TAKING COLLEGE COURSES IN HIGH SCHOOL: A STRATEGY FOR COLLEGE READINESS

THE COLLEGE OUTCOMES OF DUAL ENROLLMENT IN TEXAS

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By Ben Struhl and Joel Vargas

JOBS FOR THE FUTURE

Jobs for the Future aligns education with today's high-demand careers. With its partners, JFF develops policy solutions and new pathways leading from college readiness to career advancement for struggling and low-income populations in America.

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EXECUTIVE SUMMARY

There is no panacea when it comes to education policy, but a growing body of research suggests that allowing students in high school to complete even a single college class could significantly increase their chances of attending college and eventually graduating. After studying tens of thousands of Texas students who completed college courses in high school, we found that these students attended and completed college within the state at much higher rates than students with similar backgrounds who did not take college courses in high school.

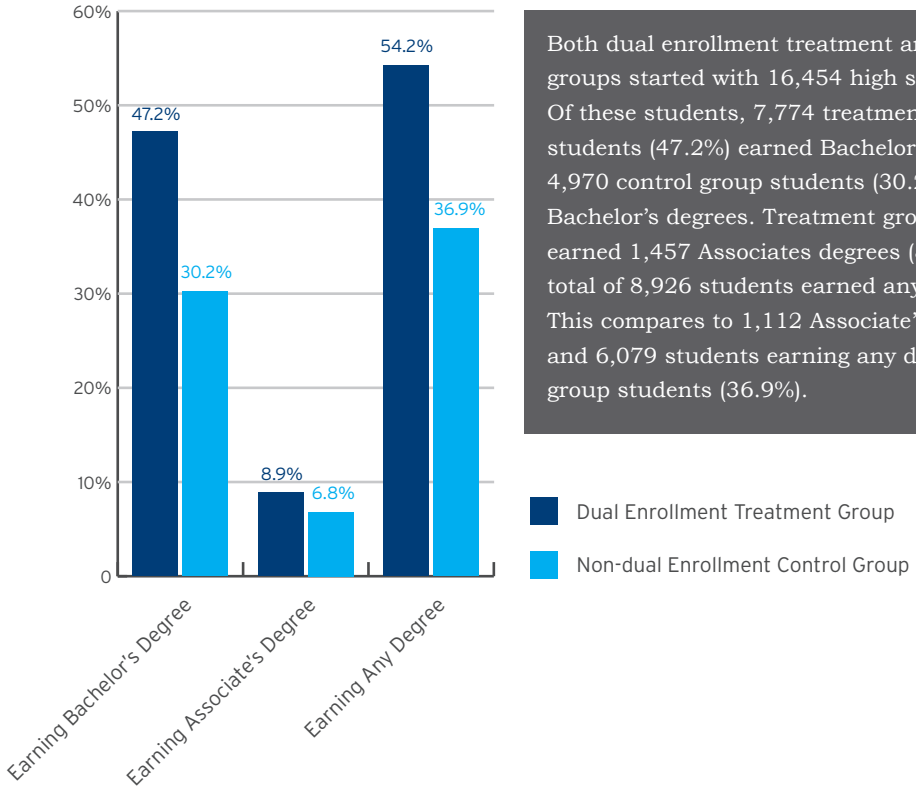
States and school districts have been searching for ways to raise rates of college readiness and success among students, and particularly among groups that are underrepresented in college. Providing students with the opportunity to take college courses in high school, known as **dual enrollment**, is one promising strategy. The theory behind dual enrollment is that enabling high school students to experience real college coursework is one of the best ways to prepare them for college success.

JFF's research contributes to this field by analyzing longitudinal data following Texas students for six years after high school graduation. This enabled us to examine not only whether students attended college but also whether they completed a degree. Another distinguishing feature of this study is that it uses a rigorous research methodology to ensure that it compares students who are similar aside from their participation in dual enrollment. This greatly increases the certainty that the better college outcomes observed for students who participate in dual enrollment are not due to other factors—for example, the possibility that dual enrollees are already more likely to have higher academic achievement.

JFF's examination revealed very promising results. High school students who had completed a college course before graduation (defined here as dual enrollees) were nearly 50 percent more likely to earn a college degree from a Texas college within six years than students who had not participated in dual enrollment (*see figure on page vi*).

Overall, students who completed college courses through dual enrollment were significantly more likely to attend college, persist in college, and complete an Associate's degree or higher within six years (*see table on page vi*). These findings held for all racial groups as well as for students from low-incomes families. In fact, dual enrollees from low-income families were particularly more likely to attend a four-year college in Texas after high school.

COLLEGE COMPLETION RATES FOR STATISTICALLY MATCHED COLLEGE ENROLLEES, TEXAS, 2004 HIGH SCHOOL GRADUATING CLASS



Both dual enrollment treatment and control groups started with 16,454 high school graduates. Of these students, 7,774 treatment group students (47.2%) earned Bachelor's degrees, while 4,970 control group students (30.2%) earned Bachelor's degrees. Treatment group students earned 1,457 Associates degrees (8.9%), and a total of 8,926 students earned any degree (54.2%). This compares to 1,112 Associate's degrees (6.8%) and 6,079 students earning any degree for control group students (36.9%).

DUAL ENROLLMENT PARTICIPANTS VS. STATISTICALLY MATCHED NON-DUAL ENROLLMENT STUDENTS, TEXAS, 2004 HIGH SCHOOL GRADUATING CLASS

	DUAL ENROLLMENT PARTICIPANTS WERE
Impact on Enrollment	2.2 times more likely to enroll in a Texas two- or four-year college
Impact on Persistence	2.0 times more likely to return for a second year of college
Impact on Completion	1.7 times more likely to complete a college degree

When considered alongside other recent rigorous research on dual enrollment, this study has important implications for policymakers:

- Encouraging the dual enrollment of high school students in college courses is a way to enhance their readiness for college, including those from low-income groups and other groups underrepresented in college.
- State policy should ensure that low-income and underrepresented students can take advantage of the benefits of dual enrollment. This can be accomplished by providing more preparation, support, and accelerated learning strategies for these populations.
- More research on dual enrollment could enable policymakers to make better strategic use of limited resources by determining which types of college courses and pathways have the strongest association with college-going outcomes.

INTRODUCTION

States and school districts are searching for strategies to raise the college and career readiness of high school graduates—imperative in an era when postsecondary credentials are the key to good jobs, better pay, and stronger economies. The creation and implementation of higher graduation standards aligned to college and career expectations is the most visible and emblematic effort by states to ensure students are prepared to succeed after high school, but it is far from the only one. A policy strategy of increasing interest is the practice of providing students with the opportunity to take college courses while in high school, known as dual enrollment.

The premise of dual enrollment is that high school students can enhance their chances for college success if they better understand what it takes to succeed in college: they do this by actually experiencing real college coursework, often earning "dual credit" for both high school and college. Through their accountability systems, several states promote dual enrollment by recognizing or rewarding school districts that see more students complete college coursework before graduation (Achieve 2011; Ward & Vargas 2011).[1]

New research, conducted in Texas by Jobs for the Future, points to the effectiveness of dual enrollment as a strategy for improving postsecondary success. This study focused on the academic outcomes of 32,908 Texas students from the high school graduating class of 2004. Half of the study group completed at least one college course before graduating from high school; an equal number of academically and demographically similar students did not. Those who completed college courses through dual enrollment were significantly more likely to attend college, persist in college, and complete an Associate's degree or higher within six years.

The results are particularly notable because they come from a state with one of the nation's fastest-growing and largest public school populations and one that saw a dramatic increase in dual enrollment participation, from 17,784 students in 2000 to 90,364 in 2010 (408 percent growth) (Texas Higher Education Coordinating Board 2011). The findings are consistent with recent research on dual enrollment in Texas (O'Brien & Nelson 2004; McCauley 2007), California, and Florida (Speroni 2011a, 2011b; Karp et al. 2007; Hughes et al. 2012), as well as national studies (An forthcoming).

Like some of these studies, our research used rigorous quasi-experimental methods to control for factors other than dual enrollment that could explain student success by comparing dual enrollees to non-dual enrollees who are otherwise closely matched academically and socially. JFF's methodological approach, known as a propensity score matching model, enabled us to account for student background characteristics to the highest degree possible short of a randomized study. This greatly increases the certainty that the better college outcomes found for dual enrollment participants are due to the effects of the dual enrollment courses they completed.

When considered alongside other recent rigorous research on dual enrollment, this study has important implications for state policymakers:

- Encouraging the dual enrollment of high school students in college courses is a way to enhance their readiness for college, including students from low-income groups and other groups underrepresented in college.
- More preparation and support for students and the use of accelerated learning strategies, such as early college schools, are needed to ensure that low-income and underrepresented students can benefit fully from dual enrollment.
- More research on dual enrollment would enable policymakers to make better strategic use of resources by determining which types of college courses and pathways have the strongest positive association with college-going outcomes.

