.150***	3.991	4.325***	5.460

Note. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05

Table C-2. RQ2-ii – Logistic Regression Model for Any Postsecondary Technical Training Enrollment

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	-40.752	1575161.431	-5.994***	0.586	-38.625	1482948.517
Parametric	IC_Mentorships	-31.263	12464762.105	-32.964	10886495.289	-31.004	10886903.438
Parametric	FRL	-1.440	1.198	-0.015	0.398	-1.288	0.683
Parametric	White	32.810	1575161.431	-0.043	0.550	32.190	1482948.517
Parametric	Hispanic	34.377	1575161.431	-0.760	1.119	0.060	2496899.593
Parametric	Female	0.347	1.041	-0.431	0.411	-0.491	0.685
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_Final GPA_m3)	1.011	1.021	1.008	1.017	1.566	1.950

Note. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05

Table C-3. RQ2-iii – Logistic Regression Model for Any Postsecondary Degree or Certification Earned

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	-2.133***	0.088	-2.041***	0.085	-2.438***	0.094
Parametric	IC_Mentorships	0.390	0.446	1.047**	0.337	0.728*	0.371
Parametric	FRL	-0.202***	0.049	-0.168***	0.050	-0.083	0.052
Parametric	White	0.454***	0.083	0.353***	0.080	0.566***	0.090
Parametric	Hispanic	0.371**	0.120	0.412***	0.115	0.619***	0.124
Parametric	Female	0.045	0.048	-0.101*	0.049	-0.063	0.051
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_FinalGPA_m3)	2.533***	3.203	9.969***	12.470	2.895***	3.659

Note. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05

Table C-4. RQ2-iv – Logistic Regression Model for Any Postsecondary Degree Earned

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	-3.467***	0.179	-4.060***	0.182	-5.312***	0.382
Parametric	IC_Mentorships	0.105	0.630	1.517***	0.382	1.071	0.618
Parametric	FRL	-0.316***	0.070	-0.267**	0.090	-0.547***	0.150
Parametric	White	0.367**	0.120	0.495**	0.161	-0.025	0.214
Parametric	Hispanic	0.110	0.182	0.497*	0.226	0.253	0.318
Parametric	Female	0.011	0.068	-0.080	0.085	0.214	0.134
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_FinalGPA_m3)	8.272***	10.379	2.393***	3.040	3.149***	4.000

Note. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05

Table C-5. RQ2-v – Logistic Regression Model for Any Postsecondary Certification Earned

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	-2.464***	0.102	-2.079***	0.088	-2.586***	0.099
Parametric	IC_Mentorships	0.588	0.465	0.415	0.401	0.452	0.420
Parametric	FRL	-0.135*	0.054	-0.148**	0.052	-0.046	0.054
Parametric	White	0.594***	0.097	0.308***	0.084	0.626***	0.095
Parametric	Hispanic	0.498***	0.136	0.328**	0.122	0.640***	0.130
Parametric	Female	-0.155**	0.054	-0.244***	0.052	-0.104	0.054
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_FinalGPA_m3)	4.138***	5.218	3.230***	4.086	2.811***	3.554

Note. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05

Table C-6. RQ2-vi – HLM for Postsecondary Total GPA

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	2.936***	0.027	2.930***	0.026	3.037***	0.024
Parametric	IC_Mentorships	-0.008	0.162	0.194	0.122	0.090	0.128
Parametric	FRL	-0.103***	0.018	-0.088***	0.017	-0.064***	0.016
Parametric	White	0.123***	0.025	0.158***	0.024	0.084***	0.023
Parametric	Hispanic	0.093*	0.038	0.163***	0.037	0.072*	0.035
Parametric	Female	-0.130***	0.017	-0.126***	0.017	-0.076***	0.016
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_FinalGPA_m3)	6.606***	8.242	6.341***	7.901	6.451***	8.030
Smooth	s(SCHOOL_ID)	0.001	1.000	0.001	1.000	0.001	1.000

Note. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05

Table C-7. RQ2-vii – HLM for Postsecondary First Semester Total GPA

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	2.398***	0.057	2.410***	0.054	2.260***	0.055
Parametric	IC_Mentorships	-0.753*	0.339	-0.192	0.250	-0.023	0.292
Parametric	FRL	-0.001	0.037	-0.007	0.035	-0.050	0.037
Parametric	White	0.002	0.052	0.062	0.050	0.026	0.052
Parametric	Hispanic	0.120	0.080	0.117	0.076	0.199*	0.080
Parametric	Female	-0.095**	0.036	-0.050	0.034	0.018	0.035
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_FinalGPA_m3)	3.627***	4.566	3.500***	4.421	3.620***	4.561
Smooth	s(SCHOOL_ID)	0.589	1.000	0.680	1.000	0.003	1.000

