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Dually Noted: Understanding the Link Between Dual Enrollment Course Characteristics and Students' Course and College Enrollment Outcomes

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Abstract

Although dual enrollment programming and interest in how that programming shapes students' college outcomes have expanded considerably in the past 20 years, policymakers, educational administrators, and practitioners do not have adequate information about which dual enrollment structural options are most effective. Using statewide administrative data in Texas on students who entered 9th grade in 2015 or 2016 and took at least one dual enrollment course through a community college, this paper examines dual enrollment course enrollments and outcomes among recent high school entrants. We describe dual enrollment coursetaking and dual enrollment course characteristics (including instructor affiliation, course location, and instructional modality) for traditional Texas public high school students (as opposed to those attending an Early College High School or charter school), illustrating how students participate in dual enrollment (e.g., the types of courses taken and when in their high school career students take these courses) and highlighting typical course characteristics. We then examine how dual enrollment course and instructor characteristics predict student course completion, course grades, and subsequent college enrollment. Our descriptive analyses illuminate striking differences between the demographic and academic backgrounds of students who take academic dual enrollment courses versus career and technical education dual enrollment courses, as well as variation in course characteristics across these two dual enrollment course types. Our regression analyses illustrate how several malleable dual enrollment course characteristics are associated with students' course outcomes and subsequent college enrollment. The relationships we identify offer insights for the design of dual enrollment courses and programs.

Table of Contents

1. Introduction

Dual enrollment—in which students take college courses during high school—presents an opportunity for students to enroll in and complete college requirements before high school graduation, accelerating progress toward postsecondary credentials. More than 80% of public high schools in the United States offer dual enrollment coursework (also referred to as dual credit coursework), and about one third of high school students complete a dual enrollment course before graduating high school (Shivji & Wilson, 2019; Taie & Lewis, 2020). Most dual enrollment courses are provided through public two-year colleges in partnership with local school districts (Mehl et al., 2020). Many colleges and their K-12 partners seek to leverage dual enrollment to improve postsecondary access and attainment; to do so, they need evidence about which dual enrollment course designs are most effective for student success.

Participation in dual enrollment (DE) has expanded dramatically over the past two decades (Kleiner & Lewis, 2005; Marken et al., 2013; Taie & Lewis, 2020). Growing evidence suggests that DE positively predicts college enrollment, persistence, and completion (An & Taylor, 2019; What Works Clearinghouse [WWC], 2017). As DE participation has expanded, so too have DE program types and course offerings. DE course characteristics, including varied instructional contexts, shape how students experience DE. Most DE students experience DE as à la carte college courses they take through a partnership between a traditional public high school and local community college (Mehl et al., 2020). This contrasts with more prescribed DE curricula taken through Early College High Schools (ECHSs), which integrate high school- and college-level courses into their course sequences. In either model, DE courses themselves can be structured in several different ways, with varying instructor affiliation (college faculty vs. qualified high school teachers), course location (college campus, high school, or elsewhere), and instructional modality (online or face-to-face). Despite the expansion of DE and growing interest in how DE shapes student success in college, policymakers, educational administrators, and practitioners do not have adequate information about which DE structures are most effective.

In this study, we constructed cohorts of recent high school entrants using statewide administrative data in Texas in order to study DE course enrollments and outcomes. We describe DE coursetaking and DE course characteristics for traditional Texas public high school students (as opposed to those attending an ECHS or charter school) who took DE courses through offerings at public two-year colleges, illustrating how students participate in DE (e.g., the types of courses taken and when in their high school career they took these courses) and highlighting typical course characteristics. We then examine how DE course and instructor characteristics predict student course completion, course grades, and subsequent college enrollment.

2. Literature Review

A large body of research demonstrates that DE increases immediate entry into college and early accrual of college credits, improving students' academic momentum and ultimately their degree attainment (An & Taylor, 2019; WWC, 2017). Most students gain access to DE courses through K-12 and college partnerships whereby students select discrete college courses from available offerings through their high school and a local college (College Board, 2017), which we refer to as the à la carte approach to DE. This approach stands in contrast to ECHS programs, which are immersive and provide coherent college course sequences and student support services (Edmunds et al., 2020). Quasi-experimental evidence confirms positive effects on college-going and completion of college-level courses among all DE participants, not just those concentrated in ECHS programming (An, 2013; Britton et al., 2019; Giani et al., 2014). However, the manner in which DE is implemented, including the subject offered, course location and modality, and instructor assigned, likely shapes student outcomes. DE course offerings and course structures vary greatly across—and within—institutions and regions (Fink et al., 2017; Villarreal, 2018). In our review of the literature, we explore which students take DE through traditional public high schools and community colleges, how those courses are typically structured, and how course characteristics shape student outcomes.

2.1 DE Student Characteristics and Coursetaking Patterns

DE coursework through public two-year colleges is offered at low or no cost to students in many states; DE may increase opportunities to earn college credit for underserved students where it is accessible to those populations (Education Commission of the States, 2022; Mehl et al., 2020). However, students from more privileged backgrounds tend to be overrepresented among DE coursetakers (Brown et al., 2018; Shivji & Wilson, 2019). Data from varying contexts illustrates that, on average, White students and more affluent students are more likely to enroll in DE programs than Black and Hispanic students and students from low-SES households (e.g., Hemelt & Swiderski, 2022; Hooker et al., 2021; Miller et al., 2017; Moreno et al., 2021; Shields et al., 2021; Taylor & Lichtenberger, 2013; Xu et al., 2021). At the same time, racial gaps in DE participation are smaller than in Advanced Placement (AP) or International Baccalaureate (IB) programs, which represent more costly alternatives for receiving college credit in state and local contexts where DE is subsidized, though DE funding structures can vary within and across states (Belfield et al., 2023; Hemelt & Swiderski, 2022; Xu et al., 2021).

Participation in DE varies across region and urbanicity (Miller et al., 2017), but school contexts also likely shape DE coursetaking patterns beyond participation. For example, when Tennessee schools worked to implement a statewide DE initiative, most public high schools offered only one DE course, and students subsequently took one DE course on average (Hemelt & Swiderski, 2022). In Texas, on the other hand, the proportion of public high school graduates who had participated in DE stagnated between 2011 and 2015, but DE participants began accumulating more DE credits within the same period (Miller et al., 2017). In fact, at the University of Texas system, the median college entrant brought in 18 college credits earned through DE (Troutman et al., 2018). While prior studies capture intensity of DE credit accrual, they do not illuminate timing of credit accrual during students' high school trajectory. Timing and total number of DE credits earned may predict subsequent college enrollment and credential attainment, though availability of DE coursework throughout the high school trajectory varies across contexts. Earlier and more intensive exposure to college credits may increase students' probability of earning a credential. At the same time, early exposure to college coursework, if students are not adequately prepared, might predict poorer course outcomes.

2.2 Structure of DE Courses and Impact of DE Course Characteristics on Student Outcomes

DE courses are offered through different combinations of instructor affiliations and course locations; they may be taught by college faculty or qualified high school teachers on a college campus, at the high school, or online. Further, students may enroll in DE courses that count toward academic degrees or for credit toward career and technical education (CTE). Thus, as institutions seek to expand DE offerings, they must determine which DE course subjects, instructional locations, and modalities to offer and which faculty to assign as instructors.

Course type and subject. Most DE course enrollments are in academic DE courses rather than in CTE DE, although half of public high schools in the country offer CTE DE courses (Thomas et al., 2013). For example, among Texas public high school graduates in 2012–2015, only 7% of DE course enrollments were in CTE DE courses (Miller et al., 2017). High school students in CTE DE courses experience an increased probability of high school graduation and college matriculation compared to their peers in non-college CTE coursework, even after controlling for prior achievement and socioeconomic status (Karp et al., 2007). However, recent evidence from Tennessee suggests that expanding CTE DE offerings rather than academic DE offerings (which often overlap with other opportunities, like AP) increased DE participation among underserved student populations but did not translate to increases DE course completion (Hemelt & Swiderski, 2022). The mechanisms that shape CTE DE course completion are unclear and were not explored in these studies, but CTE DE courses suffer from funding shortages and challenges in finding qualified teachers/industry partners, which may limit student success (The Dual Credit Task Force, 2018). Given variation in student backgrounds, course structures, and student outcomes across academic and CTE DE courses, research examining how DE implementation shapes student outcomes needs to differentiate between DE course types.

The majority of students in Texas who enroll in DE take academic general education courses, which should transfer across institutions, particularly for students planning to enroll in a public college after high school (Miller et al., 2017; Schudde et al., 2022). Core academic courses offered through DE often include English, history, and government, along with introductory math courses (Miller et al., 2017). More so than electives, DE courses taken in core academic subjects appear to positively predict students' postsecondary outcomes (Giani et al., 2014). Several studies investigate the efficacy of specific DE courses, particularly college algebra, a common prerequisite for STEM math coursework (e.g., Heavin, 2020; Hemelt et al., 2020; Minaya, 2021; Speroni, 2011). Leveraging Florida administrative data, Speroni (2011) found that taking DE college algebra positively predicted students' odds of college enrollment and completion, despite null effects for DE participation on average. Giani et al.'s (2014) research bolstered support for this result, illustrating that DE courses in math and science were stronger predictors of Texas college student outcomes than other DE courses. Compared to traditional college students who take an introductory-level academic course, DE students perform as well or better in subsequent courses in the same subject (Crouse & Allen, 2014; Radunzel et al., 2014).

Course location and modality. Nationally, approximately three quarters of high school entrants in 2009 who participated in DE took those courses at a high school, with 17% taking them on a college campus and 8% through online education (Shivji & Wilson, 2019). Exposure to community college faculty and campuses during DE may improve students' acclimation to and readiness for college (Karp, 2012; Speroni, 2011). The link between DE course location and student outcomes, however, is unclear. Findings from a study at a technical college in South Carolina suggest that students who took DE on the college campus, compared with those who took it at a high school, were more likely to persist in college, and results from Florida suggest that positive effects of DE coursework on college enrollment after high school are primarily driven by DE courses taken at the college, with no observed improvements in college enrollment among students taking DE at the high school (D'Amico et al., 2013; Speroni, 2011). However, recent estimates using nationally representative data leveraged an inverse probability weighting technique to address self-selection into courses and found no difference, on average, in immediate outcomes (such as enrolling in college and time to college enrollment) for students who took a DE course at a college campus compared with those at a high school, though more affluent students tended to benefit more from taking DE courses at a college campus than their lower SES peers (Hu & Chan, 2021). Extant research does not explore, to our knowledge, whether taking a DE course at the college campus predicts subsequent enrollment at a community college (or, more specifically, the DE host college), a practical concern that may be of interest to colleges, as DE may serve to recruit subsequent college enrollees.

In addition to course location, DE courses vary in instructional modality. The proportion of DE coursework taking place online appears to be increasing, both due to continued growth of online education in K-12 and higher education and increased dependency on online education since the COVID-19 pandemic (Barnett & Stamm, 2010; The College in High School Alliance, 2022). Evidence regarding the consequences of instructional modality for DE students' course outcomes is limited in scope; most research in this area relies on data from a small number of campuses and/or unadjusted means to evaluate the effects of instructional modality on DE student outcomes (e.g., Arnold et al., 2017; Holian et al., 2014; Lochmiller et al., 2016). Prior research on instructional modality for the broader population of community college students suggests that taking college courses online, compared with face-to-face, is associated with a lower probability of persistence in the course and a lower course grade (e.g., Xu & Jaggars, 2011; Xu & Jaggars, 2013). Despite online education's short-term negative influence on course performance, Ortagus (2018) found longer term positive associations with associate degree attainment and transfer to a four-year college, which he attributed to online education's alleviation of geographic constraints on accruing college credits. In the only large-scale study to date examining DE course modality and student outcomes, Liu et al. (2020) used state administrative data from Florida and regression analyses to estimate how the proportion of DE credits taken with different instructional modalities (majority of credits earned in face-to-face off-campus, face-to-face on-campus, or online courses) predicts high school graduation, college enrollment, and degree attainment.

