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Middle School Career Exploration Impact on High School CTE Outcomes

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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).

In previous years, HumRRO conducted studies examining the relationships between CTE programs, participation types, and post-secondary success (Mulolli et al., 2024; Mulolli et al., 2025). Those studies found that CTE participation benefits students' post-high school success. To provide a more holistic understanding of the program, this research study pivots from post-secondary success to investigating the critical role of middle school career exploration in shaping high school CTE outcomes. With the implementation of 704 KAR 3:305, mandating Individual Learning Plans (ILPs) beginning in 6th grade in the 2023-2024 school year, there is a unique opportunity to examine how early career exploration influences student pathways and achievement across all schools in Kentucky.

This study examined the relationship between middle school career exploration and high school CTE outcomes, including pathway progression, timing of entry, and achievement of key career readiness indicators such as End-of-Program (EOP) assessments, Industry Certifications, Work-Based Learning, and dual credit participation. The Research Questions (RQs) are as follows:

Primary Questions:

- RQ1: How does completion of middle school CTE courses (using MS CTE state course codes) impact End-of-Program (EOP) assessment and Industry Certification performance in high school?
- RQ2a: Do students who complete formal MS career exploration courses demonstrate greater pathway consistency compared to students who only complete ILP activities (e.g., Career Cruising)?
- RQ2b: Do students who complete formal MS career exploration courses achieve CTE concentrator status sooner compared to students who only complete ILP activities (e.g., Career Cruising)?
- RQ3: What is the relationship between early career exploration and achievement on multiple career readiness measures (EOP, Industry Certifications, Work-Based Learning, dual credit)?

Exploratory Questions:

- RQ4: At what grade levels do students typically begin CTE pathways, and how does this timing correlate with middle school career exploration experiences?
- RQ5: How does EOP/Industry Certification performance vary by grade level and attempt number, and is this influenced by prior middle school CTE exposure?
- RQ6: Do students with robust middle school career exploration more frequently engage in Work-Based Learning and dual credit opportunities?

Methods

For this study, we had data available from multiple academic years, specifically 2021-2022 through 2024-2025. While it would have been ideal to analyze earlier cohorts (e.g., 6th graders from 2021-2022) to track their progression through high school, we acknowledge that students who were 6th graders in 2021-22 were 9th graders in 2024-25, the last year of available data. Given that EOP exams are typically taken in 11th or 12th grade, we are still about 2 to 3 years away from observing meaningful outcome measures for these cohorts. Therefore, we decided to shift the analytic focus for this year's report to students who were in 8th grade in 2021-2022. This cohort reaches 11th grade by 2024-2025, making them the earliest group for which we can observe relevant EOP and Infinite Campus (IC) outcomes in the available datasets. This adjustment allowed us to produce more meaningful and timely insights.

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.

Table 1. KYSTATS Data Sources

Data Source	Data Source Description	Key Variables
IC_AnnualPerson:	Infinite Campus database of student categories	Academic_Year, SSID, Grade_Level, Race_Ethnicity, Gender, Birthyear, Diploma_Type, Diploma_Date, Final_GPA, Graduated_from_HS, Free_Reduced_Lunch_Indicator, Special_Ed_Flag, Gifted_Indicator, EL_Indicator, District_Number, School_Number
IC_Schools:	Infinite Campus database of school characteristics	Academic_Year, District_Number, School_Number, School_Name, School_District_Name, School_County, School_Type, State_Classification
KDE_Assessments:	Kentucky Department of Education database of student assessment records	Academic_Year, SSID, Assessment_Category, Assessment_Description, Scale_Score, Performance_Level
KDE_Courses:	Kentucky Department of Education database of student course enrollment records	Academic_Year, SSID, State_Course_Code, Grade_Level, Dual_Credit_Indicator, GPA_Weight, Core_Content_Code
TEDS_Enrollment:	Technical Education Database System database of CTE pathway enrollment	AcadYr, SSID, TEDS_CareerPathwayName, TEDS_CIPCodes, TEDS_ProgramLevel, TEDS_StudentObjective, TEDS_TerminationStatus, TEDS_EducationLevel, DistNo, CountyName

Table 1. (Continued)

Data Source	Data Source Description	Key Variables
TEDS_IndustryCerts:	Technical Education Database System database of industry certifications	AcadYr, SSID, TEDS_IndustryCertificate, TEDS_IndustryValid
TEDS_KOSSA:	Technical Education Database System database of Kentucky Occupational Skill Standards Assessment outcomes	AcadYr, SSID, TEDS_PassedIndicator, TEDS_SkillStandard
TEDS_Credentials	Technical Education Database System database of student credentials and diplomas earned	AcadYr, SSID, TEDS_Credential

Course Designations

For this study, CTE course records were compiled from multiple KDE sources and organized into four tiers reflecting the level and context of career and technical education engagement. The following tier designations were developed by HumRRO in collaboration with KDE staff and documented in IC_Courses (a master course classification file that serves as the primary crosswalk linking course codes to tiers across all analyses):

- Tier 1 captures formal middle school CTE career exploration through KDE-approved Middle School (MS) CTE courses spanning program areas such as Agriculture, Business and Marketing, Engineering Technology, Healthcare, and Family and Consumer Sciences, as well as a General Career Exploration category anchored by Career Choices 6-8.
- Tier 2 captures supplemental or non-CTE career exploration at the middle school level, including Experience-Based Work and the Student Technology Leadership Program (STLP). Courses in this Tier are used as indicators for the ILP.
- Tier 3 captures formal high school CTE pathway coursework drawn from the Kentucky Programs of Study directory and serves as the basis for Concentrator and Completer classification. Dual credit CTE participation is identified within Tier 3 using a dual credit flag in the enrollment records. Tier 3 enrollment is the operational definition of HS CTE participation in this study and serves as the primary pipeline outcome for RQ1 and RQ3.
- Tier 4 captures accountability-eligible Work-Based Learning at the high school level, consisting of approved CTE co-op and internship courses identified from the Kentucky Accountability Eligible Work-Based Learning Course Codes List. These courses are distinct from the non-CTE Experience-Based Work option and are tied to specific HS CTE program areas.

Analysis Models

We ran several analytic models to address the outcomes within each research question. Each model included one or two predictor variables for group comparisons, control variables to account for student-level characteristics, and one or more outcome variables. Given the nature of the research questions and the varying measurement levels of the outcomes, we applied different modeling approaches across the six research questions.

Propensity Score Analysis

We statistically matched CTE to non-CTE students using the Propensity Score Matching (PSM) technique to answer the first and second research questions. 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 include:

- **Reading Achievement Scores:** Scale scores in reading for the assessment students took in 7th grade, using Kentucky Summative Assessment (KSA) scores, given that our focal sample was 8th-grade students in academic year 2021-2022.
- **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).
- **Free_Reduced_Lunch_Indicator:** Student eligible for free or reduced lunch (e.g., 1= FRL Eligible vs 0 = Non-FRL Eligible).
- **EL_Indicator:** English Language Learner (ELL) student (e.g., 1 = English Learner vs. 0 = Not English Learner).
- **Special_Ed_Flag:** 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 0.05 on the propensity score scale, meaning that potential matches were considered valid only if the absolute difference in propensity scores between CTE and non-CTE students was no greater than 0.05, thereby discarding poor matches that exceeded this threshold.

Before matching, each research question exhibited somewhat different covariate imbalances, reflecting their distinct comparison groups. For RQ1 and RQ2b, which share the same treatment and comparison pools, the most notable pre-matching differences were demographic: White student representation (d = -0.106), female representation (d = -0.103), and FRL eligibility (d = 0.109), while baseline reading scores were nearly identical (d = 0.010). In practical terms, this means that before matching, the MS CTE group had proportionally more non-White and male students, and a higher rate of free or reduced-price lunch eligibility, than the non-CTE comparison group, suggesting the two groups were not directly comparable on these characteristics prior to adjustment. For RQ2a, which used a smaller, distinct comparison group of ILP-only students (n = 559), imbalances were generally smaller, with the largest differences in female representation (d = -0.109) and White representation (d = 0.088). Put simply, the MS

CTE group had somewhat fewer female and White students than the ILP-only comparison group before matching, though these differences were modest. Because each research question involves a different comparison (MS CTE vs. no CTE/ILP, MS CTE vs. ILP only, and MS CTE vs. no CTE/ILP with timing moderators), separate matching procedures were conducted for each to ensure that covariate balance was appropriate to that specific contrast thus effectively creating more comparable groups before estimating program effects.

After matching, covariate balance improved substantially for RQ1 and RQ2b, with all Cohen's d values falling well below the conventional 0.1 threshold, ranging from near zero (EL status: d = 0.002) to at most 0.087 for White representation. Pre-matching demographic imbalances in FRL, gender, and EL status were largely eliminated. RQ2a told a different story. Despite matching, several covariates remained notably imbalanced, including White representation (d = -0.237), FRL eligibility (d = -0.276), EL status (d = 0.238), and special education status (d = 0.199). These residual imbalances likely reflect the small sample size (n = 559 per group), limiting the matching algorithm's ability to find well-matched pairs. Results from RQ2a should therefore be interpreted with caution, as remaining differences between MS CTE and ILP-only students may confound the estimated effects.

Predictor Variables

The research questions examined in this study focus on the relationship between middle school (MS) career and technical education (CTE) exposure and subsequent high school (HS) CTE engagement and credential attainment outcomes. Research Questions 1 through 3 compare students with and without MS CTE exposure (Tier 1 completers versus matched comparison groups). Research Questions 4 and 5 focus on timing and performance patterns within the CTE pipeline. Research Question 6 examines the relationship between the breadth of MS career exploration and HS engagement outcomes. Below, we describe each of the predictor variables. In parentheses, we include the data sources used to generate these predictors in bolded text.

Primary Treatment and Exposure Variables

- **CTE_Treat** (**TEDS_Enrollment**): Binary indicator identifying whether a student completed a Tier 1 MS CTE course in 8th grade during the 2021-2022 academic year.
  - *MS CTE (Treatment)*: Student completed at least one Tier 1 MS CTE course.
  - *No MS CTE (Comparison)*: Student has no record of Tier 1 MS CTE completion.
  - This variable serves as the primary treatment indicator for RQ1 and the RQ2b comparison (Tier 1 vs. Neither). Students were matched 1:1 on demographic and academic characteristics using propensity score matching prior to analysis as described above.

- **MS_CTE_Group** (**TEDS_Enrollment**): Three-category group indicator used to operationalize the RQ2 design.
  - *Tier 1 MS CTE*: Student completed at least one Tier 1 MS CTE course in 8th grade.
  - *Tier 2 ILP only*: Student completed an ILP or other Tier 2 career exploration activity but no Tier 1 CTE course.
  - *Neither*: Student has no record of Tier 1 or Tier 2 MS career exploration activity.
  - RQ2 was implemented as two matched binary comparisons: RQ2a (Tier 1 vs. Tier 2) and RQ2b (Tier 1 vs. Neither).

- **Any_Tier1** (**TEDS_Enrollment**): Binary indicator used in RQ3, RQ4, and RQ6 as a continuous-variable supplement and in unmatched descriptive analyses.
- **Any_Tier2** (**TEDS_Enrollment**): Binary indicator for ILP or other Tier 2 career exploration activity.

Pathway and Timing Variables

- **Cluster_Consistent** (**TEDS_Enrollment**): Binary indicator for whether a student who completed MS CTE (Tier 1) subsequently enrolled in HS CTE (Tier 3) within the same career cluster.
- **MS_Career_Cluster** (**TEDS_Enrollment**): The career cluster associated with a student's MS Tier 1 CTE course record. Defined as the most frequently occurring program area among all Tier 1 courses taken.
- **Earliest_Tier1_Grade** (**TEDS_Enrollment, IC_AnnualPerson**): The lowest grade level at which a student first appears in a Tier 1 MS CTE course record. Used as a continuous predictor in RQ4 to examine whether earlier MS CTE entry predicts earlier HS CTE entry.
- **Earliest_Tier3_Grade** (**TEDS_Enrollment, IC_AnnualPerson**): The lowest grade level at which a student first appears in a Tier 3 HS CTE course record. Used as the primary outcome variable in RQ4 timing models.
- **Earliest_Tier2_Grade** (**TEDS_Enrollment, IC_AnnualPerson**): The lowest grade level at which a student first appears in a Tier 2 ILP or career exploration record. Used as the secondary predictor in RQ4 Tier 2 x Tier 3 timing correlations.
- **N_Tier1_Courses** (**TEDS_Enrollment**): Count of distinct Tier 1 MS CTE courses completed by a student. Used as a secondary predictor in RQ6 to examine whether completing more MS CTE courses is associated with higher rates of WBL and dual credit engagement.
- **MS_CTE_prior** (**TEDS_Enrollment, linked to TEDS_KOSSA**): Binary indicator appended to the EOP attempt-level file, indicating whether the student who submitted a given EOP attempt had any prior Tier 1 MS CTE completion. Used as the primary moderator in RQ5 grade-level EOP pass rate models.