Note. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05

Table C-8. RQ2-viii – HLM for Postsecondary Second Semester Total GPACohort

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	2.235***	0.061	2.204***	0.059	2.166***	0.058
Parametric	IC_Mentorships	-0.874*	0.365	-0.008	0.273	-0.518	0.304
Parametric	FRL	-0.035	0.040	-0.053	0.038	-0.103**	0.038
Parametric	White	-0.155**	0.056	-0.064	0.054	-0.093	0.054
Parametric	Hispanic	-0.033	0.086	0.078	0.083	0.084	0.083
Parametric	Female	-0.163***	0.039	-0.082*	0.037	0.057	0.037
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_FinalGPA_m3)	3.868***	4.866	3.881***	4.895	3.742***	4.712
Smooth	s(SCHOOL_ID)	0.568	1.000	0.725	1.000	0.355	1.000

Note. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05

Table C-9. RQ2-ix – HLM for Postsecondary Total Credit Earned

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	63.587***	1.111	46.039***	0.799	29.333***	0.502
Parametric	IC_Mentorships	0.128	6.809	5.429	4.342	8.591**	2.983
Parametric	FRL	-8.932***	0.723	-4.951***	0.531	-3.379***	0.337
Parametric	White	-8.793***	1.036	-3.473***	0.736	-0.802	0.469
Parametric	Hispanic	-3.798*	1.588	0.818	1.138	1.041	0.729
Parametric	Female	2.144**	0.716	3.003***	0.517	3.011***	0.329
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_FinalGPA_m3)	5.147***	6.472	5.095***	6.395	4.928***	6.194
Smooth	s(SCHOOL_ID)	0.003	1.000	0.268	1.000	0.010	1.000

Note. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05

Appendix D: Research Question 4 Regression Models

Table D-1. RQ4-i – Logistic Regression Model for Any Postsecondary Higher Education Enrollment

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	33.566	2725105.698	33.566	2652577.753	33.566	2639177.368
Parametric	HS_Dual_Credit	0.000	2088585.148	-0.000	2028640.609	0.000	2079405.424
Parametric	FRL	0.000	1436677.323	0.000	1425959.232	0.000	1378153.339
Parametric	White	0.000	2065714.118	-0.000	1985055.990	0.000	1920546.542
Parametric	Hispanic	0.000	3162462.550	-0.000	3049937.578	-0.000	2982870.153
Parametric	Female	0.000	1427088.300	-0.000	1393050.163	-0.000	1345857.058
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_FinalGPA_m3)	1.000	1.000	1.000	1.000	1.000	1.000

Note. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05

Table D-2. RQ4-ii – Logistic Regression Model for Any Postsecondary Technical Training Enrollment

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	-35.171	1874286.051	-7.271***	1.213	-49.859	39251.038
Parametric	HS_Dual_Credit	-1.141	1.251	0.786	1.048	20.644	28497.269
Parametric	FRL	-0.574	1.264	0.848	0.582	0.858	1.255
Parametric	White	28.525	1874286.051	-0.299	0.669	20.860	26993.071
Parametric	Hispanic	0.131	3153832.899	-33.354	2471986.777	-0.190	47369.806
Parametric	Female	-0.401	1.272	-0.261	0.551	-0.580	1.246
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_FinalGPA_m3)	1.004	1.008	1.005	1.009	1.865	2.376

Note. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05

Table D-3. RQ4-iii – Logistic Regression Model for Any Postsecondary Degree or Certification Earned

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	-2.826***	0.136	-2.734***	0.133	-3.133***	0.146
Parametric	HS_Dual_Credit	1.417***	0.113	1.369***	0.111	1.209***	0.120
Parametric	FRL	-0.075	0.051	-0.019	0.052	0.012	0.054
Parametric	White	0.553***	0.085	0.450***	0.083	0.663***	0.092
Parametric	Hispanic	0.353**	0.124	0.385**	0.120	0.656***	0.127
Parametric	Female	-0.155**	0.051	-0.327***	0.051	-0.225***	0.053
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_FinalGPA_m3)	1.003***	1.006	9.737**	11.352	1.006	1.011