REVIEW OF PREVIOUS RESEARCH ON DUAL ENROLLMENT

This study makes an important contribution to a decade of research focused on the potential of dual enrollment to raise high school and college success for students, including traditionally underrepresented populations.

Longitudinal Outcomes to College Degrees: A number of studies have examined college going and persistence, but few have examined completion of a postsecondary degree, which this study does using data from a large state program that follows outcomes for several years after high school.

Quasi-experimental Design: This study uses a rigorous design to compare students who are academically and socially similar except for participation in dual enrollment. This increases confidence that the results relate to completion of college courses while in high school.

Outcomes for Key Student Groups: To understand the potential for dual enrollment to make college success more likely for underrepresented students, the research examines how college-going and completion outcomes vary according to a student's social background.

Differences in Dual Enrollment Programs: High school students take a variety and quantity of college courses through dual enrollment. To understand whether these differences matter, this study examines whether college outcomes vary by the types and number of college courses students took in high school.

LONGITUDINAL OUTCOMES TO COLLEGE DEGREES

DUAL ENROLLMENT AND SHORT- TO MEDIUM-TERM OUTCOMES

A number of studies examine interim outcomes toward a college degree. Most of the rigorous research about statewide dual enrollment programs has been limited to states in which it is possible to connect secondary and postsecondary data systems or track students longitudinally between high school and college. Perhaps for this reason, no state dual enrollment program has been more studied than that of Florida, which has long had a robust state data warehouse of this nature (see Karp et al. 2007; Speroni 2011a, 2011b; Windham & Perkins 2001). However, research has also been done with data from individual college systems or programs in California, Georgia, Arizona, and New York City (Hughes et al. 2012; Michalowski 2007; University of Arizona 1999; Lynch et al. 2007).

Some of the most notable studies—using methods to partially control for student background characteristics—have found positive associations between dual enrollment and outcomes such as high school graduation, college enrollment, first-year college GPA, second-year persistence in college, and number of college credits accumulated after three years (Karp et al. 2007; Hughes et al. 2012; Michalowski 2007).

Although these studies have consistently shown positive associations between dual enrollment participation and college outcomes, most tend to study, as Brian An (forthcoming) notes, the short- to medium-term outcomes associated with dual enrollment and rarely study degree completion. Given that these interim outcomes are no guarantee that students will complete college, analyses of the relationship between dual enrollment and degree completion are important.

DUAL ENROLLMENT AND COLLEGE COMPLETION

Some studies examine longer-term outcomes such as college completion. For example, Swanson (2008) found that dual enrollment participants from the National Educational Longitudinal Study were 16 to 20 percent more likely than nonparticipants to earn a Bachelor's degree. In a study looking at a large statewide dataset, Kristin Klopfenstein (2010) examined Texas high school graduates of the class of 1997: "The effect of taking one or more dual credit classes [was] nearly triple the probability of graduating in [three years] relative to students who did not take such courses." Dual enrollment participation was also positively related to graduating in four and five years.

QUASI-EXPERIMENTAL DESIGN

Another shortcoming of most previous studies is their limits on examining the extent to which students' preexisting characteristics may influence student outcomes. This is critical. Dual enrollment participants may already be more likely to have the traits of college-ready students; if so, dual enrollment participation may not explain changes in outcomes. Short of randomly assigning students to participate in dual enrollment, it is not possible to rule out preexisting differences in students as an explanation for differences in outcomes. However, two recent studies have sought to account for preexisting differences using rigorous methodology.

Cecilia Speroni (2011b) studied the effects of dual enrollment in Florida using a quasi-experimental statistical method—one that researchers believe provides more confidence in associating interventions with outcomes. The research approximated an experiment that could assign similar students to either take or not take dual enrollment. Known as a regression discontinuity design, this method increases confidence that difference in outcomes between student groups are associated only with participation or nonparticipation in college courses. Speroni found that students who had completed college algebra for dual enrollment had Associate's degree attainment rates that were 23 percentage points higher and Bachelor's attainment rates 24 percentage points higher than students with no such experience.

An (forthcoming), also using a quasi-experimental statistical method, found that dual enrollment participation increased the probability of attaining any postsecondary degree by 8 percentage points, and dual enrollment participants were 32 percent more likely to attain a Bachelor's degree than were nonparticipants. JFF used the same methodology as did An—a propensity score matching model that compares students who were similar across recorded student background characteristics. An also employed sensitivity analysis to determine the likelihood that unobserved variables might be influencing the results. He found that only overlooking a very large factor would have undermined the results.

OUTCOMES FOR KEY STUDENT GROUPS

Can college-ready strategies support low-income students and other youth with traditionally low educational attainment? This question is critical. Some of these groups, such as Latino students, are among the fastest growing in the nation's schools and future workforce but the least likely to persist to a postsecondary credential.

In seminal research of dual enrollment in Florida and in the City University of New York (which has a larger dual enrollment program than that of most states), the Community College Research Center focused on whether the statistical relationships between dual enrollment participation and postsecondary outcomes differed for key student groups with traditionally lower educational attainment (Karp et al. 2007). Florida dual enrollees were 16.8 percent more likely to enroll in college, had college GPAs 0.2 points higher than non-dual enrollees, and were more likely to persist to the second year of college.

Of particular interest here is that male students, low-income students, and students with lower high school GPAs all were found to benefit more from dual enrollment across several college outcomes. This suggests that the benefits of dual enrollment were just as great, if not greater, for students traditionally underrepresented in college. Another study found some evidence that first-generation college goers benefit more from dual enrollment participation than do students with a college-educated parent (An 2011). Although this research was not conclusive, the findings suggest that dual enrollment participation might help first-generation students at least equally as other students.

DIFFERENCES IN DUAL ENROLLMENT PROGRAMS

The field knows little about how different aspects of college course-taking experiences may affect outcomes. These differences include taking a course on a college campus versus a high school campus, taking a class from a college adjunct versus a high school teacher, and the type of course taken. Few states have collected the types of detailed, course-level information needed to study such differences. Florida's state data system is an exception, making possible Speroni's recent analyses shedding light on some of these issues.

In one study, Speroni (2011b) examined the effect of taking any college course for dual enrollment compared with the effect of taking a college algebra course. She found no effect for participating in a dual enrollment in merely any subject, but taking algebra yielded large effects on postsecondary outcomes, especially degree attainment. Speroni (2011a) only found effects of dual enrollment for courses taken on the college campus.

As state policymakers consider how to refine and improve college-readiness strategies and optimize their investments, it is important to better understand key choices in the design of dual enrollment and other programs. Although we did not have the data to examine whether differences in outcomes varied by the location of a course on the high school versus a college campus, we do examine whether postsecondary outcomes for dual enrollees differ by the type or number of college courses students took in high school.

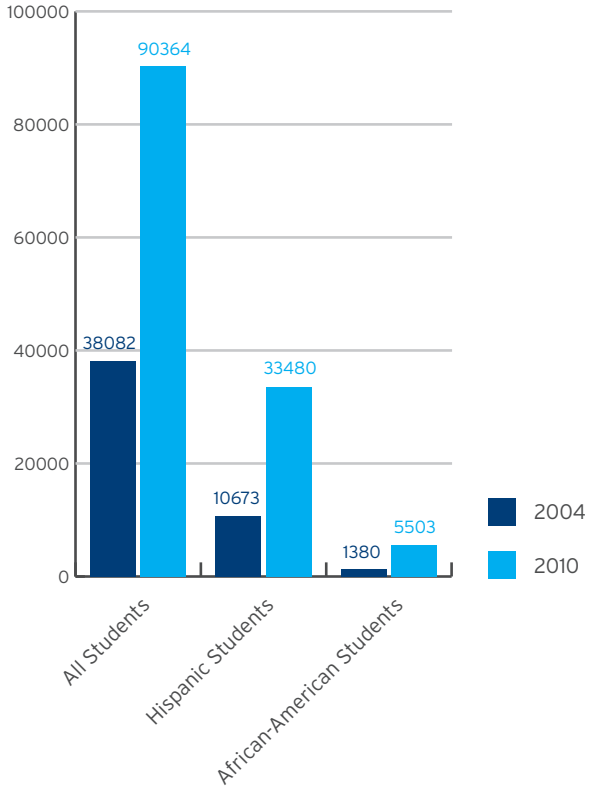
DUAL ENROLLMENT POLICY IN TEXAS

Texas has long worked to improve the college readiness and success of its public school graduates, and it is a leader in standards-based reform and the institution of higher standards. Legislative, gubernatorial, business, and philanthropic efforts promote early college course taking by high school students. In higher education, the Texas Higher Education Coordinating Board's *Closing the Gaps* report and plan, issued in 2000, documents the connection of the state's economic prospects to its ability to close postsecondary attainment gaps for its fastest-growing demographic groups. One recommendation in the report: increase dual enrollment.