EOP and Credential Variables

- **Grade_Numeric** (**TEDS_KOSSA, IC_AnnualPerson**): Numeric grade level at the time of each EOP attempt (range 9–12). Used in RQ5 to construct grade-level pass rate models and to document selection into early versus mandatory testing. The primary RQ5 model (Model B) restricted analysis to grades 10 and 11 to avoid small-sample selection at grade 9 and the structural anomaly at grade 12 (see RQ5 for details).
- **Attempt_Number** (**TEDS_KOSSA**): Sequential attempt number for each student-EOP pathway combination. The primary RQ5 analysis used only first attempts to avoid confounding grade-level effects with retake behavior.

- **District_Policy** (**TEDS_KOSSA, derived**): Categorical variable describing the district's observed EOP testing pattern.
  - *Senior mandatory*: District shows EOP attempts concentrated in grade 12.
  - *Multi-grade*: District shows EOP attempts distributed across grades 10-12.
- **EOP_Program_Area** (**TEDS_KOSSA**): Program area associated with each EOP attempt.

Control Variables

Prior research indicates that socioeconomic status, disability status, English language proficiency, sex, and race or ethnicity are associated with CTE participation and postsecondary outcomes (Princiotta et al., 2014). We included the following demographic and academic variables as controls in all inferential models to isolate the relationship between MS CTE exposure and the outcomes of interest. These variables were sourced from IC_AnnualPerson administrative records.

- **FRL**: Binary indicator of whether a student qualifies for free or reduced-price lunch. Used as a socioeconomic status proxy in all RQ1-RQ6 models.
- **IC_SpecialEducation**: Binary indicator of whether a student has an active Individualized Education Program (IEP) classification. Included to account for differential CTE access and outcome patterns among students receiving special education services.
- **IC_EL**: Binary indicator of English Learner classification. Included because English Learners may face distinct barriers to CTE enrollment, EOP testing, and credential attainment independent of MS CTE exposure.
- **Female**: Binary indicator of student sex (1 = female, 0 = male). Included because gender is associated with CTE pathway selection and concentrator rates.
- **nonWhite**: Binary indicator of whether a student identifies as a racial or ethnic group other than non-Hispanic White. Included to account for documented disparities in CTE access and postsecondary outcomes.
- **RD_Scale_Score**: Student's reading scale score from the most recent available state assessment prior to the analysis window.

Outcome Variables

All research questions reference CTE pipeline engagement and credential attainment outcomes for the 8th-grade 2021-2022 cohort, tracked through the 2024-2025 academic year. We define each outcome below. Outcomes for which the cohort has not yet reached the mandatory testing or graduation window are identified as *deferred* and will be analyzed in the future planned studies with 2025-2026 data.

Primary Observable Outcomes (Current Cohort: Grade 11 in 2024-2025)

- **Outcome_Tier3 / Any_Tier3** (**TEDS_Enrollment**): Binary indicator of whether a student enrolled in at least one Tier 3 HS CTE course at any point through 2024-2025.
- **Outcome_Concentrator / Ever_Concentrator** (**TEDS_Enrollment**): Binary indicator of whether a student achieved CTE concentrator status (completion of two courses within a single HS program of study) at any point through 2024-2025.

- **Years_to_Concentrator** (**TEDS_Enrollment, IC_AnnualPerson**): Continuous variable measuring the number of academic years elapsed between a student's first Tier 3 HS CTE enrollment and the year in which they first achieved concentrator status.
- **Timing_Flag** (**TEDS_Enrollment, IC_AnnualPerson**): Categorical variable describing when a student first achieved concentrator status relative to their high school enrollment year.
- **Outcome_Tier4 / Any_Tier4** (**TEDS_Enrollment**): Binary indicator of whether a student participated in any Work-Based Learning (WBL) activity (Tier 4 CTE) through 2024-2025.
- **Outcome_Dual_Credit / Any_Dual_Credit_CTE** (**IC_Courses**): Binary indicator of whether a student earned dual credit in a CTE course through 2024-2025.
- **Pass_Flag** (**TEDS_KOSSA**): Binary indicator of whether a student passed an EOP assessment on a given attempt.

Analytical Models

Depending on the outcome variable, we applied different analytic models:

- Primary analyses for RQ1 and RQ2 used Generalized Linear Mixed Models (GLMM) to account for the nested structure of students within middle schools. A random intercept was estimated for each MS school; Intraclass Correlation Coefficients (ICC) values of 0.12-0.14 across outcomes confirmed that the multilevel structure was warranted. HS school ICC was approximately 0.58, reflecting structural variation in program availability rather than meaningful student-level clustering, and was therefore not included as a grouping variable. Binary outcomes are reported as odds ratios (OR) with 95% profile likelihood confidence intervals.
- RQ2 also included a continuous outcome, time to concentrator status (Years_to_Concentrator), analyzed using a Linear Mixed Model (lmer) with a random intercept for MS school, estimated via Restricted Maximum Likelihood (REML). This model was restricted to students who achieved concentrator status. Coefficients are expressed in years; narrative summaries additionally convert these to months (multiplied by 12). Kruskal-Wallis tests were run as nonparametric robustness checks for each comparison.
- The primary analysis for RQ3 used the McNemar test, which is well-suited for matched-pair designs because it focuses exclusively on discordant pairs, those in which the two matched students had different outcomes. Results are reported as odds ratios and chi-square statistics. As a supplemental check, a logistic regression model with demographic controls was estimated to confirm that matched results held after accounting for student characteristics. Supplemental Tier 2 analyses, which involve unmatched comparisons, used standard logistic regression, with results reported as odds ratios with 95% confidence intervals.
- RQ4 examined the relationship between MS and HS CTE entry grades using two complementary approaches. Spearman's rank correlation served as the primary method for quantifying the association between these ordinal variables; Kendall's tau was computed as a robustness check, given the heavy ties expected from discrete grade-level data. Ordinary Least Squares (OLS) regression was used to model HS CTE entry

grade as a function of MS CTE entry grade (continuous) and a binary indicator for any Tier 1 participation.

- Grade-level models in RQ5 used logistic regression for binary outcomes in an unmatched design. Results are reported as odds ratios with 95% confidence intervals.
- Models examining work-based learning (WBL) and dual credit outcomes in RQ6 used logistic regression for binary outcomes. Results are reported as odds ratios with 95% confidence intervals.

Results

Descriptive Statistics

The analytic sample consists of 53,318 students enrolled in 8th grade during the 2021-2022 academic year. As shown in Table 2, approximately 55% of the cohort completed at least one Tier 1 MS CTE course, and the majority (77.5%) subsequently enrolled in HS CTE. Just over half (53.6%) achieved concentrator status. Work-based learning and dual credit participation were relatively rare, at 0.6% and 1.5%, respectively. Credential outcomes, including EOP pass rates, Industry Certification attainment, and any credentials, are reported descriptively in Table 2 but are deferred from formal analysis, as the cohort was in 11th grade during the 2024-2025 data pull and had not yet reached the mandatory senior-year EOP testing window. The cohort includes nearly 70% who qualify for free or reduced-price lunch, 14.4% who receive special education services, and 4.0% who are classified as English Learners.

Table 2. MS CTE Exposure, HS CTE Pipeline, and Outcome Frequencies for the 8th-Grade 2021-2022 Cohort

Variable / Category	N (%)
Total N	**53,318**
MS CTE Exposure	
Tier 1 MS CTE (any)	29,131 (54.6%)
Tier 2 ILP/Exploration only (no Tier 1)	681 (1.3%)
Both Tier 1 and Tier 2	1,198 (2.2%)
Neither Tier 1 nor Tier 2	23,506 (44.1%)
HS CTE Pipeline Outcomes	
Enrolled in HS CTE (Tier 3)	41,338 (77.5%)
Achieved CTE Concentrator Status	28,603 (53.6%)
Consistent MS-to-HS Pathway[1] (among Tier 1 students)	1,702 (7.4%)
Work-Based Learning and Dual Credit	
Participated in Work-Based Learning (Tier 4)	340 (0.6%)
Earned Dual Credit CTE	792 (1.5%)
WBL or Dual Credit (either)	1,106 (2.1%)

Table 2. (Continued)

Variable / Category	N (%)
Credential Outcomes [2] [Deferred - Cohort in grade 11]	
Passed at least one EOP assessment	7,739 (14.5%)
Earned at least one Industry Certification	12,093 (22.7%)
Any credential (EOP pass or IC)	17,468 (32.8%)
Attempted EOP (early, voluntary)	12,060 (22.6%)
Cohort Status as of 2024-25	
Confirmed graduated	156 (0.3%)
Currently enrolled (not yet graduated)	37,001 (69.4%)
Reached 12th grade or graduated	835 (1.6%)
Student Characteristics (Control Variables)	
Free or Reduced-Price Lunch (FRL)	37,043 (69.5%)
Special Education	7,696 (14.4%)
English Learner	2,122 (4.0%)
Female	25,974 (48.7%)
Non-White	14,371 (27.0%)

[1] Consistent MS-to-HS Pathway percentage is calculated among Tier 1 students with both MS and HS CTE records and non-missing cluster data.

[2] Deferred outcomes reflect early voluntary activity only. The cohort was in 11th grade during the 2024-25 data pull. Kentucky EOP policy requires testing in senior year. Full analysis deferred to 2025-26.

Research Question 1

RQ1: How does completion of middle school CTE courses (using MS CTE state course codes) impact End-of-Program (EOP) assessment and Industry Certification performance in high school?

RQ1 examines whether completing CTE courses in middle school predicts high school CTE enrollment and concentrator status, while controlling for student-level characteristics. The model below was estimated separately for each outcome using a GLMM with a logit link and a random intercept for middle school, accounting for the clustering of students within schools:

$$logit(P(OUTCOME_{ij} = 1)) = \beta_0 + \beta_1(MS\_CTE)_{ij} + \beta_{02}(FRL)_{ij} + \beta_3(SpecialEducation)_{ij} + \beta_4(EL)_{ij} + \beta_5(Female)_{ij} + \beta_6(nonWhite)_{ij} + u_{0j}$$

In this model, the outcome for each student is predicted by whether they completed middle school CTE courses, along with a set of student background characteristics included as controls: eligibility for free or reduced-price lunch (used as a proxy for low household income), special education status, English learner status, sex, and race or ethnicity. The model also accounts for the fact that students attended different middle schools, given that students within the same school tend to be more similar to each other than to students in other schools.

Therefore, the model allows each school to have its own baseline, rather than assuming all schools are identical. The primary coefficient of interest is the one associated with middle school CTE completion, which indicates whether completing CTE in middle school is associated with higher or lower odds of the outcome, after controlling for all other factors.

Two primary outcomes were examined. The first is HS CTE Enrollment, which captures whether the student enrolled in at least one high school CTE course. The second is CTE Concentrator Status, which captures whether the student completed enough CTE coursework in a focused career pathway to be classified as a CTE concentrator, which is a key milestone indicating meaningful CTE engagement. Two additional outcomes, including EOP assessment performance and Industry Certification (IC) attainment, were measured but are considered preliminary at this stage.

Regarding EOP assessment requirements, it is important to note that a student who has reached concentrator status is required to attempt either a CTE EOP Assessment or an Industry Certification prior to graduation. Specifically, a student must test in a CTE EOP Assessment in 12th grade if they have not previously tested in an EOP and are not planning to attain an Industry Certification before graduation. Additionally, it may be in the best interest of both the student and the school for a student to reattempt an EOP or Industry Certification if they previously tested but did not meet the benchmark. Because this cohort is currently in 11th grade (2024-25), full results on these outcomes will not be available until the 2025-26 school year. Early signals are reported here, but formal analysis of EOP and IC outcomes is deferred until complete data are available.

