The Impact of Dual Credit as a School District Policy on Secondary and Postsecondary Student Outcomes

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Abstract

This study estimates the effects of dual credit on outcomes that trace a student's journey from high school to undergraduate and graduate degree completion. Dual credit is a model program that allows high school students to enroll in college-level courses and simultaneously earn high school and college credit. This study investigates the potential for improving the design of dual-credit programs by exploring heterogeneous effects by program attributes. The study investigates if dual credit effects vary across course subjects. For a limited set of outcomes, the study investigates heterogeneous effects by the instructor's highest degree earned, instruction mode, and location of instruction. Using panel data with school district fixed effects, this study finds that increases in the share of students earning dual credit are associated with increases in high school graduation; increases in university application, admission, and enrollment; shortened time to degree completion; and increases in degree completion. Districts that increase their average dual credit earned improve outcomes with each increase. Furthermore, dual credit courses produce larger increases in bachelor's degree completion rates as compared to AP. Finally, evidence suggests that schools can most greatly amplify dual credit effects by prioritizing certain subjects.

Introduction

Education remains one of the most salient policy levers to promote economic self-sufficiency for individuals, their families, and the communities where they reside. Furthermore, our technology-driven global economy is making human capital development increasingly necessary for individuals and nations. By 2020, acquiring a postsecondary certificate or degree will be a requirement for nearly two-thirds of all jobs in the United States. Moreover, the benefits of postsecondary education are most crucial for large, diverse states like Texas where the fastest-growing segment of the population is young, economically disadvantaged, and from communities historically underserved by higher education institutions (Carnevale, 2013; Murdock et al., 2014).

Dual-credit programs were created as a strategy for increasing college readiness and access. Dual-credit courses have allowed eligible high school students to enroll in college-level courses and simultaneously earn college and high school credit. Dual-credit programs, also referred to as dual enrollment or concurrent enrollment, were created in the 1980's through local agreements between school districts and their local four-year or two-year colleges.

States created statewide dual-credit policies to promote access to and quality of dual-credit courses. More recently, local communities and states like Texas have adopted dual-credit programs to close educational achievement gaps between low-income students and their higher-income counterparts. Currently, all 50 states in the US have adopted dual-credit policies, with nearly 85 percent of all public high schools having enrolled students in dual-credit programs during the 2010-2011 academic year (Taylor, et al., 2015).

In Texas, where the study population of this investigation was drawn, there were two types of dual credit: academic dual credit and career and technology education (CTE) dual credit. Academic dual credit applied toward a certificate, associate, and bachelor's degree. High school students were eligible to participate in academic dual credit if they were classified as college-ready based on their performance on certain standardized exams[1]. CTE dual credit applied only to community college certificate programs and did not require students to be considered college-ready. In Texas, academic dual credit made up 85 percent of all dual credit earned during the study period. This study focused on the effects of academic dual credit on postsecondary outcomes. Hereafter, this paper refers to academic dual credit simply as dual credit.

Unlike Advanced Placement courses (AP), dual-credit courses resulted in college credit upon satisfactory completion of the course. AP courses resulted in college credit only if the student took an AP exam corresponding to their AP course and achieved a certain exam score. Students had to register to take an AP exam separate from their class registration and pay an additional fee.

Unlike dual credit, the College Board has developed a system for maintaining a national standard of quality associated with AP courses. It has created standardized curriculum for AP classes and college-credit exams. The College Board has also provided professional development for AP teachers.

Theoretical Framework

This study applied the economic theory of human capital investment developed by Becker (1962) to understanding dual credit. This theory asserts that individuals decide on pursuing additional education (in the case of this study, high school students decide on continuing their education into college) based on their expectations of the relative benefits and costs produced by the additional education. If students expect the net benefit of

[1] The standardized exams that determined college-readiness in Texas include the SAT, ACT, the Texas Success Initiative exam, and certain state-mandated high school exams.

additional education to be positive, they will pursue additional education and revisit this decision after acquiring each additional unit of education. This theory has many implications for dual credit.

Dual credit can be understood to facilitate college access and completion through five mechanisms. First, dual credit reduces the direct cost of college by allowing students to earn college credit for free or at a reduced rate, as most dual-credit programs are subsidized either by a student's school district or low-cost community college. Second, dual credit reduces the opportunity cost of foregone wages associated with postsecondary education because students acquire a head start on earning college credits before high school graduation. Third, dual-credit participation provides students valuable information to support their decision to enroll in college by allowing them to assess their ability to complete college-level coursework and develop an interest in college subjects. Fourth, dual credit can increase students' preferences for college by teaching them college-level study skills and advancing their intellectual development. Fifth, dual credit can also increase students' preferences for college by delivering knowledge about how college operates, including college enrollment systems, campuses, and classrooms.