Note. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05

Table D-4. RQ4-iv – Logistic Regression Model for Any Postsecondary Degree Earned

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	-5.369***	0.399	-5.253***	0.369	-7.263***	1.026
Parametric	HS_Dual_Credit	3.030***	0.381	2.146***	0.339	3.147**	1.003
Parametric	FRL	-0.228**	0.072	-0.149	0.092	-0.478**	0.151
Parametric	White	0.361**	0.122	0.476**	0.162	-0.042	0.215
Parametric	Hispanic	0.042	0.185	0.405	0.229	0.147	0.325
Parametric	Female	-0.167*	0.069	-0.233**	0.086	0.111	0.135
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_FinalGPA_m3)	8.811***	10.538	1.786***	2.256	2.181***	2.772

Note. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05

Table D-5. RQ4-v – Logistic Regression Model for Any Postsecondary Certification Earned

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	-3.027***	0.147	-2.723***	0.135	-3.251***	0.150
Parametric	HS_Dual_Credit	1.178***	0.116	1.241***	0.112	1.132***	0.121
Parametric	FRL	0.007	0.056	0.005	0.055	0.062	0.057
Parametric	White	0.721***	0.100	0.418***	0.087	0.725***	0.097
Parametric	Hispanic	0.485***	0.140	0.306*	0.127	0.691***	0.134
Parametric	Female	-0.359***	0.056	-0.472***	0.054	-0.269***	0.055
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_FinalGPA_m3)	4.286***	5.354	8.846***	10.452	2.205***	2.783

Note. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05

Table D-6. RQ4-vi – HLM for Postsecondary Total GPA

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	2.899***	0.034	2.894***	0.033	2.971***	0.031
Parametric	HS_Dual_Credit	0.048	0.028	0.048	0.026	0.082**	0.025
Parametric	FRL	-0.104***	0.018	-0.088***	0.017	-0.064***	0.016
Parametric	White	0.118***	0.025	0.153***	0.024	0.077***	0.023
Parametric	Hispanic	0.089*	0.038	0.160***	0.037	0.067	0.035
Parametric	Female	-0.132***	0.017	-0.128***	0.017	-0.078***	0.016
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_FinalGPA_m3)	6.205***	7.518	6.001***	7.278	6.118***	7.399
Smooth	s(SCHOOL_ID)	0.001	1.000	0.029	1.000	0.000	1.000

Note. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05

Table D-7. RQ4-vii – HLM for Postsecondary First Semester Total GPA

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	2.657***	0.073	2.728***	0.068	2.668***	0.071
Parametric	HS_Dual_Credit	-0.335***	0.057	-0.402***	0.053	-0.508***	0.057
Parametric	FRL	0.000	0.037	-0.013	0.035	-0.052	0.036
Parametric	White	0.036	0.052	0.099*	0.050	0.072	0.051
Parametric	Hispanic	0.146	0.080	0.136	0.076	0.228**	0.079
Parametric	Female	-0.080*	0.036	-0.032	0.034	0.036	0.035
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_FinalGPA_m3)	3.580***	4.468	3.482***	4.360	3.584***	4.472
Smooth	s(SCHOOL_ID)	0.639	1.000	0.690	1.000	0.002	1.000

Note. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05

Table D-8. RQ4-viii – HLM for Postsecondary Second Semester Total GPA

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	2.475***	0.078	2.440***	0.075	2.493***	0.075
Parametric	HS_Dual_Credit	-0.311***	0.062	-0.298***	0.058	-0.408***	0.059
Parametric	FRL	-0.034	0.040	-0.058	0.038	-0.105**	0.038
Parametric	White	-0.124*	0.056	-0.037	0.054	-0.057	0.054
Parametric	Hispanic	-0.009	0.086	0.092	0.083	0.107	0.083
Parametric	Female	-0.149***	0.039	-0.068	0.037	0.070	0.037
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_FinalGPA_m3)	3.780***	4.708	3.820***	4.765	3.686***	4.594
Smooth	s(SCHOOL_ID)	0.628	1.000	0.734	1.000	0.374	1.000