Taking the majority of DE courses face-to-face—whether on or off campus—compared with online was associated with slightly larger improvements in high school graduation, immediate college enrollment, and subsequent persistence in the first year of college. The results varied across race/ethnicity, with Black students experiencing better outcomes when taking the majority of DE courses online and White and Hispanic students experiencing better outcomes when taking the majority face-to-face. Because the analyses were at the student level, with instructional modality captured as a proportion of all DE coursework taken by individual students, the study cannot estimate the relationship between instructional modality of a given course and course-specific outcomes such as passing the DE course or course grade.

Class size and composition. In implementing DE coursework, community college practitioners must decide whether to include both DE students and college-only students in the same course. In the only study (to our knowledge) examining the role of peer effects on course outcomes at community colleges, Liu and Xu (2022) found that the percentage of DE students enrolled in a community college course negatively predicts academic performance among non-DE students. The study did not, however, examine how mixed-composition classrooms—those with both college-only and DE students—influence the outcomes of DE students.

Class size may also predict student outcomes. Research in K-12 settings suggests that smaller classes improve students' academic performance, potentially through shifting instructional strategies of teachers and/or increased social and academic engagement among students, compared with their experience in larger classes (Finn et al., 2003). There is minimal evidence regarding the effects of class size in higher education, though some studies in university settings link larger class sizes to fewer interactions with faculty and peers and to lower grades (Beattie & Thiele, 2016; Johnson, 2010; Kokkelenberg et al., 2008).

Instructors of DE courses. Colleges often offer DE courses under constraints of instructor availability. Course offerings, course location, and instructor affiliation for DE courses are sometimes shaped by instructor availability rather than student needs or alignment with high-demand pathways (Fink et al., 2022; Patrick et al., 2020). Both across and within states, some community colleges rely primarily on their own faculty to teach DE, and others rely on qualified high school teachers (Mehl et al., 2020). Forty-one percent of DE courses experienced by 2015 Texas public high school graduates were taught by a high school teacher (Miller et al., 2017). The existing research on how instructors' institutional affiliation predicts DE students' outcomes is largely descriptive. Results range from no relationship between instructor type and course grade (Dixon & Slate, 2014) to a positive correlation between DE math sections led by high school instructors—compared with sections led by college instructors—and student GPAs (Hébert, 2001). Among students taking accredited DE courses in Arkansas, instructor affiliation did not appear to predict subsequent college enrollment (Taylor & Yan, 2018).

Qualitative research portrays high school instructors, at least from the student perspective, as more lenient than college faculty (Duncheon, 2020). Students describe high school DE instructors as offering them additional time and opportunities to redo assignments or to earn extra credit; college instructors, on the other hand, treat students more like adults, imposing fewer rules with less hand-holding (Duncheon, 2020; Edwards et al., 2011, p. 24). High school teachers who implement DE coursework often receive instruction from both the college (which is accountable for the college-level coursework) and their school, but their school's expectations may contradict those of the college and thus undermine implementation and course rigor (Duncheon & Relles, 2020). Anticipating differing standards across instructor affiliation, postsecondary faculty have voiced concern over the rigor of DE coursework taught by high school teachers—a common tension in states seeking to increase DE course availability while maintaining course rigor (Troutman et al., 2018).

Although the association between DE instructors' institutional affiliation and student outcomes has not been tested, research on traditional-age community college students (i.e., those who attend soon after high school) community college students demonstrates that faculty characteristics, including faculty contract type, predict student performance in introductory college courses (e.g., Ran & Sanders, 2020; Ran & Xu, 2019; Solanki & Xu, 2018). Taking a course with non-tenure-track faculty—compared with tenure-track faculty—positively predicts course grades but negatively predicts subsequent milestones like enrollment and performance in the next course; students also benefit more from full-time faculty than from part-time faculty (Ran & Sanders, 2020; Ran & Xu, 2019). It is unclear how these findings translate to DE students, though they may be particularly applicable to those experiencing DE on college campuses and taught by college instructors.

Decisions on which instructors teach DE are often constrained by college accreditation rules dictating instructor credentials. In Texas, our state of inquiry, all DE instructors teaching academic courses must meet the same standards as college faculty: They must, at a minimum, have a bachelor's degree plus 18 hours of graduate credits in the discipline of the subject they teach (Southern Association of Colleges and Schools Commission on Colleges [SACSCOC], 2018). For CTE DE courses, colleges have some additional flexibility and can substitute instructors' relevant work experience for years of education; the college is responsible for justifying and documenting instructor qualifications and for evaluating whether DE instructors meet the institutions' instructional standards (SACSCOC, 2019).

3. Study Objectives and Research Questions

States across the country are investing in DE programming, but they often do so with limited information about how to implement it, including which DE course structures and characteristics are most effective. Most research on DE focuses on specific DE models like ECHSs, which are disproportionately represented in the empirical literature; yet, most students taking DE across the country experience DE within traditional high schools. Building effective DE pipelines at two-year colleges requires additional evidence to inform DE policy and practice decisions facing states, schools, and college systems. As college and K-12 leaders seek to build partnerships and ensure adequate staffing and space for DE courses, they need evidence about the consequences of programming decisions.

This study makes several contributions toward understanding the role DE coursework plays in shaping student outcomes. Although several studies in the DE literature used state administrative data to examine student outcomes (e.g., Giani et al., 2014; Hemelt & Swiderski, 2022; Liu et al., 2020; Miller et al., 2017), prior research captured both students taking DE courses in traditional public schools and students participating in accelerated models or specialized curricula through ECHSs or charter schools, which makes it hard to decipher what DE coursetaking looks like for students under the common à la carte DE model. For that reason, we focus explicitly on students engaged in DE through the most common DE partnerships: traditional public high schools (i.e., not charter schools or ECHSs) working with public two-year colleges to offer DE. This allows us to examine student characteristics and coursetaking patterns and to estimate the relationship between DE course characteristics and their consequences for student outcomes under common DE conditions.

We follow recent cohorts of high school entrants who took DE at any point in their high school trajectory. By focusing explicitly on DE participants, we illuminate their coursetaking patterns and course characteristics and examine how DE course structures predict students' course outcomes and subsequent college enrollment behavior. This differs from the prior literature, which typically compares the course outcomes of DE students to current college students (i.e., those taking college courses not through DE) or compares the college enrollment outcomes of DE students to nonparticipants (e.g., An, 2013; Britton et al., 2019; Karp et al., 2007; Miller et al., 2017). Additionally, we run separate descriptive and inferential analyses for students in academic and CTE DE, which allows us to understand differences in student characteristics and coursetaking patterns, course and instructor characteristics, and student outcomes across DE course type.

To help meet the pressing need for information about how DE course characteristics shape student outcomes, we leverage data from Texas to address the following research questions (RQs):

1. What are the demographic and academic backgrounds of public high school students taking academic and CTE DE courses through Texas community colleges? What are common coursetaking patterns among those students?
2. How are academic and CTE DE courses structured, including instructional modalities, course location, course subject, and instructor assignments and characteristics?
3. How do DE course characteristics predict student outcomes?

4. Methods

To answer our research questions, we used statewide administrative data provided through a restricted-use agreement with the Texas Education Research Center (ERC), a research center and data clearinghouse at the University of Texas at Austin. Focusing on cohorts of traditional public high schoolers, we identified dual enrolled students—those enrolled in degree-bearing college-level courses during high school—who took those courses through public two-year colleges in the state. Community and technical colleges in the state enroll over 96% of all DE students, with public universities delivering the remaining 4% (Miller et al., 2017). We first used descriptive statistics to capture the characteristics of DE students and coursework. We then used regression analyses to explore the relationships between DE course characteristics and student outcomes, such as course completion and subsequent college enrollment.

4.1 Data

The ERC data includes student-level data for the entire population of secondary and postsecondary students in Texas. We primarily used data collected by the Texas Higher Education Coordinating Board (THECB), including student demographics, college enrollment, and transcript information (e.g., course enrollment and grades), as well as demographic and occupational information on course instructors. We also used K-12 data from the Texas Education Agency (TEA) that captures high school enrollment, graduation, course enrollment, and state standardized test scores, as well as employment records of high school teachers.

To create the analytic sample, we first identified public high school students who entered 9th grade in 2015 or 2016 (N = 724,825) and took at least one DE course through a Texas community college within four years of entry, by 2019 and 2020, respectively (N = 160,493). We focused on students who attended traditional high schools and took the DE courses through community colleges (N = 125,315). We used school names and identifiers to exclude students who attended Early College High Schools (ECHSs), Pathways to Technology Early College High Schools (P-TECHs), or Texas STEM Academies (T-STEMs), all of which integrate high school- and college-level courses into their course sequences. We also restricted the analytic sample to students with scores on required state tests for Algebra I and English II (N = 120,812), which enabled us to include the test scores as proxies for academic readiness in our regression models.

Approximately 78% of students took multiple DE courses within four years, resulting in 581,088 DE course enrollments among those 120,812 students. In order to capture instructor characteristics, including instructor type (which captures institutional affiliation and faculty rank), we included only courses with course instructor records (N [course] = 505,007); our need for instructor records required us to exclude DE courses from summer terms because THECB data only included instructor information for fall and spring course sessions. Finally, we also restricted the analytic sample to students who attended high school in school districts with 10 or more DE students. This was necessary to maintain a threshold of students in each district in order to control for variation across schools in our analytic models using fixed effects. With that restriction, the final analytic sample captured 497,399 DE course enrollments among 108,256 public high school students between fall 2015 and spring 2020. This sample represents the population of traditional public high school entrants in fall 2015 and 2016 who participated in DE at community colleges through spring 2019 and 2020 and did not have missing test scores or course instructor data.

Our analytic data set is structured at the student–course level, with separate observations by student–course. A given student is present in the data more than once if they took more than one DE course, which allows us to distinguish between DE course characteristics in our main regression analyses, as described in Section 4.3. Given the overlap in students across DE courses, we present descriptive statistics in two distinct ways: (1) for students enrolled in DE courses (separately by DE course type (academic or CTE) and (2) for unique DE course sections. Cutting the data in these two different ways offers insights about which students take DE (the student-level descriptives) and how course sections were structured (the course-level descriptives).

4.2 Variables

Our main independent variables of interest include DE course characteristics and instructor characteristics. For a full description of the variables used in our analyses, along with descriptive statistics for the full analytic sample, see Appendix Table A1. In each of our analyses, we delineated two DE course types—academic and CTE—based on preliminary analyses which showed that academic and CTE courses characteristics and outcomes were substantially different from one another. Using THECB data, we were able to capture DE class size, semester credit hours, broad course subject areas, class composition (an indicator of whether course enrollments include a mix of high school and college students), and whether the course was lecture based (as opposed to a lab or independent study). We also captured DE course location—at a high school, community college, or another location (including at a multi-institution teaching center or system center)—and instructional modality. Although modality is somewhat related to course location, we found some variation across the two measures that motivated us to keep them separate. For example, although 90% of students taking DE courses at their high school took those courses face-to-face, a third of students taking a DE course at the community college took the courses through an online or hybrid format, and over half of students taking a DE course at another location took it online. In addition to DE course characteristics, we captured the grade in which students took DE courses, which allows us to understand their DE coursetaking patterns during high school.

We were also able to include characteristics of DE course instructors, including gender, race/ethnicity, age, instructor type (which captures institutional affiliation, as well as instructor rank and employment intensity), educational attainment, and nine-month salary. When a course listed more than one instructor for a given DE course, we determined instructor of record by considering educational degree attainment (to delineate between main instructors and teaching assistants), faculty responsibility for the course (captured as percentage of course-specific teaching time), and teaching time (captured as percentage of appointment related to instruction). For instructor type, we identified instructor affiliation by matching employee identification numbers from the THECB data with those from the TEA; we considered an instructor to be a high school teacher if they were concurrently employed at a school and college (following Miller et al., 2017). For high school instructors, their appointment as a high school teacher superseded their categorization as non-tenure-track employees at the DE host college so we could distinguish between high school teachers and other non-tenure-track faculty at the community college.