We can expect the first two mechanisms to produce a dosage effect because the cost of college decreases with each increase in dual credit earned. As a result, each additional dual credit earned increases the likelihood of college enrollment and completion. The last three mechanisms reduce the uncertainty of being college-ready. We can expect these mechanisms to have decreasing marginal benefits. This is because once students are aware of their college-readiness and knowledge about how college operates there are few if any more benefits to gain in this regard.

Other consequences of dual credit include effects on timely high school graduation and university admissions. If the benefits of a college education become more accessible because of dual-credit participation, as described above, student preferences for timely high school graduation increase. Dual credit on a student's high school transcript can also increase the likelihood that a university admits a student based on the economic theory of signaling (Spence, 1973; Weiss, 1995)[2]. If dual-credit participation is a signal of college-readiness (an indicator of proactive academic preparation and personal determination) to offices of university admissions, then increases in dual-credit participation can lead to increases in college admissions.

Finally, as college tuition and fees increase, demand for dual credit will increase.

Literature Review

Eight previous studies used advanced quantitative methods to estimate dual credit's impact on student outcomes[3]. They found that dual credit improves rates of high school graduation, college enrollment, college persistence, college GPA, and college degree completion. Those that estimated dual-credit dosage effects also found that enrolling in more dual credit increased the likelihood of college enrollment and completion (Karp et al., 2007; Swanson, 2008; Speroni, 2011; Allen and Dadgar, 2012; An, 2013; Giani et al., 2016; Hughes, 2016).

Dual credit was also found to vary in its effect on degree completion by subject matter. Academic subjects such as English, math, social sciences, science and foreign languages produced larger effects on postsecondary degree completion (associate or

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[2] The signaling value of education is an economic theory that asserts that part of the value of education is based on its ability to signal to decision makers, such as employers (or, in this study, offices of university admission) that a person who has achieved a certain education is more likely to possess traits desired by the decision maker.

[3] I used the online Scout search engine of the library system at University of Texas at Austin, the databases of Academic Search Complete, Education Source, ERIC, and the Google Scholar search engine. I searched for articles published in peer-reviewed journals and dissertations that included the following terms: dual credit, concurrent enrollment, postsecondary impact, college impact, postsecondary effects, college effects, high school graduation, college enrollment, and college graduation. I limited my search to research addressing dual credit in US.

bachelor's degree) than non-core courses such as computer science, health, and art. Math dual credit was also found to produce larger effect sizes on degree completion than other core dual-credit subjects (Speroni, 2011; Giani et al., 2016).

With few exceptions, studies found that the effects of dual credit on college enrollment and degree completion were greatest for socioeconomically disadvantaged students (Karp, et al., 2007; An, 2013). One study by Speroni (2011) found that dual credit increased four-year college enrollment more for minority students but did not produce an effect on postsecondary enrollment (an outcome that combined two-year and four-year college enrollment) in general. This suggested that dual credit induced students to enroll in four-year colleges who otherwise would have enrolled in two-year colleges.

Two existing studies reviewed compared dual credit to other types of college preparatory classes including Advanced Placement (AP). Giani et al. (2016) found that dual-credit courses produced larger effect sizes than advanced high school courses (non-AP) on most postsecondary outcomes examined, including bachelor's degree completion rates. Speroni (2011) tested the effect size differences between dual credit and AP on postsecondary enrollment (enrollment in a two-year or four-year college) and on enrollment in a four-year college. She found that dual credit increased postsecondary enrollment greater than AP, while AP increased four-year college enrollment greater than dual credit, all by statistically significant margins. She also found no statistically significant difference between AP and dual credit's impact on bachelor's degree attainment.

Contribution of this Study

This study built on the existing research by using a larger study sample, using a different methodology for controlling for unobserved student and school attributes, and answering new questions.

The study sample was the largest to date. This study followed 11 cohorts of more than three million students who enrolled in over one thousand school districts, from ninth grade in high school up to 13 years post high school entry. Furthermore, the student population studied was from a large and diverse state, Texas.

This study contributed to the existing literature by using a school district-level fixed-effects analysis that emphasized the effects of dual credit *as a policy*. Previous studies individually compared students who did and did not enroll in dual credit, but a student's choice to enroll in dual credit was potentially endogenous and may have produced biased effects if, say, students who already have clear college plans were more likely to enroll in dual credit. To address this weakness, my approach allowed each district to serve as its own control group, effectively controlling for time-invariant district-level confounding variables such as the socioeconomic and demographic composition of a district's student body. This was an important consideration given Texas' highly segregated public-school system (Frankenberg, 2013).