Table 3 presents the outcome rates and basic characteristics for the treatment and comparison groups across the matched sample of 37,622 students. Table 4 presents the Absolute Risk Differences (ARD) between groups for the two primary outcomes. Table 5 presents the inferential analysis results.

The results showed that students who completed CTE in middle school enrolled in high school CTE courses at a rate of 80.3%, compared to 77.0% for students without middle school CTE, a difference of 3.3 percentage points (Tables 3 and 4). While 3.3 percentage points may sound modest, it translates to a practically meaningful effect: for every 30 middle school CTE students, one additional student enrolled in high school CTE who otherwise would not have. Across a statewide cohort of nearly 19,000 students, this represents hundreds of additional students staying on a CTE pathway.

Table 3. Outcome Rates by Treatment Group (8th-Grade 2021-22 Matched Cohort)

Group	N	HS CTE (%)	Concentrator (%)	Years to Concentrator	EOP (%)	IC (%)	Graduation (%)
No MS CTE (Comparison)	18,812	77.0	54.6	1.13	14.5	23.6	1.7
MS CTE (Treatment)	18,812	80.3	58.3	1.14	17.7	24.8	1.5

Note. HS CTE = enrolled in any HS CTE course. Concentrator = ever achieved CTE concentrator status. EOP and IC rates are early/partial. Graduation = confirmed graduation. Graduation rates reflect early or accelerated completers only; the cohort is not expected to reach standard graduation rates until 2025-26.

Table 4. Absolute Risk Differences Between Treatment and Comparison Groups

Outcome	Comparison (%)	Treatment (%)	ARD (pp)	NNT	Direction
HS CTE Enrollment	77.0	80.3	3.3	30	Favors Treatment
CTE Concentrator Status	54.6	58.3	3.8	26	Favors Treatment

Note. ARD = absolute risk difference in percentage points (Treatment % − Comparison %). NNT = number needed to treat (100 / |ARD|, rounded). Positive ARD favors the MS CTE group.

The statistical model confirmed this finding. After accounting for student demographics and the middle schools attended, middle school CTE students had 18.5% higher odds of enrolling in high school CTE than their matched peers (OR = 1.185, $p < .001$; Table 5). The finding was stable across model specifications and school samples, supporting confidence in its robustness (see Appendix A, Table A-2 for robustness results).

The effect was even more pronounced for concentrator status. Students who completed middle school CTE achieved concentrator status at a rate of 58.3%, compared to 54.6% among their matched peers, a difference of 3.8 percentage points (Table 4). Statistically, middle school CTE students had 18.1% higher odds of becoming a CTE concentrator (OR = 1.181, $p < .001$), after adjusting for demographics and school context (Table 5). This means, for every 26 middle school CTE students, one additional student reached concentrator status who otherwise would not have.

Table 5. GLMM Treatment Effect Models (M1 Unadjusted, M2 Adjusted) - Fully Matched Sample

Outcome	Model	OR	95% CI	ICC	# of Students	# of MS Schools
HS CTE Enrollment	M1: Unadjusted	1.188***	[1.12, 1.26]	0.1204	37,622	169
HS CTE Enrollment	**M2: Adjusted**	**1.185*** **	**[1.12, 1.25]**	**0.1185**	**37,622**	**169**
CTE Concentrator Status	M1: Unadjusted	1.176***	[1.12, 1.23]	0.1426	37,622	169
CTE Concentrator Status	**M2: Adjusted**	**1.181*** **	**[1.13, 1.24]**	**0.1399**	**37,622**	**169**

Note. Random intercept for MS school (8th-grade 2021-22). M2 is the primary model (bold rows). M1 includes treatment only. M2 adds FRL, special education, EL, sex, and race. OR = odds ratio. 95% CI in brackets. ICC = intraclass correlation (MS school). Significance: *** $p < .001$ ** $p < .01$ * $p < .05$. $p < .10$.

Among students who completed middle school CTE, we also examined whether it made a difference if their high school CTE coursework was in the same career cluster as their middle school CTE experience (pathway consistency). The descriptive results (Appendix A, Table A-1) show that students who stayed in the same career cluster from middle to high school had the highest rates of concentrator status (62.3%) and credential attainment (43.1%). However, this group is notably small since only 1,112 students out of over 18,000 middle school CTE completers maintained a consistent cluster pathway. The inferential model for pathway consistency found that pathway-consistent students had 16.1% higher odds of achieving

concentrator status compared to pathway-inconsistent students (OR = 1.161, p = .027), after adjusting for demographics and school context (Appendix A, Table A-1).

To assess the robustness of the primary findings, the analysis was repeated using only the 108 of 169 middle schools in the matched sample that included both CTE and non-CTE students, and schools where CTE participation varied among students within the same building (34,013 students). This approach provides the most conservative test of the treatment effect because it rules out the possibility that school-level differences, such as school resources or geography, are driving the results rather than CTE participation itself. The results were virtually identical to the full-sample estimates (Appendix A, Table A-2): for HS CTE Enrollment, the odds ratio was 1.185 in both the full and restricted samples; for Concentrator Status, the odds ratio was 1.181 in the full sample and 1.192 in the restricted sample. The consistency of these results across samples strengthens our confidence that the observed relationship between middle school CTE and high school CTE outcomes is not a product of school-level selection or structural differences between schools.

EOP and Industry Certification: Early Signals

The first research question also asked about EOP assessments and Industry Certification (IC) attainment. These are the highest-stakes outcomes of CTE participation, demonstrating that students mastered the content and earned a recognized credential beyond simply enrolling in the program. At this stage, these outcomes cannot be fully evaluated. EOP testing is a required 12th-grade milestone, and the cohort being tracked (8th graders in 2021-22) is currently in 11th grade during the 2024-25 school year. Most students in this cohort have not yet had the opportunity to take their EOP assessments under standard conditions.

That said, early signals are encouraging (Table 4). The EOP pass rate based on early and partial data was 17.7% in the MS CTE group, compared with 14.5% in the comparison group, a difference of 3.2 percentage points. The Industry Certification rate was 24.8%, up from 23.6%, a difference of 1.2 percentage points. The rate of any credential earned was 36.9% versus 33.6%, a difference of 3.3 percentage points. Additionally, 26.4% of MS CTE students voluntarily attempted an EOP before their senior year, compared to 22.7% of comparison students. Because the cohort has not yet completed their senior year, formal causal analysis of EOP and IC outcomes is deferred to the 2025-26 data cycle, when the cohort will have had a full opportunity to complete these assessments.

Note on School-Level Clustering: The ICC in these models ranged from 0.10 to 0.14, indicating that approximately 10-14% of the variation in outcomes is attributable to differences between middle schools. This confirms that accounting for the school students attended was an important methodological choice, given that students within the same school tend to have more similar outcomes than students across different schools. The GLMM framework appropriately accounts for this structure.

Research Question 2

RQ2: Do students who complete formal MS career exploration courses demonstrate greater pathway consistency and achieve CTE concentrator status sooner than those who only complete ILP activities (e.g., Career Cruising)?

Two sub-analyses were conducted to address RQ2. RQ2a compares Tier 1 students (MS CTE completers) to Tier 2 students (ILP-only), examining whether formal CTE coursework in middle

school produces stronger outcomes than career exploration activities alone. RQ2b compares Tier 1 students with those who have neither a CTE nor an ILP record, providing a broader baseline. Both sub-analyses use the same model structure and outcomes, which are as follows:

$$logit(P(OUTCOME_{ij} = 1)) = \beta_0 + \beta_1(MS\_CTE)_{ij} + \beta_{02}(FRL)_{ij} + \beta_3(SpecialEducation)_{ij} + \beta_4(EL)_{ij} + \beta_5(Female)_{ij} + \beta_6(nonWhite)_{ij} + u_{0j}$$

For the concentrator timing outcome, a Linear Mixed Model (LMM) was estimated using the same covariate structure and random intercept, with years to concentrator status as the continuous outcome. In this model, β_1 represents the difference in years to concentrator status associated with group membership after adjusting for all other terms. A negative coefficient indicates that the treatment group achieved concentrator status sooner. The model was also checked using a Kruskal-Wallis non-parametric test to confirm the direction and significance of the timing result. All other terms in both models are defined as in RQ1 above.

Table 6 presents descriptive outcome rates across the three groups. Table 7 presents the absolute risk differences for the two primary comparisons.

Table 6. Outcome Rates by MS CTE Group: 8th-Grade 2021-22 Cohort

Group	N	Concentr. (%)	Mean Yrs to Conc.	Conc. by 9th (%)	Conc. by 10th (%)	Path. Consist. (%)	HS CTE (%)
Tier 1: MS CTE	18,812	58.3	1.14	10.4	40.7	5.9	80.3
Tier 2: ILP Only	559	52.2	0.99	12.7	41.0		82.6
Neither	18,812	54.6	1.13	10.8	38.4		77.0

Note. Tier 1 = MS CTE completers. Tier 2 = ILP-only students. Neither = no MS CTE or ILP record. Concentr. = ever achieved CTE concentrator status. Mean Yrs to Conc. calculated among concentrators only. Path. Consist. = HS CTE cluster matched MS CTE cluster (Tier 1 students only). HS CTE = enrolled in any Tier 3 HS CTE course.

Table 7. Absolute Risk Differences - Tier 1 vs Tier 2 and Tier 1 vs Neither

Comparison	Outcome	Treatment (%)	Comparison (%)	ARD (pp)	NNT	Direction
Tier 1 vs Tier 2	CTE Concentrator	56.9	52.2	4.7	22	Favors Tier 1
Tier 1 vs Neither	CTE Concentrator	58.3	54.6	3.8	27	Favors Tier 1
Tier 1 vs Tier 2	HS CTE Enrollment	81.8	82.6	-0.9	112	Favors Comparison
Tier 1 vs Neither	HS CTE Enrollment	80.3	77.0	3.3	30	Favors Tier 1

Note. ARD = absolute risk difference in percentage points (Tier 1 % - Comparison %). Positive ARD favors Tier 1 (MS CTE completers). NNT = number needed to treat (1 / |rate difference|, rounded).

RQ2a: MS CTE Completers vs. ILP-Only Students

The Tier 2 (ILP-only) group in RQ2a was notably small, comprising only 559 students compared to 18,812 in the Tier 1 group. This imbalance should be kept in mind when interpreting the

RQ2a results, as the limited sample size reduces statistical power and may produce unstable estimates.

In terms of concentrator status, Tier 1 students in RQ2a achieved concentrator status at a rate of 56.9%, compared to 52.2% for Tier 2 students, a difference of 4.7 percentage points (Table 6). However, the inferential model did not find a statistically significant difference between the two groups after adjusting for demographics and school context (OR = 1.243, p = .117; Table 7a). This means that while the descriptive gap is directionally consistent with the hypothesis, it does not meet conventional thresholds for statistical significance, likely in part because the Tier 2 group is small.

For HS CTE enrollment in RQ2a, Tier 2 students had a slightly higher enrollment rate than Tier 1 students (82.6% vs. 81.8%), though this difference of -0.9 percentage points is negligible and was not statistically significant (OR = 0.916, p = .611; Table 8a). There is no meaningful difference between the two groups on this outcome.

The RQ2a timing analysis produced a somewhat unexpected finding. Among students who achieved concentrator status, Tier 1 students took on average 1.9 months longer to reach that milestone than Tier 2 students (b = 0.160 years, p = .007; Appendix B, Table B-1). This finding was confirmed by the Kruskal-Wallis test (χ^2 = 7.663, p = .006). However, this result warrants cautious interpretation given the small Tier 2 sample in RQ2a.