We were also able to include a host of student demographic and academic background measures, which we use as descriptors of the DE students and as statistical controls in our regressions. TEA data include indicators of gender, race/ethnicity, and receipt of free or reduced-price lunch. As proxies for academic readiness, we leveraged scores from the State of Texas Assessments of Academic Readiness (referred to as STAAR tests)—a series of state-mandated standardized tests used in Texas public primary and secondary schools—in Algebra I and English II. We calculated individual students' z-scores on each test taken. We also included an indicator that shows whether students participated in AP or IB coursework.

To capture student performance in a given DE course, we created two course outcome measures: (1) passing the DE course (receiving a final grade of A, B, C, or P, for pass) and (2) course grade (numeric grade captured on a 4-point scale). To measure subsequent success, we captured three college enrollment outcomes within one year of high school graduation: (1) whether students enrolled in any Texas postsecondary institution, including both public and private institutions; (2) whether students enrolled in a Texas public four-year university; and (3) whether students enrolled in a Texas public two-year college.

4.3 Analytic Strategy

To understand which public high school students participate in DE through community colleges (RQ1) and what those DE courses look like (RQ2), we leveraged descriptive statistics. To examine which variables predict DE student outcomes (RQ3), we performed a series of logistic regressions for our dichotomous dependent variables, which include passing the DE course and enrolling in college post-high school. We used ordinary least squares (OLS) regression to predict numerical course grade. We ran separate regression models for each DE course type (academic or CTE) to estimate the relationships between course and instructor characteristics and student course outcomes.

For our main analytic models, to address RQ3, we had to grapple with the cross-classified nature of the data. In analyzing our student-course data set, we acknowledge that analytic variables can be classified at two distinct and hierarchical levels (i.e., student level and course level), where students are nested in DE courses, but courses are also nested in students. Traditionally, multilevel modeling (also known as hierarchical linear modeling) has been a powerful framework to analyze clustered data where individuals or observations are nested within groups; however, the approach assumes that each lower level unit should appear only once in each higher level group—for example, it anticipates that students will be nested in classes but only appear in one class (Oshchepkov & Shirokanova, 2020; Vacca et al., 2022). Our data structure does not align with that assumption because the students take multiple DE courses. The cross-classified nature of our data means it is not appropriate to disaggregate to distinct levels for multi-level analysis, though aggregating to a single level also risks biasing results due to clustering. To address this issue, we analyzed the student course data primarily at the course level—where we included the structure and characteristics of DE coursework as the focal independent variables in our analytic models—but also employed robust clustered standard errors at the individual student level to account for correlation between repeated observations (i.e., multiple courses) within each student.

For our dichotomous outcomes, we used the following logit model for student *i* in cohort *j* at district *k* in semester *t*:

$$Logit\ (pijkt) = b0 + b1X1 + b2X2 + \dots + bnXn + \xi j + \theta k + \lambda t$$

where *pijkt* is the probability of a discrete outcome occurring, *b0* is the intercept, *X1–Xn* are the independent variables, *b1–bn* are the associated regression weights, ξj is cohort fixed effects, θk is district fixed effects, and λt is semester fixed effects. Independent variables include student demographic and academic measures, DE course characteristics, and DE instructor characteristics. For college enrollment outcomes, we also included passing the DE course as an independent variable in the regressions. Given that DE offerings and experiences may vary across schools and over time, we included fixed effects for school district, cohort, and semester in all regression models to help us address this endogeneity (Cameron & Miller, 2015). As noted above, we also used robust cluster-adjusted standard errors with individuals as the clustering variable to further account for within-individual error correlation and heteroskedasticity, given the nesting of courses within individuals (Angrist & Pischke, 2009; Cameron & Miller, 2015). The logit transformation ensures that the predicted probability of the outcome lies within the 0–1 bound and tends to linearize the association between the predicted dichotomous outcome and the set of predictors (Raudenbush & Bryk, 2002). In the analysis for numerical course grade, we leveraged OLS regression to estimate the relationship between the same set of independent variables and the outcome.

Because we rely on regression, the results do not represent causal relationships. However, given the observational nature of our data and our research questions, a regression with rich covariates is our strongest analytic strategy for examining which course features predict student success. We included a variety of statistical control variables capturing student and instructor background; nevertheless, the estimated relationships could still partially be explained by unobserved factors. We acknowledge that several factors that may predict students' course selection and outcomes, such as motivation, social networks, and instructional quality, are unobservable in the data. Thus, the results are correlations that partially reflect sorting into specific DE courses; that is, some students are more inclined to enter a specific type of course than others, and those unobserved characteristics may also predict subsequent academic outcomes. However, since we are comparing within a sample of students enrolled in different DE course types (separate analytic samples of academic DE students and CTE DE students), selection bias is likely less concerning than in studies comparing DE participants to nonparticipants (as is common in most of the research on DE). Further, despite these limitations, the results stand to inform the literature on DE implementation and the state of knowledge about DE more generally.

5. Results

In what follows, we present descriptive patterns illustrating the characteristics of DE students and courses, followed by inferential findings from our regression analyses linking DE course characteristics to course outcomes and college enrollment outcomes. We begin by describing students who took DE through community colleges, both in terms of their demographics and their DE coursetaking patterns (RQ1). We then describe the structures and characteristics of DE courses experienced in the analytic sample (RQ2). Lastly, we present regression results (RQ3).

5.1 Who Takes DE and What Type of DE Courses Do They Take?

Table 1 presents means and standard deviations of student characteristics, coursetaking patterns, and college enrollment outcomes for DE students at traditional public high schools, broken down by type of DE courses taken (academic DE, CTE DE, or both). The bulk of students in our analytic sample—81%—took only academic DE courses (whom we refer to as academic DE students), with 12% taking only CTE DE (CTE DE students) and 7% taking a mix of academic and CTE DE courses (academic-CTE DE students). We observed clear differences in the demographic composition of students across DE course type. Women comprised 60% of academic DE students and only 39% of CTE DE students. Among academic DE students, 49% identified as White, 37% as Hispanic, 7% as Black, and 5% as Asian. Hispanic students comprised the majority of CTE and academic-CTE DE students. Black students appear overrepresented among CTE DE students and underrepresented among academic and academic-CTE DE students, whereas several other groups, like White, Asian, and students identified as "other," were disproportionately enrolled in academic and academic-CTE DE coursework. Two thirds of CTE DE students were from low-income families, qualifying for free or reduced-price lunch, compared with 32% of academic DE students.

Table 1. Descriptive Statistics of DE Students by Coursetaking Type

Variable	DE Student by Coursetaking Type		
	Academic DE (% or M)	CTE DE (% or M)	Academic-CTE DE (% or M)
Student *N*	87,669	13,054	7,533
Student characteristics			
Female	59.8%	38.8%	58.3%
Asian	4.8%	1.4%	2.7%
Black	6.6%	9.6%	5.8%
Hispanic	37.3%	59.9%	50.4%
White	48.7%	27.5%	39.3%
Other	2.6%	1.6%	1.8%
Low-income student	32.1%	62.6%	45.4%
AP/IB participant	68.8%	30.2%	57.7%
Algebra I test score	4,385	3,977	4,314
English II test score	4,453	3,997	4,352
DE coursetaking patterns			
Number of courses taken	4.6	2.8	7.7
Took first DE course in 9th grade	1.7%	3.6%	2.9%
Took first DE course in 10th grade	3.7%	13.2%	7.9%
Took first DE course in 11th grade	37.8%	38.1%	38.0%
Took first DE course in 12th grade	56.8%	45.1%	51.3%
Passed course	91.6%	86.6%	91.3%
DE course grade	3.2	3.1	3.3
College enrollment after high school			
Enrolled in any college in Texas	77.0%	41.4%	76.1%
Enrolled in a Texas public university	43.2%	10.2%	39.4%
Enrolled in a Texas public two-year college	34.2%	30.9%	38.1%

Notes. *N* (student) = 108,256. The table outlines student characteristics, DE coursetaking patterns, and college enrollment outcomes of DE students, reported at the student level. We provide means for continuous variables and percentages for categorical measures. Columns 1 and 2 show results for students who took academic DE only and students who took CTE DE only, respectively. Column 3 shows results for students who took both academic DE and CTE DE.

Academic backgrounds, coursetaking patterns, and college enrollment outcomes also varied across DE course types. Average Algebra and English STAAR scores—measures of academic readiness—were lower among CTE DE students than among academic or academic-CTE DE students. Perhaps not surprisingly, over two thirds of academic DE students also participated in AP or IB (with academic-CTE DE students close behind), whereas fewer than a third of CTE DE students did. Compared with DE students who took only one type of DE, academic-CTE DE students, although the smallest subgroup, took substantially more DE courses, with almost eight courses on average. Academic and CTE DE students took an average of approximately five and three DE courses, respectively. We also illustrate the timing of DE coursetaking during students' four years in high school. In all three groups, students predominantly experienced their first DE course in 11th and 12th grade, but once again we see differences across DE course types, with CTE DE students more likely to take their first DE courses earlier than the other two groups. Approximately 17% of CTE DE students took the first DE course in 9th or 10th grade compared with 5% and 11% of academic and academic-CTE DE students, respectively. In terms of DE course outcomes, we see high passing rates in all three groups of students, though the rate was slightly lower among CTE DE students than among students enrolled in any academic DE courses. The average DE course grade looked fairly similar across DE course types, with students earning just above 3.0 (equivalent to a B). College enrollment outcomes, however, differed across DE course type: Students in academic DE courses were much more likely to subsequently enroll in college than students in only CTE DE, though they were not much more likely than CTE DE students to enroll in a two-year college.

5.2 How Are DE Courses Structured and Who Teaches the DE Courses?

Table 2 presents averages and percentages for course and instructor characteristics of all unique DE sections in the analytic sample, shown separately for academic and CTE courses. The average class size of academic DE courses was larger than that of CTE DE courses by about 10 students. Both courses were worth 3 credits on average and predominantly lecture based (87% of academic DE courses and 85% of CTE DE courses) as opposed to a lab or independent study. Instructional modality appears to differ across DE course types; although both academic and CTE courses were more likely to be offered face-to-face (vs. online or hybrid), far fewer CTE DE sections (only 10%) were offered online than academic DE sections (34%). More than half of CTE DE sections (56%) were offered on college campuses, with a third on high school campuses (33%) and 12% at other locations. The course location for academic DE courses was more varied, with 46% offered on college campuses, 32% on high school campuses, and 22% at other locations. The majority of DE sections for both course types were comprised exclusively of high school students, but a greater portion of academic DE courses (45%) than CTE DE courses (30%) were of mixed composition. The bulk of academic DE course sections were in humanities and liberal arts (51%), followed by social and behavioral sciences (25%) and STEM (22%), whereas the majority of CTE DE course sections were in industry/agriculture/manufacturing/ construction (34%), followed by STEM (20%) and health (19%).

Table 2. Descriptive Statistics of DE Courses by Course Type

Variable	DE Course Type	
	Academic DE (% or M)	CTE DE (% or M)
Unique Course Section *N*	60,060	11,401
Course characteristics		
Class size	22.2	12.6
Number of credits	3.1	3.2
Lecture section	86.7%	85.1%
Instructional modality		
Face-to-face	64.0%	87.6%
Online	34.2%	10.2%
Hybrid	1.8%	2.2%
Course location		
On high school campus	32.2%	32.5%
On college campus	46.3%	55.7%
At other location	21.5%	11.8%
Mixed course composition	45.4%	29.8%
Broad course subject		
Humanities, liberal arts, and general studies	50.8%	2.1%
Social and behavioral sciences	24.6%	3.3%
STEM	21.7%	20.1%
Education	0.6%	0.3%
Business	0.5%	8.5%
Health	0.2%	19.2%
Industry/agriculture/manufacturing/construction	0.7%	33.7%
Service-oriented	0.9%	12.8%
Instructor characteristics		
Female	56.4%	41.4%
Race/ethnicity		
Asian	3.4%	0.9%
Black	5.9%	7.3%
Hispanic	15.3%	26.9%
White	70.1%	57.5%
Other	5.3%	7.5%
Age	47.8	47.8
Instructor type		
High school teacher	37.0%	46.2%
TT/Tenured	11.9%	8.0%
Full-time NTT	25.2%	32.1%
Part-time NTT	19.7%	11.2%
Unknown	6.4%	2.4%
Highest education level		
Associate degree or less	3.7%	45.5%
Bachelor's degree	1.9%	32.0%
Master's degree	77.9%	20.5%
Doctoral degree	16.5%	2.0%
Calculated 9-month salary	$31,355	$25,318

Notes. *N* (course) = 71,461. The table describes characteristics of DE courses and instructors, reported at the course level. We provide means for continuous variables and percentages for categorical measures. Columns 1 and 2 show results for academic DE courses and CTE DE courses, respectively.