This study also improved upon the existing research by including student outcomes unique to community colleges. This was an important contribution because community colleges have the most to gain from an evaluation of dual credit. They were the higher education partner in nearly all dual-credit programs in Texas and the primary provider in the US. They have the lowest degree completion rates of all higher education institutions. And, most high school graduates who attended college during the study period began at a community college.

This study was also the first to analyze dual-credit effects on university admissions, improving our understanding of the signaling value dual credit may produce in regard to university admissions. It followed students up to thirteen years from when they first enter high school to estimate dual-credit effects on graduate degree attainment. It explored dosage effects of dual credit to determine whether effect sizes plateau at higher levels of participation. And it furthered the comparative analysis between AP and dual credit by examining the dosage effects of each type of early college coursework.

Finally, this study made new contributions to the study of dual-credit program design. This study investigated how dual-credit effect sizes varied across different program attributes, though endogeneity issues made these findings tentative. Specifically, this study explored whether dual-credit effects varied between English, math, science, social science, arts, foreign languages, computer science, and "other" subjects. For a limited set of shorter-term outcomes (high school graduation, university application, university enrollment, and community college enrollment, associate degree completion), the study investigated whether instructors with a doctoral degree produced a different impact from those with a master's degree; whether impacts varied by instruction mode (traditional face-to-face classroom instruction, instruction with teacher and students connected by video, computer-based instruction, or a combination of computer and classroom instruction referred to as blended learning in this paper); and whether dual-credit courses located on a high school campus produced a different impact from those located on university or community college campuses.

In summary, the research questions this study attempted to answer include the following:

1. Did dual-credit participation cause more students to pursue a two- and four-year college degree, respectively?
2. Did dual-credit participation cause an increase in university admissions?
3. Did dual-credit participation increase educational attainment levels, measured by increasing rates of high school graduation and associate, bachelor's, and graduate degree attainment, respectively?

4. Did dual-credit participation decrease time to degree for students pursuing an associate and bachelor's degree, respectively?
5. Did marginal increases in dual-credit participation produce positive marginal benefits – was more dual credit better?
6. Were dual-credit effects on student outcomes larger than those produced by Advanced Placement (AP) courses?
7. Did dual-credit effect sizes vary by course subject, mode of instruction, location of instruction, or instructor's highest degree earned?

POLICY BACKGROUND

Dual-credit courses studied were the product of collaborations between school districts and colleges. In Texas, community colleges were the primary higher education sponsor of dual-credit programs. These collaborations were created at the local level with limited state oversight, while other states maintain a state-level regulatory framework (Taylor, Borden & Park, 2015).

There was great variety in dual-credit program design. In addition to varying by subject, dual-credit courses were taught within different settings (high school campus, community college campus, university campus, or other location such as a place of work, military facility, or correctional institution). They used different modes of instruction (face-to-face instruction, video, computer-based content only, or a blend of online coursework and face-to-face instruction). And, they were instructed by teachers with a master's degree or doctorate. (Reporting and Procedures Manual Texas for Community, Technical, and State Colleges, 2016).

Who taught dual-credit classes was a significant concern. Dual-credit instructors in Texas must hold either a master's degree or a doctorate. University faculty and administrators have questioned the rigor of dual-credit courses, which are most commonly taught by instructors with a master's degree only[4].

In 1995, the Texas legislature authorized community colleges to offer dual-credit programs in partnership with their local school districts by passing House Bill (HB) 1336. Though Texas was not an early adopter of dual-credit policy, it tried to catch up to other states. From 1995 to 2015, the legislature passed 20 bills incentivizing the creation of dual-credit programs and removing barriers to increased enrollment and program expansion. For example, in 2003, the Texas legislature passed HB 415 to allow both school districts and colleges to be paid by the state for the provision of dual-credit instruction. Three years later, the Texas legislature passed HB 1, requiring all public high schools to provide students access to 12 semester credit hours (SCH) of college credit through AP, International Baccalaureate, or dual-credit courses. In 2015, the Texas legislature prohibited the Texas Higher Education Coordinating Board (Coordinating Board) from adopting rules that limit the total number of dual-credit courses a student could enroll in (HB 505). In the same session, the Texas legislature also removed regulations that limited colleges from providing dual credit outside of their service area.