Table 8a. GLMM Binary Outcome Models - Tier 1 (MS CTE) vs Tier 2 (ILP Only)

Outcome	Model	OR	95% CI	ICC	# of Students	# of MS Schools	N Outcome = 1
CTE Concentrator	M1: Unadjusted	1.244	[0.96, 1.62]	0.06	1,118	112	610
CTE Concentrator	**M2: Adjusted**	**1.243**	**[0.95, 1.63]**	**0.06**	**1,118**	**112**	**610**
HS CTE Enrollment	M1: Unadjusted	0.919	[0.66, 1.27]	0.04	1,118	112	919
HS CTE Enrollment	**M2: Adjusted**	**0.916**	**[0.66, 1.28]**	**0.04**	**1,118**	**112**	**919**

Note. Random intercept for MS school (8th-grade 2021-22). M2 is the primary model (bold rows). M1 = treatment only. M2 adds FRL, special education, EL, sex, and race. OR = odds ratio. 95% CI in brackets. ICC = intraclass correlation (MS school). N Outcome = 1 = students with outcome present. Significance: *** p < .001 ** p < .01 * p < .05 . p < .10.

RQ2b: MS CTE Completers vs. Students with No Record

The RQ2b comparison between Tier 1 students and students with neither a CTE nor ILP record largely mirrors the RQ1 findings, as the Neither group corresponds to the matched comparison group used in RQ1. Tier 1 students in RQ2b achieved concentrator status at a rate of 58.3%, compared to 54.6% for the Neither group, a difference of 3.8 percentage points (Table 7). After adjusting for demographics and school context, Tier 1 students had 18.1% higher odds of achieving concentrator status (OR = 1.181, p < .001; Table 8b). For HS CTE enrollment, Tier 1 students had an enrollment rate of 80.3% compared to 77.0% for the Neither group, a difference of 3.3 percentage points, with Tier 1 students showing 18.5% higher odds of enrollment after adjustment (OR = 1.185, p < .001; Table 8b).

The RQ2b timing analysis did not find a statistically significant difference in years to concentrator status between Tier 1 and Tier 2 students (b = 0.014, p = .164; Appendix B, Table B-1), indicating that while MS CTE students were more likely to achieve concentrator status overall, they did not reach that milestone meaningfully sooner than students with no CTE or ILP record. The Kruskal-Wallis test produced a marginally non-significant result in the same direction ($\chi^2 = 3.196$, p = .074).

Table 8b. GLMM Binary Outcome Models - Tier 1 (MS CTE) vs Neither

Outcome	Model	OR	95% CI	ICC	# of Students	# of MS Schools	N Outcome = 1
CTE Concentrator	M1: Unadjusted	1.176***	[1.12, 1.23]	0.12	37,622	169	21,235
CTE Concentrator	**M2: Adjusted**	**1.181*** **	**[1.13, 1.24]**	**0.14**	**37,622**	**169**	**21,235**
HS CTE Enrollment	M1: Unadjusted	1.188***	[1.12, 1.26]	0.12	37,622	169	29,595
HS CTE Enrollment	**M2: Adjusted**	**1.185*** **	**[1.12, 1.25]**	**0.12**	**37,622**	**169**	**29,595**

Note. Random intercept for MS school (8th-grade 2021-22). M2 is the primary model (bold rows). M1 = treatment only. M2 adds FRL, special education, EL, sex, and race. OR = odds ratio. 95% CI in brackets. ICC = intraclass correlation (MS school). N Outcome = 1 = students with outcome present. Significance: *** p < .001 ** p < .01 * p < .05 . p < .10.

Pathway Consistency

Among Tier 1 students, pathway consistency (defined as the student's high school CTE career cluster matching their middle school CTE career cluster) remained low across both RQ2a and RQ2b. In RQ2a, 4.1% of Tier 1 students maintained a consistent pathway (23 of 556 students). In RQ2b, 5.9% did so (1,112 of 18,724 students). These rates suggest that, as shown in RQ1, while pathway consistency is associated with stronger outcomes, it remains relatively uncommon in practice, and the middle-to-high school CTE pipeline does not yet produce consistent cluster alignment for most students (Appendix B, Table B-2).

Note on School-Level Clustering: The intraclass correlation coefficients in the RQ2b models ranged from 0.12 to 0.14, consistent with the RQ1 findings and confirming the importance of accounting for school-level clustering. ICC values in the RQ2a models were notably lower (0.04-0.06), which may reflect the smaller, more geographically concentrated nature of the ILP-only group.

Research Question 3

RQ3: What is the relationship between early career exploration and achievement on multiple career readiness measures (EOP, Industry Certifications, Work-Based Learning, dual credit)?

RQ3 examines the relationship between early career exploration and achievement of multiple career readiness outcomes, including HS CTE enrollment, Work-Based Learning (WBL), and dual credit CTE. Three additional outcomes, including EOP assessment performance, Industry Certification attainment, and any credential earned, were measured but are deferred for the same reasons described in RQ1: the cohort is currently in 11th grade and has not yet reached the required EOP testing year. Early signals for these outcomes are noted descriptively but are not included in the primary inferential analysis (Appendix C, Tables C-1 and C-3).

The primary analytic method for RQ3 is the McNemar test applied to the 1:1 propensity-score matched pairs established in RQ1. This approach directly compares each MS CTE student with their matched counterpart for each outcome, providing a within-pair causal estimate that accounts for the matching structure of the data. Supplemental models using the full unmatched cohort are reported in Appendix C, Tables C-4 through C-7, and provide adjusted associations for both Tier 1 and Tier 2 course participation across the same outcomes.

Table 9 presents outcome rates for the matched treatment and comparison groups. Table 10 presents the McNemar test results for the three primary outcomes. Table 11 presents the corresponding effect sizes.

Table 9. Outcome Rates by Treatment Group - Matched Sample

Group	N	HS CTE (%)	WBL (%)	Dual Credit (%)	EOP (%)	IC (%)	Any Cred. (%)
No MS CTE (Comparison)	18,812	77.0	0.51	2.1	14.5	23.6	33.6
MS CTE (Treatment)	18,812	80.3	0.94	1.4	17.7	24.8	36.9

Note. 1:1 propensity-score matched sample. EOP, IC, and Any Credential are shown for context only as cohort has not yet reached senior year.

Table 10. McNemar Test Results - Primary Feasible Outcomes

Outcome	N Pairs	Comparison (%)	Treatment (%)	Diff. (pp)	OR (McNemar)	Chi-sq
HS CTE Enrollment (Tier 3)	18,812	77.0	80.3	3.3	1.216***	60.05
Work-Based Learning (Tier 4)	18,812	0.5	0.9	0.4	1.853***	23.62
Dual Credit CTE	18,812	2.1	1.4	-0.7	0.654***	27.15

Note. Comparison (%) and Treatment (%) = outcome rates within matched pairs. Diff. = Treatment % minus Comparison %. OR (McNemar) = n10 / n01. Chi-sq with continuity correction. Significance: *** p < .001 ** p < .01 * p < .05 . p < .10.

Table 11. Effect Sizes - ARD, NNT, and Cohen's h

Outcome	Comparison (%)	Treat. (%)	ARD (pp)	OR (McNemar)	Cohen's h	NNT	Magnitude
HS CTE Enrollment (Tier 3)	77.0	80.3	3.3	1.216***	0.081	30	Negligible
Work-Based Learning (Tier 4)	0.5	0.9	0.4	1.853***	0.048	250	Negligible
Dual Credit CTE	2.1	1.4	-0.7	0.654***	-0.054	-143	Negligible

Note. ARD = absolute risk difference (pp). NNT = number needed to treat (1 / |rate difference|, rounded). Cohen's h benchmarks: small ≥ 0.10, medium ≥ 0.20, large ≥ 0.50.

HS CTE Enrollment

MS CTE students enrolled in high school CTE courses at a rate of 80.3%, compared to 77.0% for matched comparison students, a difference of 3.3 percentage points (Table 10). The McNemar test confirmed this difference was statistically significant (OR = 1.216, p < .001; Table 10), meaning that within matched pairs, MS CTE students were more likely than their comparison counterparts to enroll in Tier 3 HS CTE. The effect size was small by conventional benchmarks (Cohen's h = 0.081), though the absolute risk difference of 3.3 percentage points and an NNT of 30 reflect a practically meaningful result at the statewide scale (Table 11). This finding is consistent with the RQ1 GLMM results and reinforces confidence in the robustness of the HS CTE enrollment advantage associated with middle school CTE participation.

Work-Based Learning

MS CTE students participated in Work-Based Learning at a rate of 0.9%, compared to 0.5% for matched comparison students, a difference of 0.4 percentage points (Table 10). While this difference is statistically significant (OR = 1.853, $p < .001$; Table 10), both rates are very low, and the absolute difference is small, yielding an NNT of 250 and a negligible Cohen's h of 0.048 (Table 11). The result should be interpreted cautiously: the statistical significance reflects the sensitivity of the McNemar test to the within-pair structure of the data, not a practically large effect. WBL participation remains rare in this cohort overall, and the finding suggests at most a modest association between middle school CTE and early WBL access.

Dual Credit CTE

The dual credit finding runs in the opposite direction. MS CTE students had a dual credit CTE rate of 1.4%, compared to 2.1% for matched comparison students, a difference of -0.7 percentage points, favoring the comparison group (Table 10). The McNemar test confirmed this difference was statistically significant (OR = 0.654, $p < .001$; Table 10). This means that within matched pairs, MS CTE students were less likely than their comparison counterparts to earn dual credit CTE. The effect size is negligible (Cohen's h = -0.054; Table 11), and both rates are low, so this should not be interpreted as a meaningful disadvantage. One possible explanation is that students who pursued formal CTE coursework in middle school may have followed a different course-taking trajectory in high school, prioritizing CTE Tier 3 enrollment and concentrator pathways over dual credit options. The supplemental joint model (Appendix C, Table C-5) is consistent with this interpretation, showing that after accounting for ILP participation, the negative association between Tier 1 and dual credit CTE remains (OR = 0.599, $p < .001$).

EOP and Industry Certification - Early Signals

As noted above, formal analysis of EOP and IC outcomes is deferred to the 2025-26 data cycle. Early descriptive patterns are consistent with the signals reported in RQ1: MS CTE students show slightly higher EOP pass rates (17.7% vs. 14.5%), comparable IC rates (24.8% vs. 23.6%), and higher any-credential rates (36.9% vs. 33.6%) than comparison students. Additionally, 26.4% of MS CTE students voluntarily attempted an EOP before their senior year, compared to 22.7% of comparison students. Among those who attempted early, pass rates were similarly high in both groups (67.1% vs. 63.7%), suggesting that early testers are a self-selected, motivated group rather than reflecting a treatment-driven difference (Appendix C, Table C-2). These patterns are encouraging but cannot support causal conclusions at this stage.

Supplemental Models

The supplemental analyses using the full unmatched cohort (Appendix C, Tables C-4 - C-7) provide additional context. The joint model, which simultaneously enters Tier 1 (MS CTE) and Tier 2 (ILP) participation, shows that both forms of early career exploration are independently associated with higher HS CTE enrollment and WBL participation after controlling for demographics and academics. The dose-response model further suggests that students with both Tier 1 and Tier 2 records had the highest odds of HS CTE enrollment and WBL participation relative to students with neither, though the pattern for dual credit CTE does not follow the same slope. These supplemental results should be interpreted as adjusted associations rather than causal estimates, given that they are based on an unmatched cohort without the same selection controls as the matched analysis.

Note on Analytic Method: The McNemar test was selected as the primary method for RQ3 because it directly leverages the matched pair structure of the data, providing within-pair comparisons that account for confounding at the pair level. The chi-square statistic includes a continuity correction. The McNemar OR is calculated as the ratio of discordant pairs and is not equivalent to a regression-based odds ratio.

Research Question 4

RQ4: At what grade levels do students typically begin CTE pathways, and how does this timing correlate with middle school career exploration experiences?

RQ4 examines at what grade levels students typically begin CTE pathways and whether the timing of middle school career exploration, either through formal MS CTE courses (Tier 1) or ILP activities (Tier 2), is correlated with earlier entry into high school CTE. We used three analytic approaches: descriptive entry grade distributions; Spearman and Kendall rank correlations between middle and high school CTE entry grades; and OLS regression predicting Tier 3 entry grade from Tier 1 participation, controlling for student background characteristics. Because the outcome variable (Tier 3 entry grade) is discrete and takes only five ordered values, the residuals from the OLS models were non-normal according to the Shapiro-Wilk test, as expected.

Table 12 presents the entry grade distributions for Tier 1 and Tier 3 among students with records in both tiers. Table 13 presents the correlation results. Table 14 presents the OLS regression results.