Table 2 also presents instructor characteristics and instructor type, which captures institutional affiliation and contract type, for academic and CTE DE courses. The descriptive statistics highlight differences in instructors across DE course type. Fifty-six percent of academic DE course sections were taught by female instructors compared with only 41% of CTE DE sections. White faculty taught approximately 70% of academic DE course sections and 58% of CTE DE course sections. In contrast, Hispanic faculty taught only 15% of academic DE courses and nearly 27% of CTE DE course sections. Instructor type differed across DE course types. When combining full-time non-tenure-track (NTT) faculty with part-time NTTs, who less commonly served as instructors, NTT faculty were the predominant instructors in both academic and CTE DE. Forty-five percent of academic DE course sections were taught by NTT community college faculty (most of whom worked full-time for the college), 37% were taught by high school teachers, and 12% were taught by tenure-track (TT) or tenured faculty. A larger proportion—46%—of CTE DE courses were taught by high school teachers, with 43% taught by NTT faculty (again, primarily those working full-time at the college) and only 8% by TT/tenured faculty. Most academic DE instructors held a graduate degree, whereas the most prevalent level of educational attainment among CTE DE instructors was an associate degree or less.

5.3 Regression Results: Course Outcomes and Subsequent College Enrollment

We next turn to results for a series of regression models predicting DE course and college enrollment outcomes, run separately for academic and CTE DE course enrollments. For ease of interpretation, we present results for logistic regressions (those performed for dichotomous outcomes) as average marginal effects (AMEs), which can be interpreted as the change in the predicted probability of the outcome for each additional unit of the independent variable.

Predictors of DE course passing and grade. Table 3 shows the estimated relationships between DE course characteristics and course outcomes for both DE course types. To better interpret regression results, it is helpful to review the mean course outcomes for each of the analytic subsamples: Among academic DE coursetakers, 91.5% passed the DE course, with an average grade of 3.164; among CTE DE coursetakers, 88.4% passed the DE course, with an average grade of 3.196. We begin by describing common predictors of DE course outcomes for both academic and CTE DE coursetakers. Taking the DE course before 12th grade, for example, is negatively associated with course outcomes in both academic and CTE DE courses; students who took a DE course in 9th, 10th, or 11th grade experienced a decrease in their probability of passing the course and in their course grade compared with students who took a DE course in 12th grade. Instructional modality of DE courses also appears consequential for both DE course types, where taking the course face-to-face is associated with better course outcomes. For example, academic DE students who enrolled in an online section or a hybrid section experienced a 4.2- and 1.9-percentage-point decrease in the probability of passing the course, respectively, compared with students who took a face-to-face section (AME = -.042, SE = .002, $p < .001$; AME = -.019, SE = .004, $p < .001$). This also translated to lower grades in the course. Mixed course composition also appears to negatively predict course passing and final course grade for both DE course types; for example, taking the academic DE course with both high school and college students decreased a DE student's probability of passing by 2.9 percentage points compared with taking it with only other high school students (AME = -.029, SE = .002, $p < .001$).

Other course characteristics also shaped student outcomes, but the patterns are mixed across the two DE course types. For academic DE courses, class size appears to have small positive relationships with passing a DE course and final course grade, whereas for CTE DE courses, class size has a small negative relationship with course grade. This suggests academic DE students benefited from larger classes—or, at the least, they did not constrain student outcomes—while CTE DE students benefited from smaller classes (at least in terms of course grade). Course location also shaped DE course outcomes. In academic DE courses, taking the course somewhere other than the high school (at the college or another location) is negatively associated with passing the course and with course grade. For example, students who took the academic DE course at the college campus experienced a .01-unit decrease in their final course grade (out of a 4.0 scale) compared with students who took the course at the high school (B = -.011, SE = .007, $p < .001$). For students in CTE DE courses, taking the course at the college rather than at the high school is also negatively correlated with course grade; however, taking the CTE DE course at another location (not high school or college) positively predicts both passing the course and course grade compared with taking it at the high school. The subject area of DE courses also appears correlated with DE course outcomes, with some differences in patterns across academic and CTE DE. For example, for students in academic DE courses, taking a course in a STEM, business, or health field, compared with taking a course in humanities and liberal arts (the reference), is associated with a lower probability of passing the course. For students in CTE DE courses, taking a course in social and behavioral sciences and health appears negatively related to passing the course compared with taking a course in humanities and liberal arts.

DE instructor characteristics also predict course outcomes. For both DE course types, taking a DE course with an instructor from the college—compared with a high school teacher—is generally associated with a lower probability of passing the course and a lower course grade. For example, students in academic DE course sections with full-time NTT instructors experienced a 1.6-percentage-point decrease in their probability of passing the course and a 0.04-unit decrease in final grade, compared with students in sections with high school teachers (AME = -.016, SE = .002, $p < .001$; B = -.036, SE = .007, $p < .001$). The only exception is that, for academic DE courses, taking DE with a part-time NTT faculty—compared with taking it with a high school teacher—is positively associated with course grade, although it negatively predicts passing the course. To further explore the relationship between instructor type and course outcomes, we present the interaction between instructor type and course location in supplemental analyses in Appendix Table A2. We show that CTE DE students experienced a decrease in their probability of passing the course and in their course grade when enrolled in a DE course with college faculty on a college campus (or another location) compared with a course with a high school teacher on a high school campus, whereas students in academic DE experienced a slight increase in their probability of passing the course (but a somewhat lower final course grade) in conditions with college faculty at a college (or other non-high-school) location compared with a course taught by a high school teacher at a high school campus.

Instructor demographics, such as gender, race/ethnicity, and age, are also associated with course outcomes, though results are mixed across DE course type and the two course outcomes. We also observe mixed relationships between the instructor's degree attainment and course outcomes. Taking a DE course with an instructor with a bachelor's degree, compared with an associate degree or below, positively predicts passing the course for both academic and CTE DE. However, our results suggest that taking a DE course with an instructor with a graduate degree negatively predicts course grade, wherein holding a master's degree is significant for CTE DE and doctorate is significant for academic DE.

Table 3. Results for Regression Models Predicting DE Course Outcomes

Variable	Passed the Course		Course Grade	
	Academic DE AME (SE)	CTE DE AME (SE)	Academic DE Coefficient (SE)	CTE DE Coefficient (SE)
Timing of DE coursetaking				
School grade (Ref. = In 12th grade)				
In 9th grade	-0.093*** (0.009)	-0.219*** (0.031)	-0.299*** (0.045)	-0.709*** (0.115)
In 10th grade	-0.075*** (0.008)	-0.128*** (0.019)	-0.238*** (0.033)	-0.459*** (0.078)
In 11th grade	-0.038*** (0.003)	-0.049*** (0.008)	-0.191*** (0.017)	-0.199*** (0.041)
DE course characteristics				
Class size	0.000*** (0.000)	0.000 (0.000)	0.001*** (0.000)	-0.004*** (0.001)
Number of credits	-0.002 (0.001)	-0.001 (0.002)	-0.050*** (0.005)	-0.059*** (0.007)
Lecture section	-0.005 (0.002)	0.030*** (0.007)	-0.036*** (0.009)	-0.111*** (0.021)
Instructional modality (Ref. = Face-to-face)				
Online	-0.042*** (0.002)	-0.038*** (0.011)	-0.110*** (0.008)	-0.392*** (0.035)
Hybrid	-0.019*** (0.004)	0.007 (0.012)	-0.067*** (0.013)	-0.110* (0.050)
Course location (Ref. = On high school campus)				
On college campus	-0.009*** (0.002)	0.004 (0.006)	-0.011*** (0.007)	-0.055** (0.017)
At other location	-0.008*** (0.002)	0.022* (0.009)	-0.034*** (0.009)	0.103** (0.037)

Mixed course composition	-0.029*** (0.002)	-0.035*** (0.005)	-0.036*** (0.005)	-0.055** (0.018)
Broad course subject (Ref. = Humanities, liberal arts, and general studies)				
Social and behavioral sciences	-0.001 (0.001)	-0.047** (0.016)	-0.016*** (0.004)	-0.070 (0.045)
STEM	-0.043*** (0.002)	-0.012 (0.011)	-0.153*** (0.005)	-0.010 (0.034)
Education	0.002 (0.007)	0.082** (0.017)	0.201*** (0.036)	0.479*** (0.104)
Business	-0.014* (0.009)	-0.007 (0.013)	0.000 (0.038)	-0.043 (0.039)
Health	-0.057*** (0.014)	-0.065*** (0.013)	-0.039 (0.052)	-0.121** (0.038)
Industry/agriculture/manufacturing/construction	0.004 (0.007)	0.019 (0.011)	0.055 (0.028)	0.016 (0.035)
Service-oriented	0.016* (0.005)	0.007 (0.012)	0.172*** (0.030)	-0.021 (0.038)
DE course instructor characteristics				
Female	-0.001 (0.001)	-0.005 (0.005)	-0.002 (0.003)	-0.069*** (0.015)
Race/ethnicity (Ref. = White)				
Asian	-0.011*** (0.003)	0.030 (0.017)	-0.088*** (0.010)	0.090 (0.073)
Black	-0.007*** (0.002)	0.018* (0.007)	-0.009 (0.008)	-0.043 (0.027)
Hispanic	-0.001 (0.002)	0.006 (0.006)	0.055*** (0.006)	0.044* (0.019)
Other	-0.007*** (0.002)	0.018* (0.007)	0.009 (0.007)	-0.042 (0.025)
Age	0.000*** (0.000)	0.000* (0.000)	0.000 (0.000)	0.001* (0.001)

Instructor type (Ref. = High school teacher)				
TT/Tenured	-0.011***	-0.086***	-0.011	-0.391***
	(0.002)	(0.011)	(0.009)	(0.033)
Full-time NTT	-0.016***	-0.063***	-0.036***	-0.273***
	(0.002)	(0.006)	(0.007)	(0.022)
Part-time NTT	-0.018***	-0.057***	0.025***	-0.267***
	(0.001)	(0.008)	(0.005)	(0.025)
Unknown	-0.012***	-0.007	-0.011	-0.032
	(0.003)	(0.012)	(0.013)	(0.056)
Highest education level (Ref. = Associate degree or less)				
Bachelor's degree	0.014***	0.013**	0.059***	-0.029
	(0.004)	(0.004)	(0.014)	(0.015)
Master's degree	0.004	0.004	0.015	-0.042*
	(0.003)	(0.005)	(0.009)	(0.018)
Doctoral degree	-0.002	0.011	-0.029**	0.012
	(0.003)	(0.013)	(0.011)	(0.050)
Calculated 9-month salary	0.000***	0.000	0.000***	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Sample Size	440,571	53,956	426,788	52,563

Notes. The table presents regression results, and each column represents a separate regression model. We used logistic regression for course passing and OLS regression for numerical letter grades captured on a 4-point scale. The top grade is an A, which equals 4; the lowest grade is an F, which equals 0; and the other grades are B, C, and D. All models included the following student characteristics: gender, race/ethnicity, low-income status, AP or IB participation, a z-score for their Algebra I test score, and a z-score for their English II test score. All models also included cohort, semester, and district fixed effects and used robust standard errors clustered by individual students. We present average marginal effects (AMEs) and standard errors (SEs) for each covariate included in the binary logistic regression models. The first two analyses included the entire sample, and the subsequent analyses included students who earned numerical course grades. The sample size across outcomes varies slightly due to the inclusion of both semester and district fixed effects, where some districts with no variation in a given outcome during a given term were dropped from those analyses. For ease of interpretation of the sample, the means for the outcomes of interest in each of the four regressions are: passed the academic DE course: 0.915; passed the CTE DE course: 0.884; grade in the academic DE course: 3.164; grade in the CTE DE course: 3.196.