Dual credit received bipartisan support from two advocacy coalitions, one dominated by Republican legislators who prioritized cost efficiencies in higher education and one dominated by Democratic legislators who prioritized college access and completion, particularly for low-income and minority students. Members of both coalitions promoted dual credit as a cost-efficient and egalitarian solution for raising educational

[4] The popular press has documented this perspective on dual credit held by university administrators. The following quote about dual credit was one example. "In terms of the rigor of the community college programs, it is a little bit of a mixed bag," [Jim Miller, Dean of Admissions at Brown University] said. "We know what an AP calculus class is. We're not sure what a calculus course is at the myriad community colleges" (Mellon, 2008).

attainment levels in the context of rising tuition rates and declining state funding for higher education.

Dual credit was also popular with public school administrators and students. School districts offering dual credit grew from 75 percent in 2001 to 92 percent in 2011, as shown in Figure 1. Within dual-credit districts, student participation in dual credit grew from 16 percent of the high school cohort who started high school in 2001 to 27 percent of the 2011 cohort, as shown in Figure 2.

Most important for this study, school districts adopted dual-credit policies at different times and experienced unique fluctuations in student participation in dual credit. It was this variation that permitted the identification of dual-credit effects. As shown in Table 1, only eight percent of school districts experienced consistent positive growth across time. School districts experienced fluctuations in dual-credit participation that varied from one to seven declines across 11 cohorts, with the largest share experiencing four declines. Furthermore, as shown in Figure 1, dual-credit adoption varied across major urban, major suburban, non-metropolitan, rural, charter, and other school districts by year. At districts that offered dual credit, student participation in dual credit also varied across these categories of school districts, as shown in Figure 2.

DATA

This study analyzed data from the Education Research Center at the University of Texas at Austin (UT ERC). The UT ERC data used included student-level administrative data collected by the Texas Education Agency (TEA) and the Coordinating Board. The data described the secondary and postsecondary education of public school students who entered high school in academic years ending in 2001 to 2011. The data also described the demographics, household poverty status, and performance on state-required tests of students.

The student population included in the analysis amounted to 3,321,366 public high school students who entered 2,554 high schools in 1,173 public school districts (district). I collapsed the student-level data into district-level data to form a data set of 1,173 unique districts with up to 11 student cohorts of data. I defined a cohort as the group of students who entered high school in the same year. As shown in Table 2, the pooled sample of 11 district-level cohorts equaled 12,021 observations and varied by student demographics, performance on state-mandated test scores, and dual credit earned by program attributes.

Data Limitations

TEA and the Coordinating Board used separate systems to collect data describing student enrollment in dual credit. A study of the two systems found that approximately a quarter of TEA-identified dual-credit students were not identified as dual-credit students by the Coordinating Board, and vice versa. The systems also lacked a course "crosswalk" to link course data (Eklund, 2009). As a consequence, researchers that modeled the effects of dual credit in Texas had to choose between the two sources of dual-credit data.

I chose to rely on TEA data to answer my primary research questions, questions one through six, because TEA data allowed me to account for AP credit earned. I used Coordinating Board data to explore heterogeneous effects of dual credit by instruction mode and location, data absent from TEA data.

A second data limitation was associated with the identification of heterogeneous effects by type of instructor, and teaching mode and location. As shown in Table 2, the observation counts associated with these variables was approximately one-fifth of the other variables. This was because the state of Texas did not begin collecting these variables until fiscal year 2012. As a result, heterogeneous effects by these attributes could only be examined for the 2008 cohort and for outcomes that occurred within two years from the cohort's expected high school graduation. Consequently, the findings of heterogeneous effects were tentative.

RESEARCH DESIGN & METHODOLOGY

Students voluntarily enrolled in dual credit. This posed a challenge to estimating the effects of dual credit unbiased by self-selection, as described earlier. For example, one would expect students with high aspirations for college to be more likely to enroll in dual credit and more likely to earn a college degree. Consequently, not controlling for the unobserved college aspirations of students would overstate dual-credit effects on college completion.

This study addressed the presence of unobserved variables by using a panel regression with school district fixed effects and probability weights. Over multiple years, a set of explanatory and outcome variables were observed for each cohort of a district. A school district's changes in dual-credit participation were then compared to its corresponding changes in student outcomes. With this within-district comparison, each school district served as its own control group over time.

School district fixed effects controlled for unobserved variables that do not vary with time, such as location and legal structure. It also controlled for much of the effects of attributes that, though not strictly time-invariant, were relatively stable across a decade, such as the socioeconomics of the student population, capital infrastructure, school culture, and the quality of faculty.

Probability weights were included to ensure that each school district contributed to the identification of dual-credit effects in proportion to their student population. Probability weights were based on a school district's average student population during the study period relative to the sum of average student populations of all districts.