These forces were a major impetus for changes to state policy that have accelerated the growth in dual enrollment in Texas. For example:

- Until 2003, school districts and colleges could not both claim per pupil funding for dual enrollees. The legislature changed this, and districts now receive full ADA funding for each high school student enrolled in college courses offered for dual enrollment. Community colleges receive the same funding for dual enrolled high school students as they receive for regular college students.
- In 2006, the legislature passed HB 1, a comprehensive college-readiness bill emphasizing secondary-postsecondary partnerships. The state directed all districts to provide every student with the opportunity to earn a minimum of 12 college credits before graduating from high school. HB 1 also allocated per-student funding ($275 per student) that could be used for this purpose.

FIGURE 1.
DUAL ENROLLMENT PARTICIPANTS, 2004-10



- In 2007, the legislature passed HB 2237, an omnibus bill providing $57.4 million in funding for innovative high school design models. A centerpiece was support for early college high schools, which help underrepresented students earn two years of college credit or an Associate's degree upon graduating from high school.

Texas Higher Education Coordinating Board figures indicate that between 2004 and 2010, the number of dual enrollment participants increased by 137 percent, from 38,082 to 90,364 students. Growth among student groups historically underrepresented in higher education was especially dramatic. For example, Hispanic participation grew from 10,673 to 33,480 (214 percent) and African-American participation from 1,380 to 5,503 (299 percent) (*see Figure 1 on page 6*).

Despite this growth, little research has examined the effectiveness of dual enrollment using methods that isolate its effects from those of other student traits. Within limitations noted below, JFF's research indicates that Texas has set a proper direction to support this strategy, and it provides baseline data for future research.

RESEARCH DESIGN AND METHODOLOGY

Three primary research questions guided JFF's research on dual enrollment in Texas:

- Is college-course completion by Texas high school students related to their college success? Does it affect enrolling, persisting in, and completing a degree at a two-year or four-year public college?
- Does the relationship between dual enrollment and college outcomes vary by race or socioeconomic status?
- Does college success vary by the type or number of courses completed by dual enrollees?

DATA AND SAMPLE

To address these questions, JFF used the most recent data available about college attendance and completion for Texas students at least six years past high school graduation. The sample was comprised of students who were high school seniors in the 2003-04 school year. We tracked these students through June 2011, tracing the path of an entire cohort of Texas dual enrollees, from high school graduation to college completion.

The Texas Education Research Center at the University of Texas at Austin provided the data. The center, one of three in the state, houses nearly all education data collected by the Texas Education Agency, the Texas Higher Education Coordinating Board, and the Texas Workforce Commission. The center merged the TEA and THECB datasets so JFF could examine the transition patterns of students from K-12 to postsecondary institutions.

In designing the research, we were sensitive to variations in the degree to which students had access to college courses. Because students in some districts had greater access to dual enrollment than others, we limited the sample to students who both stayed in the same district for all four years of high school and were in districts in which at least some students completed college classes.

TREATMENT AND COMPARISON GROUPS

One challenge in studying dual enrollment is that students who complete college courses in high school may already have strong academic backgrounds. To simply compare students who are dual enrollees to the whole population would not give a fair picture of the relationship between dual enrollment and college outcomes: With or without dual enrollment, students with stronger academic backgrounds are more likely to succeed in college.

To fairly assess the effects of dual enrollment, dual enrollees would have to be compared to students who are as similar as possible but who did not participate in dual enrollment. Like An (forthcoming), JFF used a quasi-experimental design, applying a complex statistical technique called propensity score modeling (PSM). Increasingly, educational researchers are using this method to establish comparable treatment and control groups (Graham & Kurlaender 2011).[2]

The dataset started with 132,772 students who graduated from high school in 2004 after completing all four years in the same school district.[3] The first round of analysis, a logistic regression, examined student likelihood to participate in dual enrollment. We found that students who completed college courses scored higher on state tests, were less likely to be low income, and more likely to be white than of other racial backgrounds.[4] Because these particular characteristics tend to be associated with college outcomes, using PSM, we selected a comparison group of non-dual enrollees to help control for these factors that could otherwise alternatively explain any positive results. Thousands of non-white and low-income students still remained in the sample, enabling us to analyze the effects of dual enrollment on key subgroups.

Table 1 provides details on the demographics of the entire 2004 graduating cohort and for the treatment and control groups. See Appendix 1 for more information on the propensity score model.

TABLE 1.
DEMOGRAPHICS OF THE TOTAL 2004 TWELFTH-GRADE HIGH SCHOOL GRADUATING COHORT, THE TREATMENT GROUP, AND THE CONTROL GROUP[5]

	STATE NINTH-GRADE 2004 COHORT	TREATMENT GROUP	CONTROL GROUP
Number of Students	132,772	16,454	16,454
American Indian/Alaska	0.3%	0.2%	0.3%
Asian Pacific Islander	3.6%	3.4%	3.4%
African American	12.7%	6.2%	6.6%
Hispanic	34.2%	23.9%	24.1%
White	49.3%	66.3%	65.6%
Low Income	28.5%	17.4%	17.9%
Limited English Proficiency	2.2%	0.3%	0.9%
Average High Math TLI Score	--	87.11	86.44

"Low Income" means that the student was eligible for the federal government's free or reduced price lunch program, a common measure of economically disadvantaged students.

Average High Math TLI Score = the mean score on the Texas Learning Index test in math, using the highest score achieved by each student

To summarize, the sample included a total of 17,890 dual enrollees, and by using PSM, the researchers matched 16,454 of them to very similar counterparts who were not dual enrollees.[6] This resulted in a total study sample of 16,454 matched pairs of students (32,908 students in all). Upon further review, the analysis confirmed that the college-course completers (dual enrollment treatment group) and comparison (control) group were statistically similar across demographic and academic variables.

Using the final dataset of matched treatment and control groups, we analyzed eight primary models, examining the relationship between dual enrollment and three different postsecondary outcomes: enrollment in college (access); returning to college a second year (persistence); and earning a college

degree (completion). For each of these, the analysis also separately examined outcomes among students attending two-year and four-year colleges, although we only looked at persistence and completion among students enrolling in two-year schools because of data limitations.[7]

The final models used a mixed-effects (also known as multilevel) logistic regression with robust standard errors. This type of linear-mixed model controlled for the effect that different district-level access to courses could have had on student outcomes.[8]

LIMITATIONS

To control for potential differences in access to dual enrollment due to the district students attended and to eliminate the effect of students moving to different districts, we limited our sample to Texas students who spent all four years in the same school district and graduated from high school in 2004. However, as a result, the findings are not generalizable to students who move from district to district or who do not graduate from high school.

This study was also confined to students who enrolled in public or private colleges in Texas and does not address the association between dual enrollment and outcomes for students who attend college outside of the state. Nevertheless, the findings are still quite informative for the vast majority of students who attend college in the state, given the fact that only 16.8 percent of Texas high school graduates who enrolled in four-year colleges went of state, according to 2006 National Center for Education Statistics data.

On the other hand, that factor could bias the results to the extent that students who participated dual enrollment were more or less likely to enroll out of state than students who did not participate. If dual enrollment participants are more likely to leave the state, we may be underestimating the effect of dual enrollment; if dual enrollment participants are less likely to leave, we may be overestimating.

Another limitation is that, even as the sample compared socially and academically similar groups of students, it cannot account for differences in outcomes that may be related to unobservable characteristics between dual enrollees and non-dual enrollees. For example, we did not examine the role of a student's personal motivation to enroll in a college course (a trait sometimes described as "pluck").

Finally, this study provides strong evidence that dual enrollment was positively related to college outcomes *at the time of the study*, and much has changed about Texas dual enrollment policies since the students in this study graduated. Thus, the findings may not be generalizable beyond the time period studied. Even so, these findings add to a growing body of consistent evidence that dual enrollment is an effective college-readiness strategy, and it also can function as a baseline for future studies on dual enrollment in Texas.