* $p < .05$, ** $p < .01$, *** $p < .001$.

Predictors of subsequent postsecondary education after high school. Table 4 presents regression results for college enrollment outcomes, including enrolling in any Texas postsecondary institution, enrolling in a Texas public university, and enrolling in a Texas public two-year college for subsequent postsecondary education after high school. (Additional results for enrolling in a private college or enrolling specifically at the DE host college are located in Appendix B.) The models are the same as those run for DE course outcomes, except that we added a measure of whether students passed the DE course as a predictor. Mean college enrollment outcomes for the analytic samples once again help contextualize our results: Among academic DE coursetakers, 80.3% enrolled in any college in Texas, 49.2% initially enrolled in a Texas public university, and 33.8% initially enrolled in a Texas public two-year college; among CTE DE coursetakers, 53.0% enrolled in any college in Texas, 20.1% at a Texas public university, and 35.9% at a Texas public two-year college.

Whether students passed the DE course and the timing of that course appear to shape college enrollment outcomes. Passing the DE course is associated with an 11.9- and 10.0-percentage-point increase in the probability of enrolling in any Texas postsecondary institution after high school for students in both academic and CTE DE courses, respectively (AME = .119, SE = .003, $p < .001$; AME = .100, SE = .008, $p < .001$). Course passing also appears consequential for subsequent enrollment at Texas public universities by students in both academic and CTE DE courses, while passing an academic DE course—compared with passing a CTE DE course—has a stronger relationship with the public-university enrollment outcome. Passing the DE course significantly predicts enrollment at Texas public two-year colleges after high school, but the direction of the relationship is mixed for the two DE course types: Passing an academic DE course negatively predicts enrolling in a Texas two-year college, whereas passing a CTE DE course positively predicts two-year college enrollment. The timing of coursetaking is also a significant predictor of college enrollment after high school. For example, taking a course in 9th, 10th, or 11th grade, compared with 12th grade, is negatively correlated with enrolling in any Texas college and enrolling in a Texas public two-year college after high school for both DE course types; however, the relationship between the timing of coursetaking and public university enrollment appears significant for CTE DE courses only, suggesting that the negative relationship observed between early academic DE coursetaking and subsequent college enrollment is driven primarily by two-year college enrollment.

Several DE course characteristics also predict college enrollment outcomes. The most consistently positive predictor of enrolling in any Texas college and enrolling in a Texas public two-year college is mixed course composition. Students taking the course with college-only students—compared with those taking it only with other DE students—experienced increased probabilities of enrollment in any Texas college and in a Texas public two-year college for both DE course types; the association appears stronger for CTE DE courses than for academic DE courses. Taking the DE course on the college campus also predicts any college enrollment and public two-year college enrollment in Texas. For academic DE courses, taking the course at the college, compared with at the high school, is associated with a 0.9-percentage-point increase in a student's probability of enrolling in any college in Texas and a 1.5-percentage-point increase in their probability of enrolling in a Texas public two-year college after high school (AME = .009, SE = .004, $p = .016$; AME = .015, SE = .004, $p < .001$). For CTE DE courses, taking the course at the college, compared with at the high school, is associated with a 3.0-percentage-point increase in the probability of enrolling in a Texas public two-year college (AME = .030, SE = .011, $p < .004$). Relationships between other DE course characteristics and college enrollment outcomes are more mixed across DE course type and outcome. For example, for CTE DE courses, credit hours negatively predict, and lecture-based sections positively predict, enrolling in any Texas college and in a Texas public two-year college after high school. For academic DE courses, credit hours positively predict enrolling in a Texas public university but negatively predict enrolling in a Texas public two-year college.

The instructional modality of DE courses appears consequential for subsequent college enrollment among students in academic DE courses, wherein taking the course online, compared with face-to-face, is associated with a 1.2- and 2.2-percentage-point increase in the probability of any college enrollment and public university enrollment, respectively (AME = .012, SE = .003, $p < .001$; AME = .022, SE = .004, $p < .001$). If we extrapolate from the mean college enrollment rates of academic DE coursetakers, this roughly translates to a shift from 80.3% enrolling in any Texas college and 49.2% enrolling in a Texas public university to 81.5% and 51.4%, respectively.

DE course instructors' characteristics, particularly instructor type and instructors' education background, also appear to shape students' college enrollment outcomes. Students taking a DE course taught by college faculty, compared with high school teachers, generally experienced increased probabilities of college enrollment outcomes, though the positive relationships are only present for some subgroups of college instructors, primarily predicting small shifts in any college enrollment and public university enrollment for academic DE students and a larger shift in enrollment at public two-year colleges for CTE DE students. For example, taking an academic DE course with a part-time NTT or unknown type of instructor (note that the "unknown" designation typically occurred at colleges with no faculty ranks) is associated with a 0.6- and 1.2-percentage-point increase, respectively, in the probability of enrolling in any Texas college after high school (AME = .006, SE = .002, $p = .012$; AME = .012, SE = .006, $p = .049$). Taking a CTE DE course with a part-time NTT college instructor, compared with a high school instructor, predicts a 5.1-percentage-point increase in the probability of enrolling in a Texas public two-year college (AME = .051, SE = .014, $p < .001$). We also observe positive relationships between CTE DE instructors' education background and enrolling in any Texas postsecondary institution and enrolling in a Texas public university after high school, suggesting students may benefit from CTE DE courses taught by instructors with higher educational attainment, despite the fact that CTE courses do not require instructors to have a four-year degree.

Table 4. Results for Regression Models Predicting College Enrollment Outcomes After High School

Variable	Enrolled in Any College in Texas		Enrolled in a Texas Public University		Enrolled in a Texas Public Two-Year College	
	Academic DE	CTE DE	Academic DE	CTE DE	Academic DE	CTE DE
	AME (SE)	AME (SE)	AME (SE)	AME (SE)	AME (SE)	AME (SE)
Passed the DE course[a]	0.119*** (0.003)	0.100*** (0.008)	0.152*** (0.004)	0.037*** (0.006)	-0.015*** (0.003)	0.083*** (0.008)
Timing of DE coursetaking						
School grade (Ref. = In 12th grade)						
In 9th grade	-0.191*** (0.054)	-0.311*** (0.078)	-0.064 (0.052)	-0.191** (0.054)	-0.174*** (0.044)	-0.258** (0.067)
In 10th grade	-0.106*** (0.031)	-0.211*** (0.055)	0.001 (0.035)	-0.142** (0.048)	-0.138*** (0.032)	-0.195*** (0.053)
In 11th grade	-0.056*** (0.014)	-0.124*** (0.028)	-0.007 (0.018)	-0.076* (0.031)	-0.073*** (0.019)	-0.125*** (0.031)
DE course characteristics						
Class size	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Number of credits	0.004 (0.002)	-0.010** (0.003)	0.010*** (0.003)	-0.003 (0.002)	-0.007** (0.003)	-0.010** (0.003)
Lecture section	-0.003 (0.004)	0.032** (0.011)	-0.005 (0.005)	0.001 (0.008)	0.007 (0.005)	0.044*** (0.011)
Instructional modality (Ref. = Face-to-face)						
Online	0.012*** (0.003)	0.011 (0.017)	0.022*** (0.004)	-0.005 (0.012)	0.000 (0.004)	-0.005 (0.017)
Hybrid	0.004 (0.006)	0.005 (0.023)	-0.003 (0.007)	-0.010 (0.019)	0.000 (0.007)	0.034 (0.025)
Course location (Ref. = On high school campus)						
On college campus	0.009* (0.004)	0.009 (0.010)	-0.004 (0.004)	-0.005 (0.008)	0.015*** (0.004)	0.030** (0.011)

At other location	0.002 (0.004)	0.022 (0.021)	-0.007 (0.005)	0.023 (0.016)	0.011* (0.005)	0.009 (0.021)
Mixed course composition	0.006* (0.002)	0.047*** (0.009)	-0.002 (0.003)	0.005 (0.007)	0.011*** (0.003)	0.052*** (0.010)
Broad course subject (Ref. = Humanities, liberal arts, and general studies)						
Social and behavioral sciences	-0.003 (0.001)	0.006 (0.025)	0.001 (0.002)	-0.009 (0.018)	-0.006*** (0.002)	0.027 (0.026)
STEM	0.000 (0.002)	-0.032 (0.019)	0.017*** (0.002)	0.006 (0.013)	-0.012*** (0.002)	-0.019 (0.020)
Education	-0.036* (0.015)	0.128* (0.058)	-0.040* (0.016)	0.081 (0.051)	-0.014 (0.015)	-0.071 (0.063)
Business	-0.026 (0.018)	-0.029 (0.023)	0.037 (0.020)	0.014 (0.016)	-0.037 (0.019)	-0.036 (0.023)
Health	-0.005 (0.017)	0.032 (0.022)	0.013 (0.020)	0.034* (0.016)	0.003 (0.020)	0.063** (0.023)
Industry/agriculture/manufacturing/construction	-0.018 (0.011)	-0.102*** (0.021)	0.001 (0.014)	-0.055*** (0.014)	0.003 (0.014)	-0.053** (0.021)
Service-oriented	-0.098*** (0.014)	-0.109*** (0.023)	-0.079*** (0.016)	-0.028 (0.018)	-0.028 (0.016)	-0.035 (0.024)
DE course instructor characteristics						
Female	-0.001 (0.001)	0.005 (0.009)	-0.005** (0.002)	-0.003 (0.007)	0.002 (0.002)	-0.005 (0.009)
Race (Ref. = White)						
Asian	0.009* (0.004)	-0.040 (0.038)	0.018*** (0.005)	-0.064* (0.022)	-0.006 (0.005)	0.015 (0.042)
Black	-0.007* (0.003)	0.024 (0.015)	0.003 (0.004)	0.001 (0.013)	-0.009* (0.004)	0.046** (0.016)
Hispanic	0.001 (0.003)	0.010 (0.011)	-0.001 (0.003)	0.006 (0.008)	0.001 (0.003)	0.000 (0.011)
Other	-0.001 (0.003)	0.000 (0.014)	0.003 (0.004)	-0.029* (0.011)	-0.003 (0.004)	0.005 (0.014)

Age	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	-0.001** (0.000)	0.000 (0.000)	0.000 (0.000)
Instructor type (Ref. = High school teacher)						
TT/Tenured	0.006 (0.004)	0.030 (0.019)	0.007 (0.004)	0.003 (0.015)	0.000 (0.004)	0.035 (0.019)
Full-time NTT	0.004 (0.003)	0.011 (0.013)	0.002 (0.003)	-0.009 (0.009)	-0.001 (0.003)	0.021 (0.013)
Part-time NTT	0.006* (0.002)	0.019 (0.013)	0.009*** (0.003)	-0.011 (0.010)	-0.001 (0.003)	0.051*** (0.014)
Unknown	0.012* (0.006)	0.025 (0.028)	0.016* (0.007)	-0.011 (0.020)	0.009 (0.007)	0.052 (0.031)
Highest education level (Ref. = Associate degree or less)						
Bachelor's degree	-0.010 (0.006)	0.032*** (0.009)	0.002 (0.007)	0.033*** (0.007)	0.002 (0.007)	0.004 (0.010)
Master's degree	-0.005 (0.004)	0.043*** (0.010)	0.000 (0.005)	0.036*** (0.008)	0.001 (0.005)	0.006 (0.011)
Doctoral degree	-0.007 (0.004)	0.016 (0.027)	0.004 (0.005)	0.042* (0.022)	-0.006 (0.005)	-0.025 (0.024)
Calculated 9-month salary	0.000 (0.000)	0.000 (0.000)	0.000** (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Sample Size	432,818	53,221	433,531	51,367	433,655	53,338

Notes. The table presents logistic regression results, and each column represents a separate regression model. All models included the following student characteristics: gender, race/ethnicity, low-income status, AP or IB participation, a z-score for their Algebra I test score, and a z-score for their English II test score. All models also included cohort, semester, and district fixed effects and used robust standard errors clustered by individual students. We present average marginal effects (AMEs) and standard errors (SEs) for each covariate included in the binary logistic regression models. The six analyses included high school graduates from the entire sample. The sample size across outcomes varies slightly due to the inclusion of both semester and district fixed effects, where some districts with no variation in a given outcome during a given term were dropped from those analyses. For ease of interpretation of the sample, the means for the post-high school outcomes of interest in each of the six regressions are: any Texas college enrollment for academic DE: 0.803; any Texas college enrollment for CTE DE: 0.530; Texas public university enrollment for academic DE: 0.492; Texas public university enrollment for CTE DE: 0.201; Texas public two-year college enrollment for academic DE: 0.338; Texas public two-year college enrollment for CTE DE: 0.359.