I chose to estimate the effect of dual credit as a school district (district) policy and not a school policy. I did so because district superintendents, not school principals, decided to enter into dual-credit partnerships with an institution of higher education. They were also the decision-makers with the authority and responsibility to increase dual-credit participation.

A threat to the internal validity of this research design involved trends. If the treatment variable varied along a time pattern common to other plausible explanatory variables not accounted for, these omitted variables would bias estimated effect sizes. This study mitigated time trend threats by including a fixed effect for each year. Moreover, as mentioned earlier, this research design benefited from significant variance in dual-credit participation that fluctuated cohort to cohort within each school district. This variance mitigated time trend threats.

A final threat to internal validity was district-specific trends. The statewide population of economically disadvantaged students grew by 10 percentage points from 49 percent in 2001 to 59 percent in 2011. However, districts were declining in affluence at different rates and some were even growing in affluence. These district-specific trends affected the likelihood of dual credit participation and expected postsecondary outcomes, thereby confounding the relationship between dual-credit participation and postsecondary outcomes. To mitigate this threat, this study controlled for changes in a district's economically disadvantaged student population and changes in its race and ethnic composition by including corresponding covariates.

This study analyzed the following student outcomes: (1) the percentage of students who graduated from high school within four years of entering high school; (2) the percentage of students who applied to a Texas public university (private school data was not available) before high school graduation; (3) the percentage admitted to a Texas public university before high school graduation (private school data was not available), (4) the percentage enrolled in a Texas public community college in the fifth year from entering high school (or the first year after the cohort's expected high school graduation year); (5) the percentage enrolled in a Texas university (public or private) in the fifth year from entering high school; (6) the percentage who earned an associate degree in Texas by the sixth year and (7) eighth year from entering high school; (8) the percentage who earned a bachelor's degree in Texas within eight, (9) ten, and (10) twelve years from entering high school; and (11) the percentage who earned a graduate degree in Texas within twelve years and (12) thirteen years from entering high school. As described above, all outcomes occurred in years from when a cohort entered high school. Hereafter, any reference to when an outcome occurs was in relation to high school entry.

This study answered its seven research questions by estimating six school district fixed effects regression equations using linear probability models. Linear probability models were used instead of logistic or probit models to ease the interpretation of results. The linear probability models estimated had limited risk of producing results outside of the zero to 100 percent probability distribution range because expected means were found in the middle of the range where the probability distribution is nearly linear in shape (von Hippel, 2015).

In the first model, I estimated an expected outcome for cohort *i* of district *j* (Y_{ij}) as

$$Y_{ij} = \alpha_i + \lambda_j + \beta_1 AP_{ij} + \boldsymbol{\beta_2 Z_{ij}} + \beta_3 DC_{ij} + \varepsilon_{ij} \qquad (1),$$

where α_i was the cohort fixed effect of cohort i, λ_j was the district fixed effect of district j, DC_{ij} represented the share of students earning at least one dual credit of cohort *i* of district j, and AP_{ij} represented the share of students earning credit in at least one AP course of cohort *i* of district *j*. The effect size of AP and dual-credit participation was represented by $\beta_{1,}$ and β_3, respectively. Earning AP credit meant a student successfully completed an AP class, it did not necessarily mean a certain score was achieved on an AP test.

$\mathbf{Z_{ij}}$ represented an array of time-varying attributes of cohort *i* of district *j*, including demographic and socioeconomic composition of the student body; share of immigrant students; and average scores of eighth-grade math and reading state-standardized exams (the grade before dual-credit eligibility), respectively. The error term of cohort *i* of district *j* was represented by ε_{ij} and was clustered by district to adjust for serial correlation of the errors across nearby years (Cameron & Miller, 2015). Equation 1 represented the basic model that all others are built on.

In the second regression model, I examined the effects of changes in the average amount of dual credit and AP credit earned. These explanatory variables were different from those in the first model because they could be increased by having the existing pool of dual-credit students earn more dual credit. As described earlier, as students earned more dual credit, their likelihood of enrolling and graduating from college should have increased. The second model tested this hypothesis.

A district's average amount of dual credit earned per cohort better accounted for dosage; however, it was an imperfect measure of dosage. This was because a given average could reflect many students earning few dual credit or few students earning many dual credits. Consequently, the correct interpretation of the effect size was from the district's perspective. The effect of average dual credit earned represented what follows when a district increased the average dual credit earned in a given cohort.