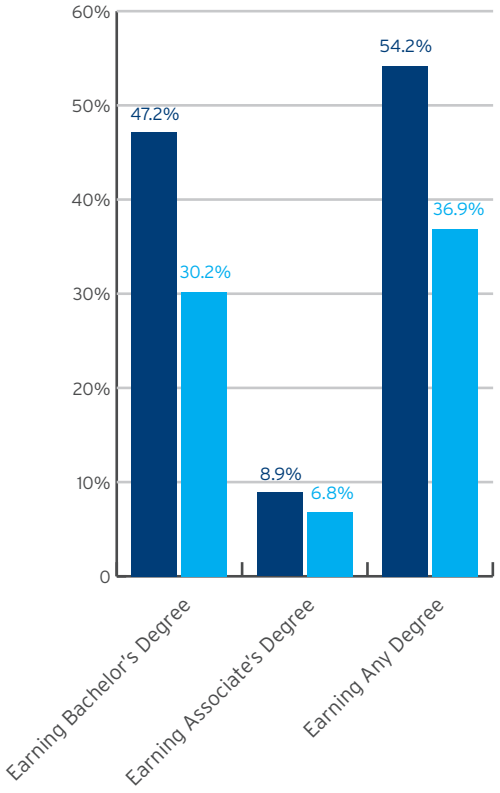
THE FINDINGS IN DETAIL

COLLEGE OUTCOMES

JFF examined student outcomes at any public postsecondary institution in Texas, including community colleges, technical colleges, and state colleges and universities. This enabled us to work with the fullest group of students across the greatest number of pathways. Our analyses also examined whether results differed when confining the analysis to two-year or four-year college students. In addition, the research first examined the effect of completing at least one dual enrollment college course (using a "yes/no" variable), and subsequent analyses examined outcomes for different quantities of these courses taken.

Overall, in our propensity score matched treatment and control groups, more college goers who completed at least one college course through dual enrollment completed their Bachelor's degree within six years than students who did not complete a dual enrollment college course—47 percent versus 30 percent, or roughly 50 percent more students (*see Figure 2 and Appendix 3*).

FIGURE 2.
COLLEGE COMPLETION RATES FOR STATISTICALLY MATCHED COLLEGE ENROLLEES, TEXAS, 2004 HIGH SCHOOL GRADUATING CLASS



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More detailed findings—based on linear mixed regressions of our propensity score matched student groups—are presented below. The research looked at differences in college access, college persistence, and college completion. It also examined the effects of completing certain types of courses, as well as the effects of differences in demographic groups and of completing more than one dual-credit course.

COLLEGE ACCESS

STUDENTS WHO COMPLETED AT LEAST ONE COLLEGE COURSE THROUGH DUAL ENROLLMENT IN HIGH SCHOOL WERE 2.21 TO 2.30 TIMES MORE LIKELY TO ATTEND ANY TYPE OF COLLEGE THAN A SIMILAR STUDENT WHO DID NOT COMPLETE DUAL ENROLLMENT.

The research first looked at students enrolling in two-year and four-year colleges. We conducted our analyses six times, each time accounting for additional factors that might influence student outcomes. No matter which control variables we included, the research still found a consistent and strong association between completion of college courses through dual enrollment and college or university enrollment (*see Table 2*).

TABLE 2.
IMPACT ON ENROLLMENT IN COLLEGE, BY VARIABLE

VARIABLES INCLUDED IN THE MODEL[9]	
Dual enrollment only	Students completing dual enrollment were **2.30 times more likely** to enroll.
Dual enrollment plus demographic controls	Students completing dual enrollment were **2.28 times more likely** to enroll.
Dual enrollment, demographics, and state test scores	Students completing dual enrollment were **2.25 times more likely** to enroll.
All the above, plus data on advanced[10] and specific categories of dual-enrollment course completion	Students completing dual enrollment were **2.21 times more likely** to enroll.

COLLEGE PERSISTENCE

STUDENTS ENROLLING IN COLLEGE WHO COMPLETED AT LEAST ONE DUAL ENROLLMENT COURSE IN HIGH SCHOOL WERE 1.79 TO 2.07 TIMES MORE LIKELY TO PERSIST FROM THE FIRST TO THE SECOND YEAR IN A TWO-YEAR OR FOUR-YEAR COLLEGE THAN A STUDENT WHO DID NOT COMPLETE DUAL ENROLLMENT.

The research examined student persistence in postsecondary from the first to second academic year. Once again, the analysis was composed of multiple models and found consistent results (*see Table 3*).

TABLE 3.
IMPACT ON PERSISTENCE IN COLLEGE

VARIABLES INCLUDED IN THE MODEL	
Dual enrollment only	Students completing dual enrollment were **2.07 times more likely** to persist.
Dual enrollment plus demographic controls	Students completing dual enrollment were **2.02 times more likely** to persist.
Dual enrollment, demographics, and state test scores	Students completing dual enrollment were **2.00 times more likely** to persist.
All the above, plus advanced and specific categories of dual enrollment course completion data	Students completing dual enrollment were **1.79 times more likel**y to persist.

COLLEGE COMPLETION

STUDENTS ENROLLING IN COLLEGE WHO COMPLETED AT LEAST ONE COLLEGE COURSE THROUGH DUAL ENROLLMENT IN HIGH SCHOOL WERE 1.66 TO 1.77 TIMES MORE LIKELY TO COMPLETE A POSTSECONDARY CREDENTIAL IN A TWO- OR FOUR-YEAR COLLEGE WITHIN SIX YEARS THAN A STUDENT WHO DID NOT COMPLETE DUAL ENROLLMENT.

College completion was judged after a period of six years. This is a common measure of completion because it gives four-year students an extra 50 percent of expected time to complete a degree. Our research found similar results for completion within four years. The research undertook multiple analyses of college completion with different control variables, again yielding consistently strong results (*see Table 4*).

TABLE 4.
IMPACT ON COLLEGE COMPLETION

VARIABLES INCLUDED IN THE MODEL	
Dual enrollment only	Students completing dual enrollment were **1.75 times more likely** to complete.
Dual enrollment plus demographic controls	Students completing dual enrollment were **1.78 times more likely** to complete.
Dual enrollment, demographics, and state test scores	Students completing dual enrollment were **1.75 times more likely** to complete.
All the above, plus advanced and dual enrollment course completion data	Students completing dual enrollment were **1.66 times more likely** to complete.

OUTCOMES FOR SPECIFIC DEMOGRAPHIC GROUPS

Each of these analyses examined whether differences in the relationship between dual enrollment and outcomes were based on students' race or economic status. The results suggest that whatever a student's economic status or race, dual enrollment is similarly beneficial. In only a few instances did the outcomes (or "interactions") for specific groups statistically differ from those of other groups.

COLLEGE ACCESS

WHITE STUDENTS WHO COMPLETED DUAL ENROLLMENT WERE 2.21 TIMES MORE LIKELY TO ENROLL THAN WHITE STUDENTS WHO DID NOT COMPLETE DUAL ENROLLMENT; AFRICAN-AMERICAN STUDENTS WHO COMPLETED DUAL ENROLLMENT WERE 1.60 TIMES MORE LIKELY TO ENROLL THAN AFRICAN-AMERICAN NON-COMPLETERS.

These data suggest that dual enrollment was still associated with increased access for African-American students but not as much as for white students. Latino students did not differ statistically from white students in this or any other analysis of the effects of dual enrollment.

FOUR-YEAR COLLEGE ACCESS

Those who are not economically disadvantaged were 2.03 times more likely to attend university immediately after graduation when completing dual enrollment; economically disadvantaged students were 2.41 times more likely to attend when completing dual enrollment.

When limiting the outcome variable to students enrolling in four-year schools, we found that completing college courses through dual enrollment raised the likelihood of college going for economically disadvantaged students. We found no other statistically significant differences in outcomes by race or economic characteristics, indicating that different demographic groups do not have significantly different outcomes related to completing college courses through dual enrollment.[11]

OUTCOMES FOR DIFFERENT COURSE SUBJECTS

We investigated whether different types of courses had different effects on college outcomes at two- and four-year institutions. The analysis revealed that completing any college course is beneficial, but some courses may be more so than others. In many cases, the samples of students who took specific courses were too small to make any statistically significant statement about differences based on course subject. However, the research did find statistically significant differences for several courses.

ENGLISH LANGUAGE ARTS—RELATED TO COLLEGE ACCESS

Students who completed an ELA college course through dual enrollment were 2.75 times as likely to enroll in college than were students who completed no dual enrollment. This compares with a 2.21 times increase in likelihood to enroll for completing any college course through dual enrollment. When studying college completion, taking ELA did not have a statistically different outcome from taking any course (*see Table 5*).

VOCATIONAL EDUCATION—RELATED TO COLLEGE ACCESS AND COMPLETION

Students who completed a vocational college course through dual enrollment were 1.53 times as likely to enroll in college than were students who completed no dual enrollment. This compares with a 2.21 times increase in likelihood to enroll for completing any college course through dual enrollment (*see Table 5*).

Students who completed a vocational college course through dual enrollment were 1.37 times as likely to complete college than were students who completed no dual enrollment. This compares with a 1.68 times increase in likelihood to complete for completing any college course through dual enrollment.

FOREIGN LANGUAGES—RELATED TO COLLEGE ACCESS

Students who completed a language college course through dual enrollment were 1.51 times as likely to enroll in college than were students who completed no dual enrollment. This compares with a 2.21 times increase in likelihood to enroll for completing any college course through dual enrollment (*see Table 5*).