[a] "Passed the DE course" was included as an independent variable in regressions on college enrollment.

*$p < .05$, **$p < .01$, ***$p < .001$.

6. Discussion

High schools and colleges across the country have ramped up efforts to provide DE coursework. More than ever, stakeholders need evidence about which DE course designs are most effective for student success. To fulfill that need, we used student-level administrative data following recent cohorts of DE participants in Texas to examine how students at traditional public high schools experience DE, how DE courses are commonly structured, and which DE course characteristics predict students' course outcomes and subsequent college enrollment.

Our descriptive analyses illuminate striking differences between the demographic and academic backgrounds of students who take academic and CTE DE. These differences are not surprising, but, given that most prior research focuses on one DE course type or lumps together all DE students, it's rare to see student characteristics for both types of DE side by side. Most DE course enrollments between 2015 and 2020 among Texas public high school students were in academic courses (81% of DE students took only academic DE), though a very small group of students enrolled in both academic and CTE DE. Only 12% took just CTE DE. Black and Hispanic students, men, and students from low-income families were overrepresented among the CTE DE-only group and underrepresented among the academic DE-only group. Academic DE students were more likely to identify as White and female and much less likely to receive free or reduced-price lunch than their CTE DE counterparts; they were also more likely to participate in other college acceleration programming like AP or IB.

Although these differences confirm prior evidence about the privilege that exists in DE course access (e.g., Brown et al., 2018; Shivji & Wilson, 2019), they also emphasize varying access to academic DE and CTE DE. Students who took both CTE and academic DE courses appear similar to the academic DE-only student population, suggesting that gaining access to academic DE courses is a primary driver of stratification. In discussions of DE as programs of privilege, it makes sense to distinguish between academic DE and CTE DE. Academic DE courses appear to be the true programs of privilege, both due to stratified participation (academic DE participants were more likely to be White and wealthier) and the longer term benefits of academic DE coursetaking for subsequent college enrollment. CTE DE courses—a small proportion of

DE programming overall—served more Black and Hispanic students and students from low-income families, and CTE DE participants who took only CTE DE were less likely to enroll in college after high school.

DE course type also appears to shape the timing of DE coursetaking. Although students, on average, took most of their DE courses in 11th and 12th grade, a larger portion of CTE DE students—17%—took their first DE courses in 9th and 10th grade, which suggests that sorting into tracks for DE course type occurs early on in high school, if not before. This tracking likely aligns with high schools' delineation between college preparation—more traditional academic coursework pathways—and vocational pathways. Although course outcomes look fairly similar across DE course types, students in academic DE courses were much more likely to subsequently enroll in college than those in CTE DE courses, though they were not much more likely to enroll at the same community college where they took DE (of course, the post-high-school offerings for CTE may be more limited than those for academic programs). In examining equity in DE access and outcomes, scholars and practitioners should consider stratification across DE type (and the outcomes within each type) rather than prioritizing increased access to DE overall.

Course characteristics also varied across DE course type. CTE DE courses were smaller and more likely to be taught by instructors who did not hold a bachelor's degree than academic DE courses, most instructors of which held a master's degree. This is not surprising, given that colleges can hire CTE DE instructors with lower educational attainment as long as it is offset by relevant work experience. A higher proportion (46%) of CTE DE courses were taught by high school teachers compared with academic DE courses (37% of academic DE course instructors were high school teachers), though the majority of DE coursework, overall, was taught by NTT faculty. CTE DE courses were more frequently offered on college campuses, perhaps due to the need for appropriate facilities and equipment or the affiliation of qualified faculty. One third of academic DE courses were offered online, which likely helped overcome geographic constraints and challenges in transporting students (or an appropriately credentialed college faculty member) in areas where the high school and college were not in close proximity.

Our regression results illustrate that students who take DE courses—whether academic DE or CTE DE—earlier in high school, compared with those who take DE in their senior year, experience worse course outcomes. The stronger course outcomes (in terms of both grades and passing) across the board for high school seniors may be related to programmatic support such as better guidance for college-level courses as students progress through their high school career. Although we also observed lowered probabilities of enrolling in any college after high school for students taking DE before 12th grade, our results suggest that, for academic DE, the correlation between DE course timing and any college enrollment appears to be driven by lower community college enrollment. We did not find a significant relationship between academic DE course timing and public university enrollment, whereas the relationship with community college enrollment (and DE host college enrollment, as shown in Appendix B) is significant and negative. The sooner students started to take DE courses, the less likely they were to attend a public two-year college after high school. It is possible that the observed relationship between DE course timing and community college enrollment—and more broadly between CTE DE course timing and all the college enrollment outcomes—could also be partially due to additional selection mechanisms into DE courses that are unobservable in the data. For instance, high school seniors may have a better sense of which college courses are of interest to them (thus improving their course performance) and may be more likely to take DE courses if they intend to continue on to college.

To further understand these patterns, we ran descriptive statistics for DE students, broken down by when they took their first DE course (see Appendix Table A3). The groups are decidedly different: Students who started DE earlier seem more likely to have taken a mix of academic and CTE courses, though we also note that the number of students who first took DE in 9th and 10th grade is quite small. Students who started taking DE later in high school were more likely to have taken academic DE courses, which further suggests that the selection of DE course type taken in later grades may be strategic—that is, with an eye toward college plans. Our findings appear to be the first empirical evidence about how DE coursework timing may shape student outcomes. However, it is important to consider the context: Our analytic sample is focused on students attending public high schools in the state that were not using prescribed DE course sequences, as students might experience under an ECHS-style model. This area merits additional inquiry to better understand the mechanisms at play in both à la carte DE and more structured DE pathways.

Our regression results illustrate that several malleable DE course characteristics appear to shape students' course outcomes and subsequent college enrollment. For example, we see that instructional modality of DE courses appears consequential for both DE course types. Across the board, course outcomes in DE sections that were online (and, for the most part, hybrid) are worse than in sections that were face-to-face. These findings are consistent with prior research on online courses in community college settings (Xu & Jaggars, 2011; Xu & Jaggars, 2013). Prior research on DE course modality has focused on the link between the proportion of DE coursework students took online and their college enrollment and completion outcomes (Liu et al., 2020); our results are the first, to our knowledge, to link DE course modality to course-specific outcomes. We illustrate that, controlling for student demographic and academic background, course outcomes for students in online DE courses are lower than those of their peers in face-to-face DE courses—i.e., they received lower grades and were less likely to pass—across the board. In contrast to Liu and colleagues' (2020) findings based on the proportion of DE coursework students took online, we found that participating in an online academic DE course section is positively associated with students' probability of going to college after high school, though the relationship is fairly small. It is possible that taking an academic DE course online removes geographic and other temporal constraints that typically limit access to college coursework, which may shift students' college enrollment decisions, illustrating that those barriers can be overcome (Ortagus, 2018). At the same time, it's also likely that students who primarily take DE coursework online differ from those who primarily take it in person. An analysis that considers individuals' overall DE coursetaking modalities (as a composite across the courses they are taking at a given time) can further illustrate the role DE course modality plays in students' college outcomes (e.g., Liu et al., 2020).

We also observed a relationship between DE course location and outcomes. In terms of immediate course outcomes, taking DE coursework on the college campus, compared with at the high school, is associated with lower grades and a lower probability of passing. Our data does not allow us to identify the mechanisms by which taking DE courses at the college is negatively associated with course outcomes, but prior research suggests that this may be partially related to higher expectations and increased accountability in courses taken at the college campus compared with courses at the high school campus (and with high school instructors) (Duncheon, 2020; Edwards et al., 2011). Our findings may further fuel the debate over the rigor of DE courses, particularly when taught by high school instructors (Hemelt & Swiderski, 2022; Troutman et al., 2018), though it is important to acknowledge that course grades and passing are imperfect measures of student learning. Despite the negative associations with course outcomes, taking a DE course on the college campus is positively associated with enrolling at a community college (primarily at that DE host college) after high school. This is a particularly important insight for community college stakeholders, who often describe building a pipeline into the college as an incentive for increasing DE course offerings. Additionally, although prior research found no difference in college enrollment between students who take DE coursework at the high school versus the college (Hu & Chan, 2021), we found a small positive correlation between taking an academic DE course on the college campus and enrolling in any Texas postsecondary institution (a 1-percentage-point boost above the baseline of 80% enrolling college), which appears to be largely driven by enrollment in community colleges. For CTE DE courses, there is a significant association only between taking the course at the college campus and public two-year college enrollment. It is possible that the differences between our results and Hu and Chan's (2021) findings—theirs used national data and focused on enrolling at any postsecondary institution, whereas we used state administrative data and found a stronger link between DE course location and enrollment at public two-year colleges—are explained by the fact that we differentiated between academic and CTE DE courses, but the differences could also stem from something specific to the Texas context.

Additional measures that capture DE course-design decisions also appear to shape students' course outcomes and college enrollment after high school. In academic DE, larger class sizes predict a higher probability of course passing and higher course grades; in CTE DE, which tends to require more hands-on experience, larger classes predict lower course grades. In the case of CTE DE, higher credit courses negatively predict both course grades and college enrollment outcomes, whereas lecture-based sections—as opposed to labs or independent studies—negatively predict grades while positively predicting college enrollment, with particularly strong results for attending a community college. For academic DE courses, students in mixed-composition DE courses—those including both high school and college-only students in the same section—were less likely to pass the course but more likely to enroll at a community college. Mixed-composition DE courses may be more similar to college-only courses, so although DE students were less likely to pass them compared to when taking the course with only other high school students, their exposure to college-only students—and the shift in the course atmosphere that exposure creates—may have encouraged students to come back to a community college (mixed course composition did not significantly predict enrollment at Texas public universities or private institutions).

Our regression results also suggest that DE instructor assignments shape course outcomes and subsequent college enrollment. Instructor type is significantly linked to course passing, course grade, and college enrollment. Taking DE with college faculty—compared with taking DE with a high school teacher—is negatively associated with course passing and final course grade. Our supplemental analyses (see Appendix Table A2) of the interaction between instructor type and course location offer further evidence that, compared with students who took DE courses at the high school with a high school instructor, students who took CTE DE courses on the college campus with a college instructor received lower grades and were less likely to pass, and those who took academic DE on the college campus with a college instructor were somewhat more likely to pass but still experienced a small decrease in final grade among some college faculty types. Qualitative research suggests that high school DE instructors offer students more flexibility and have different standards than college faculty, which may ultimately translate to better final course grades (Duncheon, 2020; Edwards et al., 2011). In our study, despite negative course outcomes, taking DE with college faculty—particularly NTT faculty—is positively associated with college enrollment outcomes, though the results differ across academic DE and CTE DE courses. For academic DE students, taking DE with part-time NTT faculty, compared with a high school instructor, positively predicts enrolling in any college after high school, whereas for CTE DE students, it primarily predicts enrolling at a public two-year college.