In the second model, I estimated an expected outcome for cohort *i* of district *j* (Y_{ij}) as

$$Y_{ij} = \alpha_i + \lambda_j + \beta_1 AP\_DOSE_{ij} + \beta_2 AP\_DOSE^2{}_{ij}$$
$$+\boldsymbol{\beta_3 Z_{ij}} + \beta_4 DC\_DOSE_{ij} + \beta_5 DC\_DOSE_{ij}^2 + \varepsilon_{ij}, \quad (2)$$

where quadratic functional forms for average AP and dual credit earned for cohort *i* of district *j* replaced AP_{ij} and DC_{ij}, and the remaining regressors from Equation 1 were included. I used a quadratic functional form in this model so that I could examine whether the effects of average dual credit plateaued or declined as average dual credit increased. β_4 and β_5 measured the effect of a one-unit (equivalent to three SCH) increase in dual credit earned. β_1 and β_2 measured the effect of a one-unit (equivalent to three SCH) increase in average AP credit earned.

The third model investigated heterogeneous effects of average dual credit earned by course subject. I modeled an expected outcome for cohort *i* of district *j* (Y_{ij}) as

$$Y_{ij} = \alpha_i + \lambda_j + \beta_1 AP_{ij} + \boldsymbol{\beta_2 Z_{ij}} + \boldsymbol{\beta_3 DC\_SUBJECT_{ij}} + \varepsilon_{ij}, \quad (3)$$

where $\mathbf{DC\_SUBJECT_{ij}}$ represented an array of regressors that respectively measured the average dual credit earned in math, English, science, social sciences, foreign languages, health, arts, computer science, and all other dual-credit subjects for cohort *i* of district *j*. $\boldsymbol{\beta_3}$ was an array that respectively measured the effects of changes in average dual credit earned by subject. In this model and the following ones, the functional form of average dual credit earned was made linear to simplify the analysis.

The fourth model investigated heterogeneous effects of average dual credit earned by instructor's highest degree. I modeled an expected outcome for cohort *i* of district *j* (Y_{ij}) as

$$Y_i = \alpha_i + \lambda_j + \beta_1 AP_{ij} + \boldsymbol{\beta_2 Z_{ij}} + \boldsymbol{\beta_3 DC\_INSTRUCTOR_{ij}} + \varepsilon_{ij}, \quad (4)$$

where $\mathbf{DC\_INSTRUCTOR_{ij}}$ represented an array of regressors that respectively measured the average amount of dual-credit earned of cohort *i* of district *j* that was taught by an instructor whose highest degree was a master's degree and one whose highest degree was a doctorate. $\boldsymbol{\beta_3}$ was an array that respectively measured the effects of changes in average dual credit earned by type of instructor.

The fifth model investigated heterogeneous effects of average dual credit earned by mode of instruction. In this analysis, I modeled an expected outcome for cohort *i* of district *j* (Y_{ij}) as

$$Y_{ij} = \alpha_i + \lambda_j + \beta_1 AP_{ij} + \boldsymbol{\beta_2 Z_{ij}} + \boldsymbol{\beta_3 DC\_Mode_{ij}} + \varepsilon_{ij}, \quad (5)$$

where $\mathbf{DC\_Mode_{ij}}$ represented an array measuring the average dual credit earned of cohort *i* of district *j* by face-to-face instruction, instruction by video, blended learning (which is a combination of face-to-face and computer-based instruction), and computer-based instruction with no live instructor, respectively[5]. $\boldsymbol{\beta_3}$ was an array that respectively measured the effects of changes in average dual credit earned by mode of instruction.

5 I combined instruction by one-way video and two-way interactive video into one category and combined distance learning with blended learning. Distance learning involves a minimum of 15 percent of the instruction time delivered through face-to-face instruction.

The sixth and final model investigated heterogeneous effects of average dual credit earned by location of instruction. In this analysis, I modeled an expected outcome for cohort *i* of district *j* (Y_{ij}) as

$$Y_{ij} = \alpha_i + \lambda_j + \beta_1 AP_{ij} + \boldsymbol{\beta_2 Z_{ij}} + \boldsymbol{\beta_3 DC\_LOCATION_{ij}} + \varepsilon_{ij}, \quad (6)$$

where $\boldsymbol{DC\_LOCATION_{ij}}$ represented an array that measured the average dual credit earned by cohort *i* of district *j* on a high school, community college, university, or other site, respectively. $\boldsymbol{\beta_3}$ was an array that respectively measured the effects of changes in average dual credit earned by location of instruction.

I tested hypotheses using a two-sided t-test. In describing the findings, I flagged statistical significance at p-value levels below .1, .05, .01, and .001, respectively.