Table 12. CTE Entry Grade Distributions - Tier 1 (MS CTE) and Tier 3 (HS CTE)

Grade	Tier 1 N	Tier 1 %	Tier 3 N	Tier 3 %
8th grade	22,981	99.6	1,104	4.8
9th grade	90	0.4	15,232	66.0
10th grade	-	-	5,054	21.9
11th grade	-	-	1,673	7.3
12th grade	-	-	8	0.0
Total	23,071	100.0	23,071	100.0

Note. Restricted to students with both Tier 1 and Tier 3 records and non-missing grade data (N = 23,071). For Tier 1, the 9th-grade row reflects atypical cases likely due to administrative coding or dual-enrollment scenarios. For Tier 3, the 8th-grade row reflects edge cases in which HS CTE enrollment was recorded in 8th grade, blurring the boundary between middle and high school CTE.

Entry Grade Distributions

The vast majority of students in this cohort began their Tier 1 (MS CTE) experience in 8th grade (99.6%), which is consistent with the study design, as this is an 8th-grade cohort from 2021-22. A small number of students (0.4%, n = 90) had Tier 1 records at or above 9th grade, which likely reflects administrative coding anomalies or atypical enrollment situations and are noted but not interpreted substantively (Table 12).

For Tier 3 HS CTE entry, the most common entry point was 9th grade, where 66.0% of students first enrolled in a substantive high school CTE course. An additional 21.9% began in 10th grade

and 7.3% in 11th grade. A small but notable group (around 4.8% of the sample (n = 1,104)) had Tier 3 records beginning in 8th grade, which blurs the middle and high school CTE boundary. These students had slightly higher credential attainment rates than those who began Tier 3 in 9th grade or later (39.4% vs. 36.9%), though EOP and IC rates remain partial given the cohort's current grade level (Appendix D, Table D-4). The overall picture is that for most students, 9th grade is the standard entry point into high school CTE, with the middle school CTE experience preceding that entry by approximately 1 year on average (mean grade gap = 1.31 years; Appendix D, Table D-1).

Correlation Between Middle and High School CTE Entry Timing

The correlation analysis found no meaningful relationship between the grade at which students began Tier 1 (MS CTE) and the grade at which they began Tier 3 (HS CTE). The Spearman correlation was essentially zero (rho = -0.001, p = .895), and the Kendall tau confirmed this result (tau = -0.001, p = .895; Table 13). The near-zero correlation is not surprising given that 99.6% of Tier 1 students entered in 8th grade, so there is virtually no variation in the Tier 1 entry grade to correlate with anything.

The Tier 2 (ILP) versus Tier 3 correlation was similarly negligible (Spearman rho = 0.009, p = .728; Kendall tau = 0.008, p = .728; Table 13). This means that the grade at which a student participated in ILP activities also shows no meaningful relationship with the grade at which they began high school CTE. Both correlations were confirmed as consistent in sign direction across the Spearman and Kendall methods.

Table 13. Spearman and Kendall Correlations - Tier 1 x Tier 3 and Tier 2 x Tier 3

Comparison	Method	N	Statistic	p-value	Consistent
Tier 1 vs Tier 3	Spearman	23,071	-0.001	0.895	-
Tier 1 vs Tier 3	Kendall	23,071	-0.001	0.895	Yes
Tier 2 vs Tier 3	Spearman	1,569	0.009	0.728	-
Tier 2 vs Tier 3	Kendall	1,569	0.008	0.728	Yes

Note. Tier 1 x Tier 3 sample: N = 23071. Tier 2 x Tier 3 sample: N = 1569. Consistent = Spearman and Kendall agree in sign direction.

OLS Regression: Does Middle School CTE Predict Earlier HS CTE Entry?

The OLS regression models further confirmed the absence of a meaningful timing relationship. In M_cont, which used the continuous Tier 1 entry grade as the predictor, the coefficient for Tier 1 entry grade was negligible and non-significant (b = -0.004, p = .910; Table 14). In M_bin, which asked simply whether having any Tier 1 experience predicted earlier Tier 3 entry, the coefficient was marginally significant at the p < .10 threshold only (b = -0.014, p = .061; Table 13), suggesting at most a trivially small association, where students with MS CTE entered Tier 3 about two hundredths of a grade level earlier than those without, which is not practically meaningful. Both models explained less than 0.5% of the variance in Tier 3 entry grade (R^2 = 0.004), indicating that the timing of high school CTE entry is largely driven by factors not captured in this model, likely including school scheduling structures, course availability, and individual student choices.

The demographic covariates in both models showed more consistent associations with Tier 3 entry timing than the CTE predictors themselves. Students eligible for free or reduced-price lunch entered Tier 3 slightly earlier (b = -0.036 to -0.038), while students with special education status (b = 0.049 to 0.068) and English learner status (b = 0.120 to 0.127) entered somewhat later on average.

Table 14. OLS Regression - Tier 3 Entry Grade Predicted by Tier 1 Participation

Term	M_cont b	95% CI	M_bin b	95% CI
Intercept	9.433***	[8.908, 9.957]	9.466***	[9.391, 9.540]
Tier 1 Entry Grade	-0.004	[-0.068, 0.061]	-	-
Any Tier 1 (binary)	-	-	-0.014	[-0.029, 0.001]
Prior Reading Score	-0.001	[-0.001, 0.000]	-0.001***	[-0.001, 0.000]
FRL	-0.038**	[-0.061, -0.015]	-0.036***	[-0.053, -0.018]
Special Education	0.068***	[0.038, 0.098]	0.049***	[0.026, 0.072]
English Learner	0.127***	[0.073, 0.180]	0.120***	[0.075, 0.164]
Female	-0.015	[-0.035, 0.005]	-0.009	[-0.024, 0.006]
Non-White	0.026*	[0.002, 0.050]	0.038***	[0.020, 0.057]
R^2	0.004	-	0.004	-

Note. Outcome = earliest Tier 3 entry grade for both models. M_cont primary predictor = Tier 1 entry grade (continuous); restricted to students with both Tier 1 and Tier 3 records (N = 18,470). M_bin primary predictor = any Tier 1 participation (binary); includes all cohort students with Tier 3 enrollment (N = 33,737). \ Covariates: prior reading score, FRL, special education status, English learner status, sex, and race/ethnicity. Significance: *** p < .001 ** p < .01 * p < .05 . p < .10.

Note on Analytic Approach: The near-complete concentration of Tier 1 entry at 8th grade (99.6%) severely limits the ability of the correlation and M_cont regression to detect a timing relationship. The absence of a significant finding for M_cont should be understood primarily as a function of this floor effect rather than as evidence that middle school CTE timing is unrelated to high school CTE timing in general. The M_bin result, which asks a more answerable question given the data structure, provides the more informative estimate.

Research Question 5

RQ5: How does EOP/Industry Certification performance vary by grade level, and is this influenced by prior middle school CTE exposure?

RQ5 examines how EOP performance varies by grade level and whether prior middle school CTE exposure is associated with higher EOP pass rates. Two questions are addressed in sequence: first, at what grades do students typically attempt EOP assessments, and how do pass rates differ across grades; and second, does having prior MS CTE exposure predict a higher probability of passing, after accounting for grade level and student background characteristics.

The primary analytic sample consists of first EOP attempts across grades 10 and 11, which together account for most MS CTE students who tested (37.3% in 10th grade and 58.5% in 11th grade among MS CTE prior students). Grade 9 testers were excluded from the primary model

due to the very small and highly selected nature of that group (N = 539), as confirmed by the demographic composition check in Appendix E, Table E-1. Grade 12 first-attempt testers were also excluded because only 184 MS CTE students (0.4% of all 12th-grade testers) appeared in that group, making it a residual subgroup rather than a meaningful comparison category (Appendix E, Table E-2). The primary model is therefore restricted to grades 10 and 11, where the analytic sample includes 59,515 first attempts from 49,185 students. All models use first attempts only. The model structure follows:

$$logit(P(EOP\_Pass_{ij} = 1)) = \beta_0 + \beta_1(GRADE)_{ij} + \beta_2(MS\_CTE)_{ij} + \beta_3(FRL)_{ij} + \beta_4(SpecialEducation)_{ij} + \beta_5(EL)_{ij} + \beta_6(Female)_{ij} + \beta_7(nonWhite)_{ij} + u_{0j}$$

where $(GRADE)_{ij}$ is a categorical indicator for testing grade (reference = 10th grade in the primary model), $(MS_CTE)_{ij}$is a binary indicator for prior middle school CTE exposure, and all other terms are defined as in previous research questions.

Table 15 presents EOP pass rates by grade. Table 16 presents pass rates by grade and MS CTE prior exposure. Table 17 presents the full primary model results. Table 18 summarizes the MS CTE effect estimate across all models.

EOP Pass Rates by Grade Level

Pass rates increased from 9th to 11th grade before leveling off slightly at 12th grade (Table 15). Among first-attempt testers, the pass rate was 46.9% in 9th grade, 54.9% in 10th grade, 61.2% in 11th grade, and 60.2% in 12th grade. The similar pass rates between 11th and 12th grade are likely due to differences in who tests at each grade: earlier testers tend to be higher-achieving students who chose to test voluntarily, while 12th grade includes all students required to test by their district. Appendix E, Table E-1 confirms this pattern, where 9th-grade testers had higher mean reading scores and lower FRL rates than 12th-grade testers, consistent with positive selection into early testing.

The grade-level pattern was similar to prior MS CTE exposure (Table 16). Compared with students without MS CTE, students with prior MS CTE had higher pass rates in 9th grade (+9.2 percentage points), 10th grade (+3.9 points), and 11th grade (+1.1 points). In 12th grade, the difference was negative (-4.9 points), but Appendix E, Table E-2 indicates that this result reflects the unusual composition of the 12th-grade MS CTE group rather than a true disadvantage.

Table 15. EOP Pass Rate by Grade - First Attempts Only

Grade	N Attempts	N Students	N Pass	Pass Rate (%)
9th	539	508	253	46.9
10th	13,067	11,422	7,175	54.9
11th	46,448	39,548	28,446	61.2
12th	50,566	40,895	30,463	60.2

Note. First EOP attempts only across all grades. N Attempts = number of first attempts at that grade. N Students = unique students.

Table 16. EOP Pass Rate by Grade and MS CTE Prior Exposure

Grade	N (No MS CTE)	Pass % (No MS CTE)	N (MS CTE)	Pass % (MS CTE)	Diff (pp)	Caution
9th	250	42.0	289	51.2	9.2	n=539 total; highly selected
10th	8,783	53.6	4,284	57.5	3.9	
11th	39,734	61.1	6,714	62.2	1.1	
12th	50,382	60.3	184	55.4	-4.9	Residual late-tester group; see Table 9

Note. Yellow shading = caution rows. 9th grade: N = 539, highly selected voluntary testers - not included in primary model. 12th grade: residual late-tester group; negative diff is sampling artifact. See Table 10 for full anomaly documentation. Diff (percentage points) = MS CTE % minus No MS CTE %.

Primary Model: Does MS CTE Prior Exposure Predict EOP Pass?

After adjusting for grade level and student demographics, students with prior MS CTE exposure had 17.6% higher odds of passing their EOP assessment compared to students without MS CTE exposure (OR = 1.176, $p < .001$; Table 17). This effect was consistent whether or not demographic controls were included, where the unadjusted estimate was OR = 1.090 and the adjusted estimate was OR = 1.176, with the adjustment actually increasing the estimated effect slightly, suggesting that MS CTE students are not simply higher-achieving students on observable characteristics.

Grade level was also a significant predictor: 11th grade testers had 38.8% higher odds of passing than 10th grade testers (OR = 1.388, $p < .001$; Table 17), consistent with the descriptive pattern in Table 15. Among the demographic covariates, FRL eligibility (OR = 0.510), special education status (OR = 0.215), English learner status (OR = 0.171), and non-White identification (OR = 0.744) were all associated with lower odds of passing, while female students had higher odds (OR = 1.179). These patterns are consistent with well-documented disparities in academic assessment outcomes.