PHYSICAL EDUCATION—RELATED TO COLLEGE ACCESS IN FOUR-YEAR SCHOOLS

When looking at enrollment in only four-year colleges, students who completed a physical education college course through dual enrollment were 1.40 times as likely to enroll than were students who completed no dual enrollment. This compares with a 2.21 times increase in likelihood for completing any college course through dual enrollment (*see Table 5*).

TABLE 5.
IMPACT ON COLLEGE ACCESS, BY TYPE OF COURSE

ANY COURSE (AVERAGE)	ELA	VOCATIONAL	LANGUAGE	PHYSICAL EDUCATION	MATH
2.21 times more likely to enroll	2.75 times more likely to enroll	1.53 times more likely to enroll	1.51 times more likely to enroll	1.40 times more likely to enroll (four-year schools only)	Not statistically difference from average

MATHEMATICS

Students who completed a math college course through dual enrollment did not differ statistically significantly in their likelihood to enroll in, persist in, or complete college. This may be due to high variance in course quality or to small numbers of students who took math, making the results less likely to be statistically significant.

One possible explanation for differences in outcomes associated with different courses is that vocational, physical education, and foreign language classes all often have lower eligibility standards than other courses. Given that students who take these courses may have lower academic achievement to begin with, this factor could account for some or all of the results in them.

OUTCOMES FOR COMPLETING MULTIPLE COURSES BEYOND THE FIRST

Despite an already large effect from completing any college course, completing ELA and math courses may provide an additional positive effect.

One model specification that was tested revolved around three treatment variables and their interaction:

- One variable to indicate that a student completed at least one college course through dual enrollment;
- One variable to indicate that a student completed either one or two college ELA or math classes through dual enrollment; and
- One variable to indicate that the student completed more than two ELA or math classes.

This model specification gave us slightly lower estimates because the analysis included more closely related variables. We chose the specifications of one to two credits and two or more credits because in many cases a single college course completed in high school will register as two dual enrollment credits. Table 6 summarizes the results.

TABLE 6.
IMPACT ON ACCESS AND COMPLETION, BY NUMBER OF COLLEGE COURSES TAKEN THROUGH DUAL ENROLLMENT

	ANY DUAL ENROLLMENT COMPLETED	1-2 ELA OR MATH CREDITS (ONE COURSE)	2+ ELA OR MATH CREDITS (MORE THAN ONE COURSE)
Impact on College Access	1.67 times more likely to enroll	1.78 times more likely to enroll	1.89 times more likely to enroll
Impact on College Completion	1.43 times more likely to complete	1.72 times more likely to complete	1.83 times more likely to complete

These results were consistent among all the different outcomes, with a larger and statistically significant benefit from completing math or English. More courses provided a larger benefit.

Again, unobserved traits of the students, rather than the content of the courses, could influence some of these results. For instance, students who complete vocational education and physical education courses may be less likely to want to attend college than other students. Overall, more research is needed about the relationship between the types and number of courses students take for dual enrollment and postsecondary outcomes. Suffice it to say that this research suggests that completing any type of college course through dual enrollment is beneficial, but some courses are probably more beneficial than others.

OUTCOMES FOR TWO-YEAR AND FOUR-YEAR COLLEGES

WHEN LIMITING THE ANALYSIS TO EITHER TWO-YEAR SCHOOLS OR FOUR-YEAR SCHOOLS, THE RESULTS WERE STILL BROADLY SIMILAR.

To investigate the effects of completing college courses through dual enrollment for students attending different types of colleges, we conducted two additional types of analyses. One analysis changed the outcome variables to examine access, persistence, and completion in regard to four-year colleges.[12] Another analysis limited the sample to only those students who initially enrolled in two-year colleges. Given that two-year colleges are open-access institutions and that it is methodologically difficult to study the factors that affect access to these schools, we did not analyze access.[13] However, the research did look at persistence and three-year college completion rates for two-year schools. Results were strong and consistently statistically significant when looking at different types of schools (*see Table 7*).

TABLE 7.
IMPACT ON OUTCOMES OF COMPLETING AT LEAST ONE COLLEGE COURSE THROUGH DUAL ENROLLMENT, BY TYPE OF COLLEGE (FULLY CONTROLLED MODELS)

	TWO-YEAR OR FOUR-YEAR COLLEGE	FOUR-YEAR COLLEGE	TWO-YEAR COLLEGE
Impact on Enrollment	2.21 times more likely to enroll	2.03 times more likely to enroll	n/a
Impact on Persistence	2.00 times more likely to persist	1.46 times more likely to persist	1.54 times more likely to persist
Impact on Completion	1.66 times more likely to complete	1.46 (6 year) times more likely to complete	1.83 (3 year) times more likely to complete

IMPLICATIONS FOR PRACTICE AND POLICY

IMPLICATIONS FOR PRACTICE AND STATE POLICY

GIVEN THE STRENGTH OF THESE RESULTS AND THE METHODOLOGY USED, THE RESEARCH STRONGLY SUGGESTS THAT ENABLING STUDENTS TO COMPLETE COLLEGE COURSES IN HIGH SCHOOL CAN BE AN EFFECTIVE STRATEGY FOR RAISING RATES OF COLLEGE ENROLLMENT, PERSISTENCE, AND COMPLETION IN TWO-YEAR AND FOUR-YEAR COLLEGES.

In all analyses, completing a college course through dual enrollment had a consistent and positive association with college enrollment, persistence, and completion. This is especially notable given that the research compared dual enrollees with non-dual enrollees who were otherwise from similar academic and demographic backgrounds.

THE RESEARCH SUGGESTS THAT DUAL ENROLLMENT IS RELATED TO BENEFITS FOR ALL DEMOGRAPHIC GROUPS.

One variance in the findings was that while African-American dual enrollees had higher college enrollment rates than non-enrollees, the positive effects on enrollment were lower than that for students from other racial groups. Another variance was that low-income students may see larger increases in four-year college enrollment when completing college courses through dual enrollment. Future research could examine whether differences in the dual enrollment or other educational experiences of these students might explain these variances.

THE FINDINGS INDICATE THAT, WHILE COMPLETING ANY COLLEGE COURSE WAS BENEFICIAL, CERTAIN COURSES MAY BE MORE BENEFICIAL THAN OTHERS IN PROMOTING POSITIVE COLLEGE OUTCOMES.

While these analyses found that all courses were positively related to college outcomes, courses that were found to have smaller effects in multiple analyses were vocational, foreign language, and physical education courses. The research also suggests that ELA course completion might be more beneficial. When we analyzed ELA and math together, this category of courses was also associated with positive college outcomes. Completing more courses beyond the first was associated with even stronger positive outcomes.

IMPLICATIONS FOR NATIONAL POLICY AND RESEARCH

These results also have national policy implications, given that they complement a number of findings from rigorous research on dual enrollment in different states that point to consistent patterns.

ENCOURAGING DUAL ENROLLMENT OF HIGH SCHOOL STUDENTS IN COLLEGE COURSES IS A WAY TO ENHANCE THEIR READINESS FOR COLLEGE. THIS INCLUDES STUDENTS FROM LOW-INCOME GROUPS AND OTHER GROUPS UNDERREPRESENTED IN COLLEGE.

Research findings consistently indicate that completing college courses as a dual enrollee is positively associated with college enrollment, persistence, college GPA, and degree completion. States should encourage—for example, through accountability and finance incentives—partnerships between districts and postsecondary institutions that enable more high school students to complete college courses before graduation as a way of promoting their college and career readiness.[14]

MORE PREPARATION, SUPPORT, AND ACCELERATED LEARNING STRATEGIES ARE NEEDED TO ENSURE THAT LOW-INCOME AND UNDERREPRESENTED STUDENTS CAN TAKE ADVANTAGE OF THE BENEFITS OF DUAL ENROLLMENT.

This and previous research (Karp et al. 2007) have suggested that low-income students and others from traditionally underrepresented college-going groups may benefit as much as their peers, if not more so, from participation in dual enrollment. However, their representation was relatively low among all dual enrollees in Texas and nationally. Raising the college and career success of these students, some of the fastest-growing populations in the country, is imperative. More strategies are needed, such as early college high schools, which enable students from these groups to accelerate through college preparatory curricula and graduate high school having earned significant college credits and momentum in college.[15]

Texas has been a leader in the early college movement, but it initiated most of these schools after the students in this study had completed high school. Future research could see whether early college high schools have raised dual enrollment completion by underrepresented students; initial data indicate that they have (JFF 2011). Texas data about the higher growth of dual enrollment participation among underrepresented racial groups since 2004 indicate that its policies have helped to increase access for these groups.