RESULTS

Dual-credit Participation Effects

In this subsection, I describe expected changes in student outcomes associated with a 10-percentage point increase in dual-credit participation. I also provide a growth rate relative to a baseline estimate of the expected outcome when dual-credit participation was zero.

As shown in Table 3, a 10-percentage point increase in dual credit was associated with an increase in high school graduation by year four by 0.66 of a percentage point. This was a 0.91 percent growth rate relative to the baseline of 73 percent.

Dual-credit effects on postsecondary outcomes also emerged. For every 10-percentage point increase in dual-credit participation, the percent of students who applied to a Texas public university while in high school increased by one percentage point. This was a growth rate of 3.84 percent relative to the baseline of 26.0 percent.

For every 10-percentage point increase in dual-credit participation, the percent of students admitted to a Texas public university while in high school increased by 0.96 of a percentage point. This was a growth rate of 4.36 percent relative to the baseline of 22.1 percent.

For every 10-percentage point increase in dual-credit participation, the percent of students who enrolled in a Texas public or private university the year following their expected high school graduation (year five from entering high school) increased by 0.82 of a percentage point. This was a growth rate of 4.1 percent relative to the baseline of 20 percent[6].

Increases in dual-credit participation did increase community college enrollment but only at a marginally statistically significant level. For every 10-percentage point increase in dual-credit participation, the percent of students who enrolled in a Texas community college the year following their expected high school graduation (year five from entering high school) increased by 0.23 of a percentage point. This was a growth rate of 0.75 percent relative to the baseline of 31 percent.

Increases in dual-credit participation were associated with increases in associate degree completion. For every 10-percentage point increase in dual-credit participation, the percent of students who earned an associate degree within two years from expected high school graduation (or year six from entering high school) increased by 0.21 of a percentage point. This was a growth rate of 25.7 percent relative to the baseline of 0.8 percent.

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[6] The difference between the baseline percent of students admitted to a Texas public college versus the percent enrolled in a Texas private or public college did not represent summer melt. The percent admitted did not include private colleges, though they were included in the enrollment figures.

Dual credit continued to affect associate degree completion rates by year eight from high school entry (or four years from expected high school graduation). For every 10-percentage point increase in dual-credit participation, the percent of students who earned an associate degree by year eight increased by 0.18 of a percentage point, a relative growth rate of 5.3 percent from its baseline estimate of 3.3 percent.

Dual credit also improved bachelor's degree completion rates. For every 10-percentage point increase in dual-credit participation, the percent of students who earned a bachelor's degree by year eight, ten, and twelve after entering high school increased by 0.51, 0.56, and 0.63 of a percentage point, respectively. These were respective growth rates of 7.4, 3.6, and 3.5 percent relative to baseline rates of seven percent within eight years from entering high school, 15.5 percent within ten years from entering high school, and 18.0 percent within twelve years from entering high school.

Finally, dual credit affected graduate degree completion. For every 10-percentage point increase in dual credit, the percent of students who earned a graduate degree within 12 years after entering high school increased by 0.08 of a percentage point. This was a growth rate of 3.45 percent relative to a baseline of 2.2 percent.

Dual credit's effect on graduate degree completion within 13 years after entering high school was not statistically significant though it was positive.

Was More Dual Credit Better?

The second model of this study investigated whether school districts improved student outcomes by increasing the average amount of dual credit earned measured in semester credit hours (SCH). As shown in Table 4 and illustrated in Figure 3, this study found more dual credit improved student outcomes.

School districts improved four-year high school graduation rates by increasing average dual credit earned up to nine SCH. At nine SCH of average dual credit, high school graduation rates reached 77 percent; afterwards high school graduation rates began to decline.

School districts improved university application, admissions, and enrollment rates by increasing average dual credit earned. University application rates rose to 44 percent at 27 SCH. Admission rates increased to 38 percent at 24 SCH. University enrollment increased to 39.5 percent at 30 SCH.

School districts decreased community college enrollment in the year following high school graduation with every increase in average dual credit earned after 3 SCH. But with each increase, they exponentially improved associate degree completion. Associate degree completion by year six reached 48 percent at 30 SCH. Similarly, dual credit effects on associate degree completion by year eight reached 27 percent at 24 SCH but stopped being statistically significant at higher levels of average dual credit earned. Associate degree completion could rise as community college enrollment declined because high school students were earning their associate degree when they graduated from high school or during their enrollment at a four-year college.

Increased levels of dual credit had the greatest impact on bachelor's degree attainment. By year eight, bachelor's degree attainment reached 52 percent at 30 SCH. By year 10, it reached 77 percent at 30 SCH. By year 12, bachelor's degree attainment reached 67 percent at 27 SCH.