Table 17. Model B1 - Full Adjusted Results (Primary Model, Grades 10-11)

Term	OR	95% CI
Intercept	1.943***	[1.854, 2.036]
Grade: 11th	1.388***	[1.331, 1.447]
MS CTE Prior (1 = Yes)	1.176***	[1.123, 1.231]
FRL	0.510***	[0.492, 0.529]
Special Education	0.215***	[0.201, 0.230]
English Learner	0.171***	[0.146, 0.199]
Female	1.179***	[1.138, 1.220]
Non-White	0.744***	[0.712, 0.777]

Note. Primary model. Reference grade = 10th. Covariates: FRL, SpEd, EL, Female, Non-White. N = 59515 attempts, 49185 students.

Does the MS CTE Effect Differ by Grade?

An interaction model was estimated to test whether the MS CTE advantage varied between 10th and 11th grade. The interaction term was not statistically significant (OR = 0.940, p = .205; Appendix E, Table E-3), and the likelihood ratio test confirmed that adding the interaction did not meaningfully improve model fit (χ^2 = 1.606, p = .205). The MS CTE effect on EOP pass probability is therefore consistent across 10th and 11th grade, supporting the use of the main effects model as the primary specification.

Robustness of the MS CTE Effect

The MS CTE effect was robust across multiple model specifications (Table 18). The all-grades model with 12th grade as reference produced a nearly identical estimate (OR = 1.165, p < .001; Appendix E, Table E-4). The multi-grade districts' sensitivity model, which restricted the sample to districts where EOP testing occurs across multiple grades, produced an estimate of OR = 1.173, closely replicating the primary model (Appendix E, Table E-5). The only model that did not replicate the finding was the seniors-only sensitivity model (OR = 0.798, p = .146), based on the 184 MS CTE students who tested in 12th grade, the same residual group identified as anomalous in the descriptive analysis. This non-significant result should not be interpreted as contradicting the primary finding; it reflects the unrepresentative nature of that subgroup rather than a true absence of effect.

Table 18. MS CTE Prior Effect on EOP Pass - All Models

Model	OR	95% CI
B0: Unadjusted (grades 10-11)	1.090***	[1.044, 1.139]
B1: Adjusted – Primary Model	1.176***	[1.123, 1.231]
C: All grades, 12th ref	1.165***	[1.114, 1.218]
SA: Seniors only	0.798	[0.589, 1.085]
SB: Multi-grade districts 10-11	1.173***	[1.120, 1.228]

Note. Consistent OR direction across models indicates a robust finding. A B0 vs B1 comparison shows the covariate's impact. SA provides the cleanest estimate (no grade-level selection). Significance: *** p < .001 ** p < .01 * p < .05 . p < .10.

Industry Certification

IC outcomes cannot be modeled at the attempt level because ICs are awarded through a different administrative process than EOP assessments. Descriptive IC rates by grade and MS CTE prior exposure are provided in Appendix E, Table E-6. Across grades 9 through 11, MS CTE students consistently showed higher IC rates than comparison students, with differences of 1.3 percentage points at 9th grade, 3.7 percentage points at 10th grade, and 8.6 percentage points at 11th grade. The 12th-grade pattern reverses sharply, but this reflects the very small number of MS CTE students still enrolled in 12th grade in this cohort rather than a meaningful disadvantage. Formal inferential analysis of IC outcomes is deferred to the 2025-26 data cycle, as noted in previous research questions.

Note on Program Area Variation: Descriptive pass rates by EOP program area show that the MS CTE effect is near zero across most program areas, with differences ranging from -0.6 to +1.5 percentage points. This suggests that the overall MS CTE advantage in EOP pass rates is not concentrated in a particular career cluster but reflects a general pattern across programs.

Research Question 6

RQ6: Do students with robust middle school career exploration more frequently engage in Work-Based Learning and dual credit opportunities?

RQ6 examines whether students with more robust middle school career exploration are more likely to engage in Work-Based Learning (WBL) and dual credit CTE in high school. Three outcomes were examined: WBL participation (Tier 4), dual credit CTE enrollment, and either WBL or dual credit. Two primary exposure variables were used: any MS CTE participation (binary) and MS CTE course count as a dosage indicator. A third exposure variable, namely cluster alignment between MS and HS CTE, was considered but not modeled. Nearly half of all MS CTE students (48.3%, n = 102,358) were classified under a catch-all category called General Career Exploration, which has no corresponding high school pathway and makes alignment structurally impossible for that group. Among students in specific clusters, the overall alignment rate was only 16.8%, with only Family and Consumer Sciences reaching an interpretable level (38.6%). Given these limitations, the cluster-aligned independent variable was replaced with descriptive tables by MS cluster (Appendix F, Tables F-3 and F-4). ILP (Tier 2) participation was included as a supplemental exposure. All models were adjusted for prior reading score, FRL, special education status, English learner status, sex, and race/ethnicity.

The model structure for each binary outcome follows:

$$logit(P(OUTCOME_i = 1)) = \beta_0 + \beta_1(MS\_CTE)_i + \beta_2(ReadingScale)_i + \beta_3(FRL)_i + \beta_4(SpecialEducation)_i + \beta_5(EL)_i + \beta_6(Female)_i + \beta_7(nonWhite)_i$$

where MS_CTEi is either the binary exposure indicator or the course count, depending on the model specification. All models are estimated on the full unmatched cohort and should be interpreted as adjusted associations rather than causal estimates.

Table 19 presents descriptive outcome rates by MS CTE exposure. Table 20 presents the adjusted odds ratios across all exposure variables and outcomes. Table 21 presents the absolute risk differences.

Table 19. Outcome Rates by MS CTE Exposure

Group	N	WBL (%)	Dual Credit (%)	Either (%)
No MS CTE	24,187	0.51	1.89	2.33
Any MS CTE	29,131	0.74	1.15	1.86

Note. WBL = Work-Based Learning (Tier 4). Dual Credit = dual credit CTE courses. Either = WBL or Dual Credit (or both). Unmatched descriptive - not causal.

Descriptive Patterns

Overall rates of WBL and dual credit CTE participation were low in this cohort (Table 19). Among students without MS CTE, WBL participation was 0.5%, and dual credit CTE was 1.9%. Among MS CTE students, WBL participation was slightly higher (0.7%) while dual credit CTE was lower (1.1%). The pattern for ILP students was different: they had higher WBL rates (1.3%) than non-ILP students (0.6%), with comparable dual credit rates (Appendix F, Table F-1). WBL participation was concentrated in two activity types: CTE internships and CTE co-ops, with MS CTE students showing higher counts in both (Appendix F, Table F-2).

The dosage analysis showed a modest descent for WBL but a different pattern for dual credit (Appendix F, Table F-5). Students with more MS CTE courses were somewhat more likely to participate in WBL, but dual credit rates were actually higher among students with more courses, suggesting that heavier MS CTE engagement may channel students toward CTE concentration rather than dual credit pathways, a pattern consistent with the RQ3 findings.

Inferential Results

The inferential results present a split picture depending on the outcome (Table 20). For WBL, MS CTE students had 62.3% higher odds of participation compared to students without MS CTE (OR = 1.623, $p < .001$). The course count model confirmed this direction, with each additional MS CTE course associated with 18.9% higher odds of WBL participation (OR = 1.189, $p = .009$). ILP students showed an even stronger association with WBL (OR = 2.498, $p < .001$), suggesting that career exploration activities in general, whether formal CTE courses or ILP activities, are positively associated with later WBL engagement.

Table 20. Adjusted Odds Ratios for WBL and Dual Credit CTE - All Exposure Variables

Exposure	Outcome	OR	95% CI	N
(a) Any MS CTE (binary)	Work-Based Learning	1.623***	[1.286, 2.059]	42,834
	Dual Credit CTE	0.600***	[0.515, 0.699]	42,834
	WBL or Dual Credit	0.824**	[0.725, 0.935]	42,834
(b) MS CTE Course Count	Work-Based Learning	1.189**	[1.040, 1.352]	42,829
	Dual Credit CTE	0.944	[0.856, 1.039]	42,829
	WBL or Dual Credit	1.029	[0.950, 1.113]	42,829
(c) Tier 2 ILP (supplemental)	Work-Based Learning	2.498***	[1.582, 3.751]	42,834
	Dual Credit CTE	1.160	[0.761, 1.687]	42,834
	WBL or Dual Credit	1.532**	[1.121, 2.041]	42,834

Note. All models adjusted for prior reading score, FRL, special education status, English learner status, sex, and race/ethnicity. Exposure (a) = any MS CTE participation (1 vs. 0); reference group = no MS CTE. Exposure (b) = number of distinct MS CTE courses; restricted to Tier 1 students with valid course count (N = 42,829). Exposure (c) = any ILP participation (1 vs. 0); supplemental only - no matched design for Tier 2, adjusted associations should not be interpreted causally. IV (c) cluster-aligned was not modeled due to low and structurally limited alignment rates (see text). Significance: *** $p < .001$ ** $p < .01$ * $p < .05$. $p < .10$.

The dual credit findings run in the opposite direction. MS CTE students had 40% lower odds of dual credit CTE participation compared to students without MS CTE (OR = 0.600, p < .001), and the course count model did not show a significant association (OR = 0.944, p = .247). ILP participation showed no significant association with dual credit (OR = 1.160, p = .464). This negative relationship between MS CTE and dual credit is consistent with the pattern observed in RQ3 and likely reflects the same course-taking trajectory explanation, where students who pursue formal CTE pathways in middle school tend to concentrate their high school efforts in CTE Tier 3 coursework and concentrator pathways rather than dual credit options.

For the combined outcome of WBL or dual credit, MS CTE students had slightly lower odds than comparison students (OR = 0.824, p = .003), driven largely by the dual credit effect. ILP students showed higher odds of either outcome (OR = 1.532, p = .005).

The absolute risk differences confirm that the effects, while statistically significant, are small in absolute terms (Table 21). The WBL advantage for MS CTE students was 0.2 percentage points (NNT = 423), and the dual credit disadvantage was -0.7 percentage points (NNT = 135). These small differences reflect the overall low prevalence of both outcomes in the cohort at this stage, and the practical significance of these findings may increase as the cohort progresses through 12th grade and more WBL and dual credit opportunities become available.

Note on Outcome Prevalence: WBL participation (0.7%) and dual credit CTE (1.7%) remain rare outcomes in this cohort, which is currently in 11th grade. Both outcomes are likely to increase as students reach 12th grade, and the current estimates should be understood as partial. The statistical significance of some findings reflects the large sample size rather than the practical significance of large effects.

Table 21. Absolute Risk Differences (ARD) Practical Significance

Comparison	Outcome	Comparison (%)	Treat. (%)	ARD (pp)	NNT
Any MS CTE vs None	Work-Based Learning	0.5	0.7	0.2	423
Any MS CTE vs None	Dual Credit CTE	1.9	1.1	-0.7	135
Any MS CTE vs None	WBL or Dual Credit	2.3	1.9	-0.5	216
Any ILP vs None	Work-Based Learning	0.6	1.3	0.7	151
Any ILP vs None	Dual Credit CTE	1.5	1.5	0.0	20,408
Any ILP vs None	WBL or Dual Credit	2.1	2.7	0.6	164

Note. ARD = Treat. % minus Comparison % (pp). NNT = number needed to treat (1 / |rate difference|, rounded). Positive ARD favors the exposure group.

Discussion

The findings from this study offer a meaningful early look at how middle school career exploration shapes students' CTE trajectories in high school. Taken together, the results tell a coherent and largely encouraging story: middle school CTE participation is associated with stronger high school CTE engagement, greater pathway persistence, and improved assessment performance, though effect sizes are generally modest and several key outcome measures remain incomplete for a cohort that has not yet reached 12th grade.

Across multiple research questions and analytic approaches, middle school CTE participation was consistently linked to higher odds of achieving concentrator status, stronger EOP assessment performance, and greater engagement in Work-Based Learning. These associations are held across grade levels, model specifications, and school contexts, suggesting that the benefits of early CTE exposure are not an artifact of any single analytic choice. Importantly, the RQ4 findings help clarify the mechanism through which these benefits operate: because 9th-grade entry into high school CTE was nearly universal regardless of prior middle school CTE experience, the advantages associated with early exposure appear to work through enhanced pathway engagement and persistence over time rather than through accelerated entry into coursework. In other words, middle school CTE may not get students into CTE sooner, but it appears to help them go further once they are there.