For CTE courses, we also observed a link between educational attainment of instructors and college-going behavior among students. Although CTE DE courses have more flexibility in terms of the educational attainment of instructors—years of experience in the field can substitute for postsecondary education, so instructors do not need a college degree—taking a CTE DE course with an instructor who holds a baccalaureate or post-baccalaureate degree increased students' probability of enrolling in college after high school. This may be because exposure to an instructor with a four-year degree (or beyond) boosts students' educational aspirations, though additional research is necessary to understand how those processes might work in CTE DE settings. Almost half of all CTE DE courses were taught by instructors who had not attained at least a bachelor's degree (the state laws allow experience in the field to count toward educational experience). In CTE fields in which a college credential is particularly important for entry into a career in that field, colleges might benefit from further emphasizing educational attainment in their hiring of CTE DE instructors, as feasible.

7. Conclusion

Declining numbers in high school graduating classes, combined with increased competition from public regional four-year institutions, online universities, and other providers, create strong pressures for community colleges to expand and diversify the pool of students in local high schools who are motivated to enter community college after high school. To accomplish these goals, community colleges will have to partner more intentionally with high schools to recruit, support, and engage DE students as a means to both boost current enrollment numbers and build a pipeline of subsequent enrollees. K-12 leaders also have strong incentives to improve college access, especially among underserved students, and DE is one way of achieving this goal. Our findings provide evidence about which course characteristics K-12 and college stakeholders can leverage to improve course outcomes and subsequent college enrollment among DE students.

The relationships we illuminate offer insights for policymakers, administrators, and practitioners seeking evidence for how to design DE courses for students and colleges. We also highlight additional areas for inquiry. Our descriptive statistics show variation in how DE coursework is offered and illustrate the complexity of designing DE courses, given that colleges and their K-12 partners are often working to overcome challenges of instructor availability, geographic proximity and feasibility of bringing students to the college campus, and resource constraints. In designing evidence-based practices, educational leaders will have to balance the interests of various institutional partners and weigh the potential influence on both short- and long-term outcomes.

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Appendix A: Supplemental Tables

Table A1. Variable Descriptions and Descriptive Statistics for Analytic Sample

Variable	Variable Description	Mean (SD)
DE Course Type		
Academic DE	General academic DE course	0.887 (0.317)
CTE DE	Career and Technical Education DE course	0.113 (0.317)
Dependent Variables		
DE Course Outcomes		
Passed the course	Indicates whether the student passed the DE course, including grades of A, B, C, or P (for Pass)	0.912 (0.284)
Course grade	Numerical grade earned in the DE course on a 4-point scale	3.168 (0.963)
Subsequent College Enrollment		
Enrolled in any college in Texas after high school	Indicates whether the student enrolled in any postsecondary institution in Texas within 1 year after high school graduation	0.772 (0.419)
Enrolled in a Texas public university after high school	Indicates whether the student enrolled in a Texas public four-year university within 1 year after high school graduation	0.451 (0.498)
Enrolled in a Texas public two-year college after high school	Indicates whether the student enrolled in a Texas public two-year college within 1 year after high school graduation	0.334 (0.472)
Independent Variables		
Timing of DE coursetaking		
School grade	Grade the student took the DE course in	
In 9th grade	Took the DE course in 9th grade	0.018 (0.134)
In 10th grade	Took the DE course in 10th grade	0.049 (0.216)
In 11th grade	Took the DE course in 11th grade	0.404 (0.491)
In 12th grade	Took the DE course in 12th grade	0.529 (0.499)
DE course characteristics		
Class size	The number of students enrolled in the DE course	26.904 (22.783)
Number of credits	Semester credit hours	3.078 (0.430)
Lecture section	The DE course is lecture based	0.896 (0.305)
Instructional modality		

Face-to-face	The DE course was taught in person	0.750 (0.433)
Online	The DE course was taught online	0.232 (0.422)
Hybrid	The DE course was taught hybrid	0.019 (0.135)
Course location		
On high school campus	The DE course was taught on a high school campus	0.464 (0.499)
On college campus	The DE course was taught on a college campus	0.352 (0.478)
At other location	The DE course was taught at other location	0.184 (0.387)
Mixed course composition	Indicates whether class included both high school and college students	0.245 (0.430)
Broad course subject	Eight classifications for broad course subjects	
Humanities, liberal arts, and general studies	Course in humanities, liberal arts, and general studies	0.517 (0.500)
Social and behavioral sciences	Course in social and behavioral sciences	0.214 (0.410)
STEM	Course in science, technology, engineering, and mathematics	0.173 (0.378)
Education	Course in education	0.002 (0.050)
Business	Course in business	0.010 (0.098)
Health	Course in health	0.026 (0.159)
Industry/agriculture/manufacturing/construction	Course in industry, agriculture, manufacturing, and construction	0.039 (0.194)
Service-oriented	Course in service-oriented	0.019 (0.138)
DE course instructor characteristics		
Female	Identifies as female	0.562 (0.496)
Race/ethnicity		
Asian	Identifies as Asian, non-Hispanic	0.025 (0.155)
Black	Identifies as Black, non-Hispanic	0.052 (0.221)
Hispanic	Identifies as Hispanic	0.154 (0.361)
White	Identifies as White, non-Hispanic	0.708 (0.455)
Other	Identifies as Other race, non-Hispanic	0.062 (0.241)
Age	Age at the time of teaching	47.254 (11.968)
Instructor type		
High school teacher	High school teacher	0.470 (0.499)
TT/Tenure	Tenure-track assistant professor or tenured full/associate professor	0.091 (0.288)
Full-time NTT	Full-time non-tenure-track faculty	0.220 (0.414)
Part-time NTT	Part-time non-tenure-track faculty	0.180 (0.384)
Unknown	Faculty in colleges without ranking system and no other information on faculty type	0.039 (0.193)
Highest education level		
Associate degree or less	Associate degree or less	0.091 (0.288)

Bachelor's degree	Bachelor's degree	0.055 (0.227)
Master's degree	Master's degree	0.733 (0.443)
Doctoral degree	Doctoral degree or equivalent	0.121 (0.326)
Calculated 9-month salary	The calculated 9-month salary based on the length of employment contract and total salary	$25,659 ($25,762)
Student characteristics		
Female	Identifies as female	0.594 (0.491)
Race/ethnicity		
Asian	Identifies as Asian, non-Hispanic	0.040 (0.195)
Black	Identifies as Black, non-Hispanic	0.061 (0.239)
Hispanic	Identifies as Hispanic	0.393 (0.488)
White	Identifies as White, non-Hispanic	0.482 (0.500)
Other	Identifies as Other race, non-Hispanic	0.024 (0.154)
Low-income status	Indicates whether the student was eligible for free or reduced-price school meals	0.342 (0.474)
AP/IB participation	Indicates whether the student ever took any AP or IB course	0.638 (0.481)
Algebra I test score	Constructed z-score of the student's STAAR Algebra I test results among all students in the analytic sample	0.115 (0.980)
English II test score	Constructed z-score for student's STAAR English II test results among all students in the analytic sample	0.112 (0.961)

Notes. Total DE student *N* = 108,256; Total DE course *N* = 497,399. The table describes analytic variables and presents means and standard deviations (SD) for all DE course sections taken by the DE students in the analytic sample.

Table A2. Results for Regression Analyses With Instructor Type-Course Location Interactions: DE Course Outcomes

Variable	Passed the Course		Course Grade	
	Academic DE Coefficient (SE)	CTE DE Coefficient (SE)	Academic DE Coefficient (SE)	CTE DE Coefficient (SE)
Timing of DE coursetaking				
School grade (Ref. = In 12th grade)				
In 9th grade	-1.071*** (0.084)	-1.809*** (0.208)	-0.298*** (0.045)	-0.700*** (0.114)
In 10th grade	-0.912*** (0.081)	-1.229*** (0.157)	-0.237*** (0.033)	-0.455*** (0.078)
In 11th grade	-0.533*** (0.046)	-0.565*** (0.093)	-0.191*** (0.017)	-0.199*** (0.041)
DE course characteristics				
Class size	0.004*** (0.000)	-0.002 (0.002)	0.001*** (0.000)	-0.004*** (0.001)
Number of credits	-0.027 (0.019)	-0.008 (0.022)	-0.050*** (0.005)	-0.059*** (0.007)
Lecture section	-0.068* (0.033)	0.300*** (0.066)	-0.036*** (0.009)	-0.115*** (0.021)
Instructional modality (Ref. = Face-to-face)				
Online	-0.544*** (0.026)	-0.316** (0.100)	-0.108*** (0.008)	-0.354*** (0.036)
Hybrid	-0.264*** (0.047)	0.070 (0.146)	-0.067*** (0.013)	-0.118* (0.049)
Course location (Ref. = On high school campus)				
On college campus	-0.160*** (0.035)	0.018 (0.090)	0.001 (0.009)	-0.017 (0.022)
At other location	-0.179*** (0.042)	0.466*** (0.141)	-0.032** (0.011)	0.188*** (0.040)
Mixed course composition	-0.384*** (0.019)	-0.363*** (0.053)	-0.035*** (0.005)	-0.052** (0.018)
Broad course subject (Ref. = Humanities, liberal arts, and general studies)				
Social and behavioral sciences	-0.011 (0.015)	-0.488** (0.158)	-0.016*** (0.004)	-0.085 (0.045)

STEM	-0.538***	-0.150	-0.153***	-0.019
	(0.019)	(0.129)	(0.005)	(0.034)
Education	0.027	1.515**	0.202***	0.460***
	(0.112)	(0.519)	(0.036)	(0.104)
Business	-0.207	-0.087	0.000	-0.053
	(0.121)	(0.149)	(0.038)	(0.039)
Health	-0.686***	-0.627***	-0.037	-0.133***
	(0.134)	(0.136)	(0.052)	(0.038)
Industry/agriculture/manufacturing/construction	0.066	0.221	0.054	0.006
	(0.104)	(0.133)	(0.028)	(0.035)
Service-oriented	0.255**	0.075	0.172***	-0.027
	(0.094)	(0.143)	(0.030)	(0.038)
DE course instructor characteristics				
Female	-0.010	-0.069	-0.002	-0.072***
	(0.013)	(0.050)	(0.003)	(0.015)
Race/ethnicity (Ref. = White)				
Asian	-0.146***	0.440	-0.089***	0.092
	(0.033)	(0.228)	(0.010)	(0.074)
Black	-0.102***	0.201*	-0.008	-0.046
	(0.027)	(0.080)	(0.008)	(0.027)
Hispanic	-0.011	0.069	0.054***	0.044*
	(0.022)	(0.060)	(0.006)	(0.019)
Other	-0.097***	0.221**	0.009	-0.039
	(0.028)	(0.084)	(0.007)	(0.025)
Age	0.003***	0.003	0.000	0.001*
	(0.001)	(0.002)	(0.000)	(0.001)
Instructor type (Ref. = High school teacher)				
TT/Tenured	-0.266***	0.084	-0.017	-0.067
	(0.053)	(0.304)	(0.014)	(0.069)
Full-time NTT	-0.294***	-0.576***	-0.022*	-0.169***
	(0.034)	(0.101)	(0.009)	(0.029)
Part-time NTT	-0.233***	-0.939***	0.031***	-0.298***
	(0.031)	(0.137)	(0.007)	(0.044)
Unknown	-0.430**	0.130	-0.034	-0.030
	(0.152)	(0.600)	(0.038)	(0.185)
Highest education level (Ref. = Associate degree or less)				
Bachelor’s degree	0.208***	0.143**	0.060***	-0.027
	(0.058)	(0.050)	(0.014)	(0.015)