Note. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05

Table D-9. RQ4-ix – HLM for Postsecondary Total Credits Earned

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	60.002***	1.398	42.343***	1.015	25.365***	0.657
Parametric	HS_Dual_Credit	5.807***	1.072	5.341***	0.770	5.505***	0.517
Parametric	FRL	-9.021***	0.737	-4.841***	0.542	-3.336***	0.343
Parametric	White	-9.335***	1.061	-3.620***	0.753	-0.975*	0.478
Parametric	Hispanic	-3.981*	1.623	0.963	1.157	0.648	0.742
Parametric	Female	1.759*	0.732	2.567***	0.529	2.799***	0.335
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_FinalGPA_m3)	5.091***	6.305	4.877***	6.044	4.773***	5.918
Smooth	s(SCHOOL_ID)	0.015	1.000	0.489	1.000	0.010	1.000

Note. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05

Appendix E: Research Question 5 Regression Models

Table E-1. RQ5-i – Logistic Regression Model for Any Postsecondary Higher Education Enrollment

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	1.477***	0.074	1.479***	0.073	1.567***	0.073
Parametric	EOP_Pass	0.190***	0.057	0.298***	0.058	0.194***	0.054
Parametric	IND_Certified	0.162***	0.043	0.083	0.043	0.150***	0.043
Parametric	FRL	-0.404***	0.044	-0.398***	0.044	-0.280***	0.044
Parametric	White	-0.614***	0.066	-0.578***	0.063	-0.547***	0.064
Parametric	Hispanic	-0.198*	0.099	-0.144	0.097	-0.332***	0.095
Parametric	Female	0.510***	0.044	0.594***	0.044	0.467***	0.044
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_FinalGPA_m3)	3.561***	4.484	3.088***	3.898	4.221***	5.285

Note. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05

Table E-2. RQ5-ii – Logistic Regression Model for Any Postsecondary Technical Training Enrollment

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	-57.260	695093.909	-35.676	773104.604	-64.257	1532169.760
Parametric	EOP_Pass	-24.525	396854.505	-0.606	0.740	0.359	0.789
Parametric	FRL	-1.465	1.206	-0.053	0.396	-1.269	0.678
Parametric	White	24.527	639462.377	-0.144	0.553	27.983	1550147.363
Parametric	Hispanic	26.159	639462.377	-0.899	1.121	-0.526	2498051.295
Parametric	Female	0.318	1.051	-0.466	0.416	-0.509	0.691
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_FinalGPA_m3)	1.006	1.011	1.008	1.016	1.567	1.949

Note. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05

Table E-3. RQ5-iii – Logistic Regression Model for Any Postsecondary Degree or Certification Earned

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	-2.064***	0.091	-2.036***	0.089	-2.370***	0.100
Parametric	EOP_Pass	-0.565***	0.062	-0.528***	0.065	-1.039***	0.076
Parametric	IND_Certified	0.061	0.048	0.172***	0.049	0.237***	0.052
Parametric	FRL	-0.224***	0.049	-0.180***	0.050	-0.128*	0.053
Parametric	White	0.483***	0.083	0.374***	0.080	0.577***	0.090
Parametric	Hispanic	0.398***	0.121	0.423***	0.116	0.590***	0.125
Parametric	Female	0.036	0.049	-0.110*	0.049	-0.058	0.052
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_FinalGPA_m3)	2.424***	3.062	9.681***	11.458	2.790***	3.518

Note. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05

Table E-4. RQ5-iv – Logistic Regression Model for Any Postsecondary Degree Earned

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	-3.465***	0.229	-3.857***	0.186	-4.878***	0.424
Parametric	EOP_Pass	-0.303***	0.079	-0.376***	0.102	-0.837***	0.162
Parametric	IND_Certified	-0.116	0.068	-0.290***	0.086	-0.935***	0.138
Parametric	FRL	-0.329***	0.070	-0.267**	0.091	-0.530***	0.151
Parametric	White	0.391**	0.120	0.504**	0.161	0.020	0.215
Parametric	Hispanic	0.126	0.182	0.517*	0.226	0.308	0.320
Parametric	Female	0.008	0.068	-0.077	0.085	0.249	0.135
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_FinalGPA_m3)	9.128***	10.613	2.362***	2.995	3.436***	4.330

Note. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05

Table E-5. RQ5-v – Logistic Regression Model for Any Postsecondary Certification

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	-2.427***	0.105	-2.141***	0.093	-2.609***	0.106
Parametric	EOP_Pass	-0.565***	0.071	-0.530***	0.070	-1.051***	0.083
Parametric	IND_Certified	0.147**	0.053	0.289***	0.052	0.407***	0.055
Parametric	FRL	-0.156**	0.054	-0.164**	0.053	-0.094	0.055
Parametric	White	0.615***	0.098	0.326***	0.084	0.623***	0.096
Parametric	Hispanic	0.517***	0.137	0.333**	0.123	0.595***	0.131
Parametric	Female	-0.166**	0.054	-0.255***	0.052	-0.102	0.055
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_FinalGPA_m3)	4.116***	5.162	8.082***	9.812	2.733***	3.448