MORE RESEARCH IS NEEDED ABOUT THE TYPES OF COLLEGE COURSES AND PATHWAYS THAT HAVE THE STRONGEST POSITIVE ASSOCIATION WITH COLLEGE-GOING OUTCOMES. LIKE OTHER RECENT RESEARCH, THIS STUDY FOUND POSTSECONDARY OUTCOMES TO VARY BY THE TYPE OF COURSE TAKING COMPLETED BY DUAL ENROLLEES.

As policymakers and practitioners adopt and refine the design of dual enrollment, it will be important for them to have the best possible evidence about how different college-course experiences relate to student outcomes. Key design choices are likely to revolve around the college-course subject areas that are offered, the number of courses that students complete, whether the courses are located on a college or high school campus, and whether the instructor is a full-time college instructor or an adjunct. We encourage states to collect more data at this level of detail about the college courses taken by high school students. Future research and knowledge would be enhanced by data that illuminate whether and how these factors make a difference in outcomes.

CONCLUSION

After the students in this study graduated, Texas advanced many policies to expand dual enrollment opportunities for diverse populations. Our findings suggest that this was a wise strategy, given dual enrollment's consistently strong results among different demographic groups. Before its expansion, dual enrollment was associated with positive benefits for large numbers of students in every region of the state. In the dataset, each region had at least 12 districts offering dual enrollment, with an average of 50 districts per region offering courses.

If the expansion of dual enrollment by Texas policymakers after 2004 extended a similarly beneficial college course-taking experience to more students, then the policy changes are likely to have provided enormous benefit to more students across the state. Efforts should be made to study later dual enrollment cohorts in a similar manner to determine whether these results still hold.

These results suggest that policymakers nationally should encourage dual enrollment as strategy to increase college readiness and success. Supporting students in high school to complete even a single college class is associated with a higher likelihood that these students will attend college and eventually graduate.

APPENDICES

APPENDIX 1
PROPENSITY SCORE MODEL

Dependent variable: Took at least one college class through dual enrollment during their junior or senior year of high school.

MOST SIGNIFICANT TERMS IN THE PROPENSITY SCORE MODEL

ENTERED IN STEPWISE MODEL	VARIABLE NAME	SIGNIFICANCE	ODDS-RATIO ESTIMATE
1	Access to Dual Enrollment in District	<.0001	1.058
2	Highest Math TLI score	<.0001	1.075
3	Completed Dual Social Studies Fr/Soph Year	<.0001	0.119
4	Met the minimum math TLI cutoff (interacts with other TLI variables)	<.0001	0.052
5	Female	<.0001	1.582
6	Completed Dual Voc Ed Fr/Soph Year	<.0001	0.454
7	Gifted	<.0001	1.524
8	Percent attending in district	<.0001	1.085
9	Highest Reading TLI score	<.0001	1.049
10	Met the minimum reading TLI cutoff (interacts with other TLI variables)	<.0001	0.046
11	African American	<.0001	0.474
12	Economically Disadvantaged	<.0001	0.807
13	Asian	<.0001	0.507
14	Met all minimum TLI cutoff scores (interacts with other TLI variables)	<.0001	13.680
15	Met the minimum writing TLI cutoff (interacts with other TLI variables)	<.0001	0.180
16	ESL (English Second Language)	<.0001	0.394
17	Completed Dual Language Fr/Soph Year	<.0001	0.608
18	Hispanic	<.0001	0.791
19	Special Ed	<.0001	0.562
20	Completed Dual Science Fr/Soph Year	<.0001	0.373
21	DualPHYSED0102Total	<.0001	0.275
22	Completed Advanced Sci Fr/Soph Year	<.0001	0.373
23	Completed Advanced Math Fr/Soph Year	<.0001	0.865
24	Voc Ed Student	<.0001	1.094
25	Completed Advanced Soc. Fr/Soph Year	0.0003	1.087
26	Completed Dual ELA Fr/Soph Year	0.0058	0.476
27	Completed Advanced ELA Fr/Soph Year	0.0073	1.050
28	Completed Advanced Language Fr/Soph Year	0.0182	1.085

The odds-ratio estimate is the increased likelihood of the outcome variable given the variable. Odds ratios are a method of expressing the changing likelihood for an outcome given the change in a variable. If the outcome is enrolling in college and the variable "female" is 1.24, that means that among the students enrolled in college there are 1.24 females for every male.

Note: More variables were considered in the propensity score model, but the ones that were not statistically significant were not used, and are not listed here. Researchers at the UT Austin Education Research Center tested the treatment and control groups and concluded that they were balanced in terms of background covariates.

APPENDIX 2
COHORT, TREATMENT, AND CONTROL GROUP, BY REGION

	2004 COHORT OF GRADUATING HIGH SCHOOL SENIORS		TREATMENT GROUP		CONTROL GROUP	
Region	**Count**	**Percent**	**Count**	**Percent**	**Count**	**Percent**
1	8,463	6.4	1,070	6.5	792	4.8
2	3,822	2.9	357	2.2	286	1.7
3	1,672	1.3	432	2.6	333	2.0
4	28,762	21.7	3,173	19.3	4,495	27.3
5	3,058	2.3	432	2.6	330	2.0
6	3,933	3.0	736	4.5	544	3.3
7	5,108	3.8	740	4.5	619	3.8
8	1,889	1.4	411	2.5	339	2.1
9	1,502	1.1	221	1.3	199	1.2
10	18,158	13.7	1,862	11.3	1,931	11.7
11	11,267	8.5	1,216	7.4	1,314	8.0
12	3,466	2.6	648	3.9	473	2.9
13	10,586	8.0	1,032	6.3	1,042	6.3
14	1,501	1.1	298	1.8	217	1.3
15	2,283	1.7	372	2.3	362	2.2
16	2,957	2.2	540	3.3	350	2.1
17	3,030	2.3	409	2.5	352	2.1
18	3,160	2.4	672	4.1	630	3.8
19	5,877	4.4	347	2.1	637	3.9
20	12,278	9.2	1,486	9.0	1,209	7.3
Total	**132,772**	**100.0**	**16,454**	**100.0**	**16,454**	**100.0**

Note: Treatment and control groups were matched based on the propensity score model (*see Appendix 1*).

APPENDIX 3
EDUCATIONAL ATTAINMENT OF TREATMENT AND CONTROL GROUPS

SIX-YEAR RATES	TREATMENT GROUP (N)	TREATMENT GROUP (%)	CONTROL GROUP (N)	CONTROL GROUP (%)
Bachelor's Ever	7,774	47.2	4,970	30.2
Associate's Ever	1,457	8.9	1,112	6.8
Certificate Ever	319	1.9	357	2.2
Any Degree Ever	8,926	54.2	6,079	36.9
Bachelor's 4 years	4,108	25.0	2,394	14.5
Any Degree 3 years	1,342	8.2	794	4.8

Note: Treatment and control groups were matched based on the propensity score model (*see Appendix 1*)

APPENDIX 4
TEST SCORES BY TREATMENT AND CONTROL GROUPS

ASSESSMENTS	FINAL TREATMENT GROUP MEAN	FINAL CONTROL GROUP MEAN
Highest Math TLI	87.11	86.44
Highest Reading TLI	92.14	91.26
Dual Access	26.46	27.80

COUNT OF STUDENTS WHO MET MINIMUM TLI IN ALL SUBJECTS	FINAL TREATMENT GROUP	FINAL TREATMENT GROUP	FINAL CONTROL GROUP	FINAL CONTROL GROUP
	Count	**Percent**	**Count**	**Percent**
Minimum ALL	16,133	98.05	15,904	96.66

APPENDIX 5
ODDS RATIOS FOR COLLEGE ACCESS MODEL

Odds ratios are a method of expressing the changing likelihood for an outcome given the change in a variable. If the outcome is enrolling in college and the variable "female" is 1.24, that means that among the students enrolled in college there are 1.24 females for every male.

Each model used more variables to explain the relationship between taking a college course through dual enrollment and college access. Four of the models are given below.