Not all findings pointed in a uniformly positive direction, and the nuances are worth acknowledging. The comparison between MS CTE completers and ILP-only students did not yield statistically significant differences in primary outcomes, though this may partly reflect the small size of the ILP-only group rather than a true absence of effect. MS CTE completers also took slightly longer than ILP-only students to reach concentrator status, which may suggest that students with formal middle school CTE experience explore a broader range of options before committing to a pathway, a pattern consistent with the exploratory purpose of middle school career education. The negative association between MS CTE participation and dual credit CTE, which appeared consistently across multiple analyses, likely reflects the fact that MS CTE students tend to channel their high school efforts into CTE concentration pathways rather than dual credit options, representing two distinct but potentially equally valid routes to career readiness. Pathway consistency between middle and high school remained low across all analyses, suggesting that structural alignment between the two levels is still developing and deserves continued attention as ILP implementation matures.

Limitations

A key limitation of the current study is that the most consequential credential outcomes, such as CTE EOP pass rates, Industry Certification attainment, and other end-of-program measures, cannot be meaningfully analyzed for the 2021-2022 cohort at this time. Because this cohort was still in 11th grade during the 2024-2025 data pull, most students had not yet entered the mandatory senior-year testing window. Descriptive credential rates reported here should therefore be interpreted as early signals only, with formal analysis deferred until 2025-2026 data become available.

The discretionary nature of EOP and IC attempts at both the student and district levels also complicates the interpretation of assessment-related findings. Absence from EOP or IC data cannot be treated as non-performance, and observed variation in attempt rates across districts likely reflects local testing policies rather than true differences in student preparation. Future analyses will distinguish between concentrator eligibility, assessment attempt, and pass/fail outcome, and will account for district-level testing norms and first versus repeat attempt status to ensure valid comparisons.

Finally, while the 2021-2022 8th-grade cohort represents the earliest group for whom meaningful high school outcomes are currently observable, the 2023-24 6th-grade cohort will serve as the long-term baseline for future reports. As the first group fully subject to the ILP mandate under 704 KAR 3:305, this cohort will be essential for evaluating the policy's impact as they progress through high school.

References

Mulolli, D., Liu, J., & Dickinson, E. R. (2024). *Relationship of career and technical education participation and postsecondary outcomes* (2024 No. 088). Human Resources Research Organization.

Mulolli, D., Liu, J., Koehler, N., & Dickinson, E. R. (2025). *Relationship of career and technical education participation and postsecondary outcomes* (2025 No. 061). Human Resources Research Organization.

Princiotta, D., Lippman, L., Ryberg, R., Schmitz, H., Murphey, D., & Cooper, M. (2014*).* Social Indicators Predicting Postsecondary Success. Publication# 2014-21. *Child Trends*.

What Works Clearinghouse. (2022). *What Works Clearinghouse procedures and standards handbook, version 5.0*. U.S. Department of Education, Institute of Education Sciences, National Center for Education Evaluation and Regional Assistance. Retrieved from https://ies.ed.gov/ncee/wwc/handbooks

Appendix A: Supplementary Tables for RQ1

Table A-1. Outcome Rates and GLMM Results by Pathway Consistency - MS CTE Completers Only

Pathway Consistency	N	HS CTE (%)	Concentrator (%)	Yrs to Conc.	Any Cred. (%)	OR (Concentrator)	95% CI
Inconsistent (MS to HS)	17,612	79.1	58.2	1.14	36.6	Reference	-
Consistent (MS to HS)	1,112	100.0	62.3	1.25	43.1	1.161*	[1.02, 1.32]
No HS Pathway	88	73.9	28.4	1.32	12.5	-	-

Note. Restricted to MS CTE completers (N = 18,724; 146 middle schools). The OR column reflects the adjusted odds of achieving CTE concentrator status relative to the inconsistent pathway group, estimated from a GLMM with covariates for FRL, special education status, EL status, sex, and race/ethnicity, and a random intercept for middle school (ICC = 0.111). An OR for HS CTE Enrollment is not reported because 100% of pathway-consistent students enrolled in Tier 3 HS CTE, producing an unstable model estimate; the descriptive rate in the HS CTE column is the more meaningful result for that outcome. Any Cred. = any credential earned by 2024-25. Significance: * p < .05.

Table A-2. Robustness Check - Full Sample vs. Schools with Within-School Treatment Variation (M2 Specification)

Outcome	Sample	OR	95% CI	ICC	# of Schools	# of Students
CTE Concentrator Status	Full sample (169 schools)	1.181***	[1.13, 1.24]	0.1399	169	37,622
CTE Concentrator Status	Mixed schools only (108 schools)	1.192***	[1.14, 1.25]	0.1168	108	34,013
HS CTE Enrollment (Tier 3)	Full sample (169 schools)	1.185***	[1.12, 1.25]	0.1185	169	37,622
HS CTE Enrollment (Tier 3)	Mixed schools only (108 schools)	1.185***	[1.12, 1.25]	0.1006	108	34,013

Note. Mixed schools = MS schools where 10-90% of matched students were in the treatment group (genuine within-school treatment variation). Full sample includes all 169 MS schools. OR = odds ratio. 95% CI in brackets. Significance: *** p < .001 ** p < .01 * p < .05 . p < .10.

Appendix B: Supplementary Tables for RQ2

Table B-1. Concentrator Timing - Linear Mixed Model and Kruskal-Wallis Check

Comparison	b (yrs)	95% CI	Months Diff.	Direction	# of Concentrators	# of Schools	KW chi-sq
Tier 1 vs Tier 2	0.160**	[0.043, 0.278]	1.9	Later	608	94	7.663**
Tier 1 vs Neither	0.014	[-0.006, 0.033]	0.2	Later	21,218	154	3.196

Note. Restricted to students who achieved concentrator status (ever_concentrator = 1). b = unstandardized regression coefficient from lmer (REML); negative b = sooner. Months Diff. = b x 12. KW = Kruskal-Wallis non-parametric check for lmer result. N Conc. = concentrators in analytic sample. Significance: *** p < .001 ** p < .01 * p < .05 . p < .10.

Table B-2. Pathway Consistency Rates - Tier 1 (MS CTE) Students Only

Comparison	N Treated	N Consistent	% Consistent	# of Schools
Tier 1 vs Tier 2	556	23	4.1	99
Tier 1 vs Neither	18,724	1,112	5.9	146

Note. Restricted to Tier 1 (MS CTE completers) only. Consistent = student's HS CTE career cluster matched their MS CTE career cluster. Rates are descriptive; no inferential model is estimated for this table.

Appendix C: Supplementary Tables for RQ3

Table C-1. Outcome Rates by Exploration Group - Full 8th-Grade 2021–22 Cohort (Unmatched)

Exploration Group	N	HS CTE (%)	WBL (%)	Dual Credit (%)	EOP (%)	IC (%)	Any Cred. (%)
Neither	23,506	75.3	0.5	1.9	13.5	22.4	31.8
Tier 2 only	681	81.9	1.6	2.3	12.9	22.6	31.4
Tier 1 only	27,933	79.0	0.7	1.2	15.5	23.0	33.8
Both T1 and T2	1,198	84.4	1.1	1.0	12.1	19.8	28.4

Note. Unmatched cohort - descriptive only, no causal interpretation. Tier 1 = MS CTE completers. Tier 2 = ILP-only. EOP, IC, and Any Credential rates are early/partial - cohort is in grade 11.

Table C-2. Early Tester Profile - Descriptive Only (Not Causal)

Group	EOP Status	N	EOP Pass (%)	IC (%)	Any Cred. (%)	HS CTE (%)	WBL (%)
No MS CTE (Comparison)	No EOP attempt yet	14,543	0.0	21.9	21.9	76.3	0.3
No MS CTE (Comparison)	Attempted EOP (early)	4,269	63.7	29.4	73.4	79.6	1.1
MS CTE (Treatment)	No EOP attempt yet	13,852	0.0	23.0	23.0	80.0	0.7
MS CTE (Treatment)	Attempted EOP (early)	4,960	67.1	29.8	75.8	81.1	1.5

Note. Early testers = students who voluntarily attempted EOP before senior year. Rates are descriptive and cannot support causal inference - selection bias is expected (motivated students test early).

Table C-3. Outcome Feasibility by Variable - Primary vs. Deferred

Outcome	Variable	Observable Now	% > 0	Analysis Status	Reason
HS CTE Enrollment (Tier 3)	**outcome_tier3**	**Yes**	**78.7**	**PRIMARY ANALYSIS**	**Records current through 2024-25**
Work-Based Learning (Tier 4)	**outcome_tier4**	**Yes**	**0.7**	**PRIMARY ANALYSIS**	**Records current through 2024-25**
Dual Credit CTE	**outcome_dual_cred**	**Yes**	**1.7**	**PRIMARY ANALYSIS**	**Records current through 2024-25**
EOP Pass	outcome_EOP	No	16.1	DEFERRED - 2025-26	Cohort in grade 11; not yet required to test
Industry Certification	outcome_IC	No	24.2	DEFERRED - 2025-26	Cohort in grade 11; most untested
Any Credential (EOP or IC)	outcome_any_cred	No	35.2	DEFERRED - 2025-26	Cohort in grade 11; incomplete

Note. Bold rows = included in primary analysis. Shaded rows = deferred to 2025-26. % > 0 = percentage of matched students with outcome = 1 as of 2024-25.

Table C-4. Right-Censoring Assessment - Matched Sample by Treatment Group

Group	N	Grad. N	Grad. (%)	Enrolled N	Enrolled (%)	Gr. 12+ N	Gr. 12+ (%)	Full Opp. N	Full Opp. (%)	EOP Att. (%)
No MS CTE (Comparison)	18,812	46	0.2	13,358	83.4	191	1.0	223	1.2	22.7
MS CTE (Treatment)	18,812	41	0.2	13,997	83.6	265	1.4	298	1.6	26.4

Note. Gr. 12+ = confirmed at or beyond grade 12. Full Opp. = graduated or reached grade 12 (had full EOP testing opportunity). EOP Att. = voluntarily attempted EOP before senior year. Complete matched pairs with full

Table C-5. Credential Pattern by Treatment Group - IC Substitution Check

Group	N	EOP Only (%)	IC Only (%)	Both (%)	Neither (%)
No MS CTE (Comparison)	18,812	10.0	19.2	4.5	66.4
MS CTE (Treatment)	18,812	12.1	19.2	5.6	63.1

Note. EOP Only = passed EOP but no IC. IC Only = earned IC but no EOP pass. Both = passed EOP and earned IC. Differential IC-Only rates between groups would indicate IC substitution bias in deferred EOP analysis.

Table C-6. Concordance Table - Matched Pair Counts

Outcome	Both + (11)	Treat + Ctrl - (10)	Treat - Ctrl + (01)	Both - (00)
HS CTE Enrollment (Tier 3)	11,639	3,468	2,851	854
Work-Based Learning (Tier 4)	1	176	95	18,540
Dual Credit CTE	10	250	382	18,170

Note. 11 = both treatment and comparison have outcome. 10 = treatment has outcome, comparison does not. 01 = comparison has outcome, treatment does not. 00 = neither has outcome. McNemar test uses only the discordant pairs (10 and 01).

Table C-7. Tier 2 (ILP) Adjusted Odds Ratios - Unmatched Cohort

Outcome	Exposure	OR	95% CI	N	N Outcome = 1
HS CTE Enrollment (Tier 3)	Tier 2 (ILP)	1.35***	[1.18, 1.56]	42,834	33,737
Work-Based Learning (Tier 4)	Tier 2 (ILP)	2.50***	[1.58, 3.75]	42,834	306
Dual Credit CTE	Tier 2 (ILP)	1.16	[0.76, 1.69]	42,834	697

Note. Unmatched logistic regression. Firth correction applied if EPP < 10. Covariates: FRL, SpEd, EL, Female, nonWhite, RD Scale Score. N Outcome = 1 = students with outcome present. Significance: *** p < .001 ** p < .01 * p < .05 . p < .10.