Note. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05

Table E-6. RQ5-vi – HLM for Postsecondary Total GPA

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	2.953***	0.028	2.926***	0.028	3.045***	0.026
Parametric	EOP_Pass	-0.024	0.019	-0.027	0.019	-0.044*	0.017
Parametric	IND_Certified	-0.029	0.017	0.025	0.017	0.013	0.016
Parametric	FRL	-0.103***	0.018	-0.089***	0.017	-0.068***	0.016
Parametric	White	0.125***	0.025	0.159***	0.024	0.085***	0.023
Parametric	Hispanic	0.094*	0.038	0.163***	0.037	0.070*	0.035
Parametric	Female	-0.130***	0.017	-0.129***	0.017	-0.077***	0.016
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_FinalGPA_m3)	6.197***	7.510	5.974***	7.247	6.124***	7.407
Smooth	s(SCHOOL_ID)	0.001	1.000	0.022	1.000	0.000	1.000

Note. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05

Table E-7. RQ5-vii – HLM for Postsecondary First Semester Total GPA

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	2.372***	0.060	2.338***	0.057	2.181***	0.059
Parametric	EOP_Pass	0.112**	0.041	0.233***	0.039	0.193***	0.039
Parametric	IND_Certified	-0.014	0.036	0.037	0.034	0.041	0.036
Parametric	FRL	0.002	0.037	-0.009	0.035	-0.043	0.037
Parametric	White	-0.007	0.052	0.046	0.049	0.023	0.051
Parametric	Hispanic	0.111	0.080	0.103	0.076	0.202*	0.080
Parametric	Female	-0.089*	0.036	-0.042	0.034	0.019	0.035
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_FinalGPA_m3)	3.555***	4.437	3.437***	4.305	3.591***	4.480
Smooth	s(SCHOOL_ID)	0.666	1.000	0.696	1.000	0.002	1.000

Note. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05

Table E-8. RQ5-viii – HLM for Postsecondary Second Semester Total GPA Cohort

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	2.215***	0.065	2.116***	0.063	2.125***	0.063
Parametric	EOP_Pass	0.102*	0.044	0.250***	0.042	0.121**	0.041
Parametric	IND_Certified	-0.022	0.038	0.066	0.037	0.005	0.037
Parametric	FRL	-0.032	0.040	-0.056	0.038	-0.097*	0.038
Parametric	White	-0.163**	0.056	-0.081	0.054	-0.095	0.054
Parametric	Hispanic	-0.042	0.086	0.061	0.083	0.087	0.083
Parametric	Female	-0.157***	0.039	-0.075*	0.037	0.057	0.037
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_FinalGPA_m3)	3.765***	4.690	3.800***	4.741	3.675***	4.581
Smooth	s(SCHOOL_ID)	0.646	1.000	0.739	1.000	0.361	1.000

Note. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05

Table E-9. RQ5-ix – HLM for Postsecondary Total Credits Earned

Type	Term	2021-2022 Estimate	2021-2022 SE	2022-2023 Estimate	2022-2023 SE	2023-2024 Estimate	2023-2024 SE
Parametric	(Intercept)	63.815***	1.164	46.671***	0.851	30.505***	0.539
Parametric	EOP_Pass	2.039*	0.838	0.455	0.613	-1.624***	0.378
Parametric	IND_Certified	-1.811*	0.714	-1.570**	0.519	-1.638***	0.333
Parametric	FRL	-8.852***	0.723	-4.925***	0.531	-3.381***	0.338
Parametric	White	-8.868***	1.037	-3.500***	0.736	-0.663	0.468
Parametric	Hispanic	-3.922*	1.588	0.856	1.139	1.135	0.729
Parametric	Female	2.277**	0.716	3.091***	0.518	3.104***	0.329
Type	**Term**	**edf**	**Ref.df**	**edf**	**Ref.df**	**edf**	**Ref.df**
Smooth	s(IC_FinalGPA_m3)	5.010***	6.212	4.952***	6.138	4.792***	5.944
Smooth	s(SCHOOL_ID)	0.011	1.000	0.330	1.000	0.004	1.000

Note. Statistical significance: '***' < 0.001 < '**' < 0.01 < '*' < 0.05