Highlighted values are significant at p<.05 (5%)

MODEL NUMBER		1	2	3	4
Took a College Course Through Dual Enrollment Junior or Senior Year	Odds-Ratio	2.304	2.281	2.254	2.208
	Pr>t	<.0001	<.0001	<.0001	<.0001
Female	Odds-Ratio		1.249	1.254	1.251
	Pr>t		<.0001	<.0001	<.0001
Native American	Odds-Ratio		0.717	0.709	0.718
	Pr>t		0.14	0.135	0.1442
Asian	Odds-Ratio		1.252	1.242	1.202
	Pr>t		0.02	0.003	0.0093
African American	Odds-Ratio		0.805	0.867	0.884
	Pr>t		0.001	0.037	0.072
Hispanic	Odds-Ratio		0.7	0.726	0.752
	Pr>t		<.0001	<.0001	<.0001
Low Income (Free and reduced price lunch)	Odds-Ratio		0.647	0.659	0.673
	Pr>t		<.0001	<.0001	<.0001
English Second Language	Odds-Ratio		0.348	0.419	0.459
	Pr>t		<.0001	<.0001	<.0001
Gifted	Odds-Ratio		1.352	1.277	1.102
	Pr>t		<.0001	<.0001	0.0165
Special Education Student	Odds-Ratio		0.423	0.674	0.722
	Pr>t		<.0001	0.001	0.0025

MODEL NUMBER		1	2	3	4
Vocational Ed Student	Odds-Ratio		0.988	0.993	1.033
	Pr>t		0.684	0.82	0.2518
Highest Reading TLI Score	Odds-Ratio			1.007	1.007
	Pr>t			0.039	0.016
Highest Math TLI Score	Odds-Ratio			1.013	1.007
	Pr>t			0.0002	0.0327
Met minimum on all tests to be eligible to take dual enrollment	Odds-Ratio			1.194	1.364
	Pr>t			0.1894	0.0176
Took a college ELA course any year	Odds-Ratio				1.245
	Pr>t				0.0052
Took a college math course any year	Odds-Ratio				1.409
	Pr>t				0.1169
Took a college sociology course any year	Odds-Ratio				1.016
	Pr>t				0.814
Took a college science course any year	Odds-Ratio				0.826
	Pr>t				0.4313
Took a college physical education course any year	Odds-Ratio				0.631
	Pr>t				0.0794
Took a college language course any year	Odds-Ratio				0.683
	Pr>t				0.001
Took a college arts course any year	Odds-Ratio				0.959
	Pr>t				0.8667
Took a college computer course any year	Odds-Ratio				1.468
	Pr>t				0.2358
Took a college vocational ed course any year	Odds-Ratio				0.695
	Pr>t				0.0039
Took any other college course any year	Odds-Ratio				1.29
	Pr>t				0.7007

MODEL NUMBER		1	2	3	4
Took an advanced high school ELA course any year	Odds-Ratio				1.072
	Pr>t				0.0709
Took an advanced high school math course any year	Odds-Ratio				1.372
	Pr>t				<.0001
Took an advanced high school sociology course any year	Odds-Ratio				1.15
	Pr>t				0.0005
Took an advanced high school science course any year	Odds-Ratio				0.945
	Pr>t				0.4028
Took an advanced high school language course any year	Odds-Ratio				0.794
	Pr>t				0.0004
Took an advanced high school arts course any year	Odds-Ratio				0.911
	Pr>t				0.0968
Took an advanced high school computer course any year	Odds-Ratio				1.029
	Pr>t				0.6715
Took any other advanced high school course any year	Odds-Ratio				0.402
	Pr>t				0.0063
Number of dual credit courses the student had access to in the district	Odds-Ratio				0.999
	Pr>t				0.3289

APPENDIX 6
ODDS RATIOS FOR COLLEGE COMPLETION MODEL

Odds ratios are a method of expressing the changing likelihood for an outcome given the change in a variable. If the outcome is enrolling in college and the variable "female" is 1.24, that means that among the students enrolled in college there are 1.24 females for every male.

Each model used more variables to explain the relationship between taking a college course through dual enrollment and college completion. Four of the models are given below.

Highlighted values are significant at p<.05 (5%)

MODEL NUMBER		1	2	3	4
Took a College Course through Dual Enrollment Junior or Senior Year	Odds-Ratio	1.752	1.775	1.75	1.658
	Pr>t	<.0001	<.0001	<.0001	<.0001
Female	Odds-Ratio		1.505	1.579	1.531
	Pr>t		<.0001	<.0001	<.0001
Native American	Odds-Ratio		0.692	0.685	0.676
	Pr>t		0.1953	0.1831	0.1743
Asian	Odds-Ratio		1.252	1.242	1.202
	Pr>t		0.02	0.003	0.0093
African American	Odds-Ratio		0.54	0.607	0.636
	Pr>t		<.0001	<.0001	<.0001
Hispanic	Odds-Ratio		0.673	0.705	0.69
	Pr>t		<.0001	<.0001	<.0001
Low Income (Free and reduced price lunch)	Odds-Ratio		0.589	0.59	0.6
	Pr>t		<.0001	<.0001	<.0001
English Second Language	Odds-Ratio		0.844	0.819	0.921
	Pr>t		0.4683	0.4527	0.7305
Gifted	Odds-Ratio		2.124	1.87	1.369
	Pr>t		<.0001	<.0001	<.0001
Special Education Student	Odds-Ratio		0.517	0.688	0.788
	Pr>t		<.0001	0.0373	0.0967

MODEL NUMBER		1	2	3	4
Vocational Ed Student	Odds-Ratio		0.898	0.905	0.968
	Pr>t		0.005	0.0075	0.3695
Highest Reading TLI Score	Odds-Ratio			0.997	0.995
	Pr>t			0.7426	0.326
Highest Math TLI Score	Odds-Ratio			1.061	1.039
	Pr>t			<.0001	<.0001
Met minimum on all tests to be eligible to take dual enrollment	Odds-Ratio			0.298	0.544
	Pr>t			<.0001	0.0012
Took a college ELA course any year	Odds-Ratio				0.907
	Pr>t				0.1345
Took a college math course any year	Odds-Ratio				1.25
	Pr>t				0.1387
Took a college sociology course any year	Odds-Ratio				1.059
	Pr>t				0.2503
Took a college science course any year	Odds-Ratio				0.968
	Pr>t				0.8397
Took a college physical education course any year	Odds-Ratio				0.86
	Pr>t				0.3235
Took a college language course any year	Odds-Ratio				1.061
	Pr>t				0.625
Took a college arts course any year	Odds-Ratio				0.833
	Pr>t				0.456
Took a college computer course any year	Odds-Ratio				0.95
	Pr>t				0.6194
Took a college vocational ed course any year	Odds-Ratio				0.828
	Pr>t				0.0098
Took any other college course any year	Odds-Ratio				1.731
	Pr>t				0.3098

MODEL NUMBER		1	2	3	4
Took an advanced high school ELA course any year	Odds-Ratio				1.279
	Pr>t				<.0001
Took an advanced high school math course any year	Odds-Ratio				1.828
	Pr>t				<.0001
Took an advanced high school sociology course any year	Odds-Ratio				1.324
	Pr>t				<.0001
Took an advanced high school science course any year	Odds-Ratio				1.106
	Pr>t				0.0835
Took an advanced high school language course any year	Odds-Ratio				1.499
	Pr>t				<.0001
Took an advanced high school arts course any year	Odds-Ratio				1.166
	Pr>t				0.0353
Took an advanced high school computer course any year	Odds-Ratio				1.016
	Pr>t				0.7916
Took any other advanced high school course any year	Odds-Ratio				3.834
	Pr>t				0.0007
Number of dual credit courses the student had access to in the district	Odds-Ratio				0.999
	Pr>t				0.2897

APPENDIX 7
DUAL-CREDIT STUDY METHODOLOGY

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As discussed in the literature review of this report, a number of studies have investigated the impact of dual-credit coursework on students' likelihood of gaining access to a postsecondary institution and earning a degree or certificate. However, because none of these studies randomly assigned students to dual-credit courses and non-dual credit courses, the types of correlational analyses they employed might incorrectly estimate the effect of dual-credit course taking, given the inherent bias in students' self-selecting to take dual-credit courses. In other words, if students who take dual-credit courses differ systematically on preexisting attributes (e.g., academic achievement), and if the research methods fail to control for these systematic differences, the estimates of the influence of dual credit may be biased. The methods used for this study attempt to control for this selection bias to arrive at more accurate estimates of the impact of dual credit on postsecondary outcomes.

SAMPLE

The original sample of students for this study included all ninth graders in public high schools in Texas during the 2000-01 school year, totaling 382,236 students. This cohort of students was followed through all four years of high school, and the data on their course-taking patterns were integrated into the dataset. The final cohort included only students who made it through all four years of high school, did not repeat or skip any grade, attended public high schools for the duration of their secondary schooling, and graduated on time in 2004.

Also, the final cohort included only students who attended the same district for all four years of high school. The primary reason was because access to dual-credit coursework is heavily contingent upon the district that a student attends. Because districts must establish partnerships with colleges or universities in order to offer dual-credit courses, students who changed districts during high school may have experienced significantly different levels of access to dual-credit courses over time, preventing us from fully capturing this variation in access and potentially biasing our estimates. Out of the original ninth-grade sample of 382,236 students, 174,530 students progressed sequentially through public high schools, attended the same district for all four years, and graduated on time.