Master's degree	0.064	0.041	0.016	-0.041*
	(0.037)	(0.059)	(0.009)	(0.018)
Doctoral degree	-0.027	0.046	-0.028**	-0.005
	(0.040)	(0.153)	(0.010)	(0.050)
Calculated 9-month salary	0.000***	0.000	0.000***	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Instructor type-course location interactions (Ref. = High school teacher × On high school campus)				
TT/Tenured × On college campus	0.107	-0.998**	-0.001	-0.371***
	(0.062)	(0.319)	(0.017)	(0.076)
TT/Tenured × At other location	0.227***	-0.935*	0.011	-0.314**
	(0.068)	(0.366)	(0.018)	(0.105)
Full-time NTT × On college campus	0.112*	-0.051	-0.022	-0.119***
	(0.044)	(0.121)	(0.012)	(0.034)
Full-time NTT × At other location	0.132**	-0.562**	-0.030*	-0.365***
	(0.049)	(0.180)	(0.013)	(0.061)
Part-time NTT × On college campus	-0.012	0.441**	-0.027*	0.010
	(0.046)	(0.167)	(0.012)	(0.054)
Part-time NTT × At other location	0.000	0.060	0.005	0.061
	(0.047)	(0.248)	(0.012)	(0.080)
Unknown × On college campus	0.247	-0.201	0.014	0.001
	(0.157)	(0.617)	(0.041)	(0.191)
Unknown × At other location	0.340*	—	0.049	—
	(0.163)		(0.042)	
Sample Size	440,571	53,956	426,788	52,563

Notes. The table presents regression results from supplemental models that include interactions between instructor type and course location, and each column represents a separate regression model. We used logistic regression for course passing (results are presented as log odds) and OLS regression for numerical letter grades captured on a 4-point scale. The top grade is an A, which equals 4, and the lowest grade is an F, which equals 0. All models included the following student characteristics: gender, race/ethnicity, low-income status, AP or IB participation, a z-score for their Algebra I test score, and a z-score for their English II test score. We included cohort, semester, and district fixed effects and used robust standard errors clustered by individual students in all models. The analyses for passing the course included the entire sample, and the analyses on course grades included only students who earned numerical course grades (i.e., those who withdrew or received Pass/Fail or incompletes could not be included). The sample size across outcomes varies slightly due to the inclusion of both semester and district fixed effects, where some districts with no variation in a given outcome during a given term were dropped from those analyses. For ease of interpretation of the sample, the means for the outcomes of interest in each of the four regressions are: passed the academic DE course: 0.915; passed the CTE DE course: 0.884; grade in the academic DE course: 3.164; grade in the CTE DE course: 3.196.

* $p < .05$, ** $p < .01$, *** $p < .001$.

Table A3. Descriptive Statistics of DE Students by Timing of the First DE Coursetaking

Variable	Timing of First DE Course			
	9th grade (% or M)	10th grade (% or M)	11th grade (% or M)	12th grade (% or M)
Student *N*	4,082	10,698	58,380	35,096
Student characteristics				
Female	55.5%	54.1%	57.5%	57.7%
Race/ethnicity				
Asian	2.9%	2.5%	3.6%	6.1%
Black	9.5%	6.7%	5.8%	8.5%
Hispanic	43.6%	45.4%	39.6%	41.5%
White	41.6%	43.3%	48.5%	41.5%
Other	2.4%	2.2%	2.5%	2.4%
Low-income student	41.6%	41.1%	34.3%	38.9%
AP/IB participant	49.8%	58.3%	64.3%	64.8%
Algebra I test score	4,282	4,338	4,346	4,308
English II test score	4,361	4,383	4,415	4,357
DE coursetaking patterns				
Number of courses taken	7.5	6.5	5.3	2.6
Coursetaking type				
Academic DE only	69.5%	63.7%	82.9%	84.4%
CTE DE only	14.1%	20.3%	10.1%	12.6%
Both academic DE & CTE DE	16.4%	16.0%	7.0%	3.0%
Course passing rate	87.9%	91.8%	92.0%	88.9%
DE course grade	3.2	3.3	3.2	3.1
College enrollment after high school				
Enrolled in any college in Texas	53.8%	68.7%	74.1%	73.5%
Enrolled in a Texas public university	32.2%	41.4%	41.4%	34.9%
Enrolled in a Texas public two-year college	21.2%	27.8%	33.3%	38.9%
Enrolled in a Texas private postsecondary institution	4.5%	5.4%	5.8%	5.0%
Returned to the DE-host college	13.2%	18.6%	23.1%	26.9%

Notes. *N* (student) = 108,256. The table describes student characteristics, DE coursetaking patterns, and college enrollment outcomes of DE students, reported at the student level. We provide means for continuous variables and percentages for categorical measures. Each column corresponds to the initial grade in which the student subpopulation took their first DE course; thus, column 1 includes those who first took DE in 9th grade, column 2 in 10th grade, and so on.

Appendix B: Regression Results for Additional College Enrollment Outcomes

In our main results, we presented logistic regressions estimating the relationship between DE coursework characteristics and college enrollment outcomes, namely, enrolling in any college in Texas, enrolling in a Texas public university, and enrolling in a Texas public two-year college. In Table B1, we include regression results from two additional college enrollment outcomes to inform readers of how DE coursework characteristics are associated with other types of college enrollment after high school: (1) returning to the DE host college where the student took the given DE course and (2) enrolling in a Texas private postsecondary institution. The supplemental analyses used the same predictive variables outlined in Table 4.

As with the results for enrolling in a Texas public two-year college (presented in Table 4), passing the DE course significantly predicts returning to the host DE college, but the direction of the relationship was mixed across the two DE course types. Passing an academic DE course is negatively associated with returning to the DE host college, whereas passing a CTE DE course is positively associated with the DE host college enrollment outcome. For academic DE courses only, course passing appears consequential for subsequent enrollment at Texas private postsecondary institutions. The timing of DE coursetaking also predicts additional college enrollment outcomes. For CTE DE courses, taking the course in 9th, 10th, or 11th grade, compared with 12th grade, is negatively associated with enrollment at the DE host college, while the relationship between the timing of CTE DE coursetaking and private college enrollment appears significant only for taking DE in 9th grade. For academic DE courses, the timing of DE coursetaking is negatively associated with returning to the DE host college, but the relationship between coursetaking timing and enrollment at private postsecondary institutions is not significant (similar to results for public university enrollment).

DE course characteristics also predict the additional college enrollment outcomes, but the significant relationships are primarily present for returning to the DE host college. The patterns are similar to those for enrolling in a Texas two-year college, since the majority of two-year college enrollments after high school occurred at the DE host college. The results for Texas private institutions more closely resemble those for public universities; however, the condition of taking an academic DE course hybrid, compared with face-to-face, is positively associated with enrolling in a private postsecondary institution (whereas the online condition is significant for enrolling at a public university).

Several DE instructor characteristics are also associated with students' college enrollment outcomes, but the patterns are mixed across the additional college enrollment outcomes. Students taking a CTE DE course taught by a TT/tenured or part-time NTT college instructor, compared with a high school teacher, experienced an increased probability of returning to the host college, whereas the instructor type did not predict private college enrollment. We also observed positive relationships between the instructor's education background and returning to the DE host college for academic DE courses. Race/ethnicity among instructor demographics is somewhat associated with college enrollment outcomes, though results are mixed across DE course types and institution types.

Table B1. Results for Regression Models Predicting Additional College Enrollment Outcomes

Variable	Returned to the DE Host College		Enrolled in a Texas Private Postsecondary Institution	
	Academic DE AME (SE)	CTE DE AME (SE)	Academic DE AME (SE)	CTE DE AME (SE)
Passed the DE course[a]	-0.008** (0.003)	0.083*** (0.007)	0.022*** (0.002)	0.004 (0.003)
Timing of DE coursetaking				
School grade (Ref. = In 12th grade)				
In 9th grade	-0.163*** (0.038)	-0.216** (0.062)	0.026 (0.030)	-0.035* (0.011)
In 10th grade	-0.133*** (0.029)	-0.172** (0.050)	0.015 (0.019)	-0.023 (0.012)
In 11th grade	-0.072*** (0.018)	-0.111*** (0.030)	0.007 (0.009)	-0.015 (0.008)
DE course characteristics				
Class size	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Number of credits	-0.003 (0.002)	-0.006* (0.003)	-0.001 (0.001)	0.001 (0.001)
Lecture section	-0.003 (0.004)	0.036*** (0.010)	0.000 (0.003)	-0.004 (0.005)
Instructional modality (Ref. = Face-to-face)				
Online	-0.007* (0.003)	-0.005 (0.016)	0.002 (0.002)	0.011 (0.007)
Hybrid	-0.005 (0.006)	0.006 (0.024)	0.012** (0.004)	-0.014 (0.006)
Course location (Ref. = On high school campus)				
On college campus	0.022*** (0.004)	0.048*** (0.010)	0.002 (0.003)	0.002 (0.005)

At other location	0.012** (0.005)	-0.025 (0.019)	0.000 (0.003)	0.001 (0.007)
Mixed course composition	0.015*** (0.003)	0.064*** (0.010)	0.001 (0.002)	-0.006 (0.003)
Broad course subject (Ref. = Humanities, liberal arts, and general studies)				
Social and behavioral sciences	-0.003* (0.001)	0.060* (0.024)	0.000 (0.001)	0.006 (0.012)
STEM	-0.008*** (0.002)	0.022 (0.017)	0.003* (0.001)	-0.008 (0.010)
Education	-0.016 (0.013)	0.070 (0.077)	0.002 (0.010)	0.010 (0.041)
Business	-0.032 (0.017)	0.009 (0.020)	-0.016 (0.010)	0.000 (0.012)
Health	0.038* (0.019)	0.108*** (0.021)	0.005 (0.012)	0.008 (0.012)
Industry/agriculture/manufacturing/construction	-0.017 (0.012)	-0.008 (0.018)	-0.003 (0.007)	-0.016 (0.011)
Service-oriented	-0.006 (0.014)	0.005 (0.021)	-0.016 (0.011)	-0.017 (0.011)
DE course instructor characteristics				
Female	0.002 (0.001)	-0.008 (0.009)	0.001 (0.001)	-0.001 (0.004)
Race/ethnicity (Ref. = White)				
Asian	-0.004 (0.004)	0.053 (0.041)	0.000 (0.003)	0.016 (0.020)
Black	-0.011** (0.003)	0.052*** (0.016)	-0.003 (0.002)	0.001 (0.005)
Hispanic	0.001 (0.003)	-0.001 (0.011)	0.000 (0.002)	0.000 (0.004)
Other	-0.005 (0.004)	0.009 (0.014)	0.000 (0.002)	0.020*** (0.006)

Age	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Instructor type (Ref. = High school teacher)				
TT/tenured	-0.002 (0.004)	0.037* (0.018)	0.002 (0.002)	-0.008 (0.007)
Full-time NTT	-0.001 (0.003)	0.017 (0.012)	0.002 (0.002)	-0.006 (0.004)
Part-time NTT	0.000 (0.002)	0.038** (0.013)	0.001 (0.002)	-0.005 (0.005)
Unknown	0.009 (0.006)	0.050 (0.028)	0.006 (0.004)	-0.004 (0.011)
Highest education level (Ref. = Associate degree or less)				
Bachelor's degree	0.013* (0.007)	-0.002 (0.009)	-0.006 (0.004)	0.001 (0.003)
Master's degree	0.009* (0.004)	0.009 (0.010)	-0.002 (0.003)	0.008* (0.004)
Doctoral degree	0.002 (0.005)	-0.014 (0.023)	0.000 (0.003)	-0.001 (0.008)
Calculated 9-month salary	0.000 (0.000)	0.000** (0.000)	0.000 (0.000)	0.000 (0.000)
Sample size	428,660	51,751	412,185	39,887

Notes. The table presents logistic regression results, and each column represents a separate regression model. All models included the following student characteristics: gender, race/ethnicity, low-income status, AP or IB participation, a z-score for their Algebra I test score, and a z-score for their English II test score. All models also included cohort, semester, and district fixed effects and used robust standard errors clustered by individual students. We present average marginal effects (AMEs) and standard errors (SEs) for each covariate included in the binary logistic regression models. The four analyses included high school graduates from the entire sample. The sample size across outcomes varies slightly due to the inclusion of both semester and district fixed effects, where some districts with no variation in a given outcome during a given term were dropped from those analyses. For ease of interpretation of the sample, the means for the post-high-school outcomes of interest in each of the four regressions are: returned to the DE host college for academic DE: 0.229; returned to the DE host college for CTE DE: 0.263; Texas private college enrollment for academic DE: 0.066; Texas private college enrollment for CTE DE: 0.022.

*$p < .05$, **$p < .01$, ***$p < .001$.