Table C-8. Joint Model - Tier 1 and Tier 2 Simultaneously

Outcome	Exposure	OR	95% CI	N	N Outcome = 1
Dual Credit CTE	Tier 1 (MS CTE)	0.60***	[0.51, 0.70]	42,834	697
Dual Credit CTE	Tier 2 (ILP)	1.21	[0.79, 1.76]	42,834	697
HS CTE Enrollment (Tier 3)	Tier 1 (MS CTE)	1.17***	[1.14, 1.25]	42,834	33,737
HS CTE Enrollment (Tier 3)	Tier 2 (ILP)	1.33***	[1.16, 1.53]	42,834	33,737
Work-Based Learning (Tier 4)	Tier 1 (MS CTE)	1.60***	[1.27, 2.03]	42,834	306
Work-Based Learning (Tier 4)	Tier 2 (ILP)	2.41***	[1.53, 3.62]	42,834	306

Note. Both Tier 1 and Tier 2 entered simultaneously. Tier 1 OR = MS CTE effect after accounting for ILP participation (most conservative estimate). Covariates: FRL, SpEd, EL, Female, nonWhite, RD Scale Score. Significance: *** p < .001 ** p < .01 * p < .05 . p < .10.

Table C-9. Dose-Response Model - Exploration Group vs. Neither (Reference)

Outcome	Exploration Group	OR	95% CI	N	N Outcome = 1
Dual Credit CTE	Both T1 and T2	0.63	[0.32, 1.09]	42,834	697
Dual Credit CTE	Tier 1 only	0.61***	[0.52, 0.71]	42,834	697
Dual Credit CTE	Tier 2 only	1.37	[0.78, 2.24]	42,834	697
HS CTE Enrollment (Tier 3)	Both T1 and T2	1.54***	[1.30, 1.85]	42,834	33,737
HS CTE Enrollment (Tier 3)	Tier 1 only	1.20***	[1.14, 1.26]	42,834	33,737
HS CTE Enrollment (Tier 3)	Tier 2 only	1.41**	[1.13, 1.77]	42,834	33,737
Work-Based Learning (Tier 4)	Both T1 and T2	2.95***	[1.53, 5.18]	42,834	306
Work-Based Learning (Tier 4)	Tier 1 only	1.71***	[1.34, 2.20]	42,834	306
Work-Based Learning (Tier 4)	Tier 2 only	4.18***	[2.10, 7.51]	42,834	306

Note. Reference = Neither (no Tier 1 or Tier 2). Ordered groups: Tier 2 only → Tier 1 only → Both T1 and T2. Monotonic gradient would support dose-response relationship. Covariates: FRL, SpEd, EL, Female, nonWhite, RD Scale Score. Significance: *** p < .001 ** p < .01 * p < .05 . p < .10.

Table C-10. Tier 2 Outcome Rates - Unmatched Descriptive

Tier 2 Group	N	HS CTE (%)	WBL (%)	Dual Credit (%)	EOP (%)	IC (%)	Any Cred. (%)
No Tier 2	51,439	77.3	0.6	1.5	14.6	22.7	32.9
Tier 2 (ILP)	1,879	83.5	1.3	1.5	12.4	20.8	29.5

Note. Unmatched full cohort. EOP, IC, and Any Credential are early/partial - cohort in grade 11. Descriptive context for Tier 2 supplemental analysis.

Appendix D: Supplementary Tables for RQ4

Table D-1. Grade Gap Summary - Tier 3 Entry Grade Minus Tier 1 Entry Grade

N	Mean	SD	Median	% Positive	% Zero	% Negative
23,071	1.31	0.69	1	94.9	4.9	0.3

Note. Grade gap = Tier 3 entry grade minus Tier 1 entry grade. Positive = Tier 3 came after Tier 1 (expected). Zero = same grade. Negative = Tier 3 recorded before Tier 1 (possible data anomaly or early HS CTE).

Table D-2. Mean Tier 3 Entry Grade by Tier 1 Entry Grade Category

Tier 1 Entry Grade	N	Mean T3 Grade	SD T3 Grade	Mean Grade Gap	% T3 in 9th
8th grade	22,981	9.32	0.68	1.32	66.0
9th+ (atypical)	90	9.33	0.75	-0.90	66.7

Note. Mean T3 Grade = average Tier 3 entry grade for students in each Tier 1 entry category. Mean Grade Gap = average difference (T3 grade − T1 grade). % T3 in 9th = percentage entering HS CTE in 9th grade.

Table D-3. Cross-Tabulation - Tier 1 Entry Grade by Tier 3 Entry Grade

Tier 1 Entry Grade	8th (edge case)	9th grade	10th grade	11th grade	12th grade
8th grade	1,099	15,172	5,039	1,663	8
9th+ (atypical)	5	60	15	10	0

Note. Cells = number of students with that Tier 1 entry grade (rows) and Tier 3 entry grade (columns). Concentration on the diagonal or above indicates earlier MS CTE associates with earlier HS CTE entry.

Table D-4. Edge Case Analysis - Students Beginning Tier 3 in 8th Grade

Group	N	% of Total	Mean T1 Grade	Mean T3 Grade	Mean Gap	Any Cred. (%)	EOP (%)	IC (%)
T3 started 9th grade or later	21,967	95.2	8.01	9.38	1.37	36.9	15.4	26.5
T3 started 8th grade	1,104	4.8	8.01	8.00	-0.01	39.4	19.2	26.2

Note. 1104 students (4.8%) began Tier 3 in 8th grade. These students blur the MS/HS CTE boundary. Any Cred., EOP, and IC rates are early/partial - cohort is currently in grade 11.

Appendix E: Supplementary Tables for RQ5

Table E-1. Demographic Composition by Testing Grade - Selection Check

Grade	N	Pass (%)	FRL (%)	SpEd (%)	Non-White (%)	Mean Reading
9th	539	46.9	62.5	9.3	18.9	161.4
10th	13,067	54.9	58.2	8.7	17.8	161.6
11th	46,448	61.2	57.0	8.5	21.5	159.4
12th	50,566	60.2	55.2	9.3	21.4	158.7

Note. Demographic differences across grades indicate selection bias in voluntary early testing. Grade 9 has lower FRL and higher reading scores than grade 12 - confirming that early testers are positively selected.

Table E-2. 12th Grade MS CTE Anomaly Documentation

Item	Value
N MS CTE students in 12th grade (first attempt)	184
% of all 12th-grade first-attempt testers	0.4%
Pass rate diff - 12th grade (MS vs No MS)	-4.9 pp
Pass rate diff - 11th grade (MS vs No MS)	1.1 pp
Pass rate diff - 10th grade (MS vs No MS)	3.9 pp
Interpretation	Most MS CTE students tested in grades 10-11. 12th grade MS CTE = residual group likely on IC track or late testers. Negative diff is a sampling artifact, not causal.

Note. Only 184 MS CTE students (0.4% of 12th-grade testers) appear in the grade 12 first-attempt file. This residual group is not representative of MS CTE students generally. Primary model restricted to grades 10-11.

Table E-3. Model B2 - Interaction Model (Grade x MS CTE Prior)

Term	OR	95% CI
Intercept	1.917***	[1.822, 2.018]
Grade: 11th	1.410***	[1.343, 1.481]
MS CTE Prior (1 = Yes)	1.224***	[1.133, 1.322]
FRL	0.510***	[0.492, 0.529]
Special Education	0.215***	[0.201, 0.230]
English Learner	0.171***	[0.146, 0.199]
Female	1.179***	[1.138, 1.220]
Non-White	0.744***	[0.712, 0.777]
Interaction: Grade 11th x MS CTE	0.940	[0.855, 1.034]

Note. Interaction terms test whether MS CTE effect differs by grade. LRT comparing B1 vs B2 shown in Table 15.

Table E-4. Model C - All Grades, 12th Grade as Reference

Term	OR	95% CI
Intercept	2.483***	[2.417, 2.551]
Grade: 9th	0.531***	[0.443, 0.635]
Grade: 10th	0.735***	[0.704, 0.767]
Grade: 11th	1.018	[0.991, 1.047]
MS CTE Prior (1 = Yes)	1.165***	[1.114, 1.218]
FRL	0.543***	[0.529, 0.558]
Special Education	0.212***	[0.202, 0.222]
English Learner	0.164***	[0.147, 0.183]
Female	1.264***	[1.232, 1.296]
Non-White	0.732***	[0.709, 0.756]

Note. Secondary model. Reference grade = 12th. All first-attempt testers included. MS CTE Prior = bold. N = 110620 attempts.

Table E-5. Sensitivity Models - MS CTE Prior Coefficient Only

Model	Term	OR	95% CI
SA: Seniors only (adjusted)	MS CTE Prior (1 = Yes)	0.798	[0.589, 1.085]
SB: Multi-grade districts 10-11	MS CTE Prior (1 = Yes)	1.173***	[1.120, 1.228]

Note. SA = seniors only (grade 12, mandatory testing). SB = multi-grade districts, grades 10-11. Both models include full demographic covariates. OR shown for MS CTE Prior only.

Table E-6. IC Rate by Grade and MS CTE Prior Exposure

Latest Grade	N (No MS CTE)	N (MS CTE)	N IC (No MS CTE)	N IC (MS CTE)	IC % (No MS CTE)	IC % (MS CTE)	Diff (pp)
6	25,908	29,122	0	0	0.0	0.0	0.0
7	14,346	37,424	0	0	0.0	0.0	0.0
8	12,779	43,267	2	19	0.0	0.0	0.0
9	22,291	41,218	653	1,733	2.9	4.2	1.3
10	28,912	34,512	2,384	4,112	8.2	11.9	3.7
11	37,996	24,418	6,939	6,568	18.3	26.9	8.6
12	191,204	2,032	47,958	208	25.1	10.2	-14.9

Note. Descriptive - not attempt-level. Diff (pp) = MS CTE IC rate minus No MS CTE IC rate at each grade. IC inferential analysis (any_IC as binary outcome) is embedded in RQ1 and RQ3 deferred outcome tables.

Appendix F: Supplementary Tables for RQ6

Table F-1. Outcome Rates by ILP Exposure (Tier 2) - Supplemental Descriptive

Group	N	WBL (%)	Dual Credit (%)	Either (%)
No ILP / Tier 2	51,439	0.61	1.49	2.05
Any ILP / Tier 2	1,879	1.28	1.49	2.66

Note. Tier 2 = ILP or other non-CTE MS career exploration. Unmatched descriptive only. Inferential Tier 2 estimates in Table 10.

Table F-2. WBL Type by MS CTE Exposure

WBL Type	N (No MS CTE)	N (MS CTE)
CTE Internship	89	111
CTE Co-op	38	110

Note. Restricted to WBL participants in the 8th-grade 2021-22 cohort. N (MS CTE) = WBL students with prior MS CTE. N (No MS CTE) = WBL students without.

Table F-3. Outcome Rates by MS Career Cluster

MS Career Cluster	N	% Aligned	WBL (%)	Dual Credit (%)	Either (%)	WBL (Aligned %)	DC (Aligned %)
Engineering Technology	10,357	11.5	0.85	1.51	2.32	0.42	0.08
Family & Consumer Sciences	1,480	34.2	0.61	0.41	1.01	0.59	0.00
Business & Marketing / Computer Science / Computer Science	873	18.9	0.92	0.92	1.83	0.61	0.00

Note. Restricted to Tier 1 students with Tier 3 enrollment and non-missing alignment data. % Aligned = cluster-consistent MS to HS. WBL (Aligned %) and DC (Aligned %) = rates among aligned students only. See Table 7 for IV (c) decision rationale.

Table F-4. Family and Consumer Sciences - Aligned vs. Not Aligned (Exploratory)

Alignment	N	WBL (%)	Dual Credit (%)	Either (%)
FCS → Different HS Cluster	974	0.62	0.62	1.23
FCS → FCS (Aligned)	506	0.59	0.00	0.59

Note. FCS is the only MS cluster with an interpretable alignment rate (38.6%). Comparison is descriptive and exploratory only - no matched design for this subgroup.

Table F-5. Outcome Rates by Tier 1 Course Count (MS CTE Dosage)

T1 Courses	N	WBL (%)	Dual Credit (%)	Either (%)
2	21,335	0.79	0.93	1.69
3	6,424	0.67	1.65	2.27
4+	1,372	0.44	2.26	2.70

Note. Restricted to Tier 1 students with valid course count > 0. 1 = one Tier 1 course; 4+ = four or more courses.