Additionally, only students enrolled in a district that gave students access to dual credit were eligible for our analyses. Dual-credit access was defined empirically by calculating the percentage of students in each district who were enrolled in at least one dual-credit course. The implications of restricting the sample in this way will become clearer in the following section, but including students without access to dual credit may have also biased our estimates of the impact of dual credit. Of the 174,530 students who attended the same district throughout high school and graduated on time, 132,772 attended a district that offered dual-credit courses and were thus eligible for our analyses.

The data for this report were provided by the Education Research Center at The University of Texas at Austin.

METHODS

Propensity Score Matching

To control for the potential self-selection bias inherent in observational studies such as the current one, the research team employed propensity score matching techniques (Rosenbaum & Rubin 1984). PSM matches treatment cases to control cases based on the predicted probability that a student would be assigned to the treatment group. This study matched each student who took dual-credit with one who did not but had the same propensity (predicted probability) to have taken dual-credit courses.

Our PSM technique consisted of two separate steps. In the first step, the probability of taking dual-credit coursework was estimated using logistic regression techniques. In logistic regression, the outcome variable is dichotomous (took dual credit/did not take dual credit), and the estimated outcome is the probability that a student would take dual credit. The PSM logistic regression model included a number of demographic variables that were presumed to influence the likelihood that a student would enroll in a dual-credit course, such as race/ethnicity, gender, income status, and program status (e.g., ESL, gifted, special education). However, to arrive at the most accurate estimates possible, the research team also believed that including data on previous coursework and scores on accountability assessments was necessary. The difficulty with this aspect of the estimation procedure was that using these data to predict whether a student would have taken dual credit at any point in high school may have resulted in using future data (e.g., twelfth-grade advanced coursework) to predict past outcomes (e.g., dual-credit course taking as a freshman). We thus elected to define our outcome variable as attempting and passing any dual-credit course during the junior or senior year of high school, and our predictor variables only included data from students' freshman and sophomore years.

Matching

After the logistic regression analysis was modeled, the propensities of attempting and completing at least one dual-credit course during 2002-03 or 2003-04 were saved as a new variable. Each student who did pass at least one dual-credit course (treatment) was then matched to a student who did not pass at least one dual-credit course (control). The technique used for the matching was the gmatch, or "greedy matching," macro developed by the Mayo Clinic to be used in the SAS® statistics program (Fraeman 2010). Greedy matching implies a 1:1 matching of treatment and controls.

The gmatch technique first divides the total sample into separate treatment and control datasets and orders the datasets based on students' predicted probabilities of assignment to treatment. Each treatment student is then matched to a control student and both students are removed from their respective datasets and placed into a newly created dataset. The threshold used for the matching was 0.001, meaning that treatment students would only be matched to controls if there was a control student that had a propensity score that differed 0.1 percent or less from theirs. Out of the 17,890 original treatment students who had taken dual credit, 16,454 were matched to a control case. This resulted in 1,436 treatment students with significantly different predicted probabilities of taking dual credit to be excluded from the final sample, as well as the remaining 116,318 potential control students. The final sample thus included 32,908 students.

ANALYSES

After PSM balanced the control and treatment groups on the majority of covariates (meaning that students in the treatment and control groups did not statistically differ in group averages on variables such as low income or limited English proficiency—see Table 1 and Appendix 4), the research team analyzed the influence of dual-credit coursework on a variety of postsecondary outcomes. The analyses were of three primary outcomes: postsecondary access; first-to-second year persistence; and eventual completion of a course of study.

Three separate models were run for each analysis. The first included all main effects of the variables described above, as well as the variable that indicated assignment to the treatment group. The second model added dual credit by demographic variable interaction terms to assess if the impact of dual-credit course taking varied by demographic group. The final model used a stepwise procedure to exclude all variables found to be non-significant statistically, resulting in a parsimonious model that only included significant variables.

Because each outcome variable of interest was dichotomous and occurred at a specific point in time, logistic regression techniques were once again used. With logistic regression, the outcome variable is defined as the odds that the outcome will occur. Odds represent the probability of an event occurring over the probability of the event not occurring. For example, if 10 white students were included in the analysis and 6 of them gained access to a postsecondary institution, the odds of access for a white student would be 6/4, or 3/2. Each variable in the model predicts the difference in the odds that the outcome of interest will occur. Thus, variables with estimates greater than one increase the odds of the outcome occurring, while estimates between zero and one represent a decrease in the likelihood of the outcome. To calculate the estimated odds for an individual student, the estimates of each specific variable would be added together.

While logistic regression is designed to model dichotomous outcome variables, one concern of using standard logistic regression analyses in studies such as the current one is the potential for certain statistical assumptions to be violated due to "nesting." Nesting occurs when individuals in the sample share certain features of their environment, such as attending the same school or district. This nesting violates one of the principle assumptions of logistic regression—that individuals in the sample are independent of one another. The codependence introduced by nesting has the potential to bias the estimates of the predictors and artificially reduce the standard errors of the estimates. However, if this codependence is modeled correctly, the estimates of the variables in the model will be less biased.

For the current study, the logistic regression analyses were therefore conducted using the "GLIMMIX" procedure in SAS®. With this procedure, the model can include both fixed and random effects and it can correct for the possibility of correlated residuals (Schabenberger 2005). Given the fact that the study only included only students who remained in the same district for all four years of high school, we allowed the intercept in the models to vary randomly based on the district that a student attended. Therefore, for each model we estimated the amount of variability in the outcome that could be explained by district-level factors. Additionally, we included a command for each analysis that performs a correction on the standard errors of the covariates, resulting in more robust estimates of the variables in the models.

Given the large number of variables in the model, there was a potential for multicollinearity to occur between the covariates. To test for this multicollinearity, a variance inflation factor (VIF) test was conducted to determine if the standard error estimates were being biased this phenomenon. VIF values of less than 10 are considered to indicate the absence of potentially biasing multicollinearity. Of all of the variables originally included in the models, only the TAAS accountability assessment variables were shown to have VIFs of greater than 5. Other variables were thus excluded from the analyses. After these variables were excluded, no other variable had an estimated VIF greater than 3.5.

ENDNOTES

[1] When we refer to course completion, we define it as meaning that a student passed a course with a C or above.

[2] The What Works Clearinghouse, and initiative of the U.S. Department of Education's Institute of Education Sciences, defines PSM as a quasi-experimental technique, a term indicating that this statistical method approximates a random assignment study, which has been established as the best way to show causality between treatments and outcomes (Shadish, Cook, & Cambell 2002).

[3] Data was limited this way because our propensity score model looked at the likelihood of taking a dual enrollment course junior or senior year based on freshman or sophomore dual enrollment course taking and other freshman and sophomore variables. One particular concern is that transferring students may have not been eligible for dual enrollment because they missed an earlier prerequisite.

[4] The tests in our dataset were the Texas Learning Index (TLI) for math, reading and writing.

[5] Non-mobile students who spent four years in the same high school and graduated.

[6] We used a method called "nearest neighbor" matching.

[7] The data used in this study did not enable us to determine student enrollment intent, which limited our understanding of which students might have chosen to enroll in a two-year school but instead chose a four- year school or to not attend college. In addition, the fact that most two-year schools are open-access institutions makes this analysis less interesting from a policy standpoint.

[8] Taking this factor into consideration enabled us to make inferences about when district effects might link with individual effects (Gelman 2006). We also tested all of our models to ensure that we had a low "variance inflation factor" to account for problems related to correlated explanatory variables (known as multicollinearity).

[9] Many variables were included in both the PSM and the dual enrollment analysis. This is because the influence of one variable (e.g., race) on a student's likelihood for taking dual enrollment is different than the influence of that same variable on a student's likelihood of enrolling in or completing college. Although demographic controls were used in the PSM model, the research must still account for these variables when studying college outcomes to get the most reliable estimate of the effect of dual credit on college outcomes.

[10] Advanced courses are defined as advanced by TEA and in a core subject area (math, science, social studies, English/language arts, and foreign language). This category contains both Advanced Placement (AP) and International Baccalaureate (IB) courses.

[11] We tested multiple model specifications containing interacted terms for the effect of taking a college course through dual credit for different races and for low-income students.

[12] This analysis treated enrollment in a four-year college as the outcome of interest, and included students who enrolled in two year schools with students who did not enroll in any college. Persistence and completion outcomes were determined only for students who initially enrolled in a four year college.

[13] Both very academically prepared students and academically unprepared students might choose not to enroll in two-year schools. Prepared students may instead enroll in four-year schools, while unprepared students may not go to college at all. This makes it difficult to analyze the population that did *not* attend two-year schools.

[14] Examples of policies that promote dual enrollment can be found in Ward & Vargas (2012) and Hoffman, Vargas, & Santos (2008).

[15] See: *Portrait in Numbers* (JFF 2011); *Making the Grade* (JFF 2011); Edmunds et al. (2010); SRI (2011).

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