Finally, school districts improved graduate degree attainment by year 12 and 13 by increasing average dual credit. Graduate degree attainment by year 12 reached 5.1 percent at 12 SCH of average dual credit earned. It equaled 4.7 percent by year 13 when average dual credit earned reached 9 SCH.

Dual-credit effects Compared to Advanced Placement (AP)

Equation 1 compared the effect of students earning at least one credit of dual credit to one credit of AP. As shown in Table 3, AP effects were larger than and statistically distinct from dual credit in seven of the twelve outcomes examined. The AP advantage occurred with the following outcomes: high school graduation, university application, community college enrollment, bachelor's degree completion at year 10 and 12, and graduate degree attainment by year 12 and 13.

Equation 2 compared the effect of students earning increased levels of dual credit to increased levels of AP. As shown in Figure 3, increases in dual credit earned produced greater benefits that were statistically distinct from AP for every student outcome.

The most meaningful difference found between AP and dual credit was that increasing levels of average dual credit were associated with larger increases in bachelor's degree completion. Average dual credit of 30 SCH increased the rate of bachelor's degree attainment at year eight and ten to 52 percent and 77 percent, respectively. In contrast, average AP caused bachelor's degree attainment to peak at lower levels. And, the statistical significance of AP effects was generally lost after 18 SCH of average AP earned. Average AP of 18 SCH increased the rate of bachelor's degree attainment at year eight and ten to ten percent and 16 percent, respectively.

Dual-Credit Effects by Subject

This study found that dual-credit subjects were not equally beneficial, and one decreased bachelor's degree attainment as shown in Table 5. The effect sizes described below were statistically significant based on a two-sided t-test and p-value of less than .05. They were also statistically distinct from each other, unless otherwise noted.

High School Graduation

A three-SCH increase in a district's average foreign languages and social science dual credit was associated with an increase in high school graduation within four years by 8.5 and 1.9 percentage points, respectively. A three-SCH increase in a district's average math dual credit was associated with a decrease in high school graduation by 3.4 percentage points.

Texas Public University Application

A three-SCH increase in a district's average foreign languages, English, and social science dual credit was associated with an increase in university application rates by 8.7, 4.0, and 3.4 percentage points, respectively.

Texas Public University Admissions

A three-SCH increase in a district's average foreign language, English and social science dual credit was associated with an increase in university admission rates by 7.8, 3.9, and 3.8 percentage points, respectively.

Texas Public or Private University Enrollment

A three-SCH increase in a district's average foreign languages, social science, and English dual credit was associated with an increase in Texas university enrollment rates of 5.5, 3.6, and 2.6 percentage points, respectively.

Texas Community College Enrollment

A three-SCH increase in a district's average computer science dual credit was associated with an increase in Texas community college enrollment of 11.4 percentage points.

Associate Degree Attainment

A three-SCH increase in a district's average "other", art, science, English, and social science dual credit was associated with an increase in associate degree attainment by year six of 14.2, 9.4, 3.3, 1.3, and 0.5 percentage points, respectively. When the time frame for associate degree completion was extended to year eight, the only subject that maintained its effect on associate degree attainment was English with an effect sizes of 2.6 percentage points.

Bachelor's Degree Attainment

A three-SCH increase in a district's average computer science, foreign languages, English, social science, and math dual credit was associated with an increase in bachelor's degree attainment by year eight of 5.3, 3.4, 3.3, 2.2, and 2.0 percentage points, respectively. A three-SCH increase in a district's average health dual credit was associated with a decrease in bachelor's degree attainment by year eight of 4.3 percentage points.

When the time frame for bachelor's degree completion was extended to year 10, the subjects that maintained their effect were computer science, English, and social science with effect sizes of 11.4, 4.5, and 2.6 percentage points, respectively. As before, a three-SCH increase in a district's average health dual credit was associated with a decrease in bachelor's degree attainment by year 10. The negative effect size of average health dual credit equaled 7.2 percentage points.

When the timeframe was extended further to year 12, a three-SCH increase in a district's average English, math, and social science dual credit was associated with an increase in bachelor's degree attainment of 4.6, 4.1, and 3.3 percentage points, respectively.

Graduate Degree Attainment

No subjects produced a statistically significant effect on graduate degree attainment.

Dual-Credit Effects by Instructor's Highest Degree

In the regression model that explored heterogeneous effects by instructor type, point estimates of regression coefficients varied, as shown in Table 6. However, formal hypotheses tests that compared the statistical equivalence of coefficients found no statistically significant difference between the point estimates.

Dual-Credit Effects by Instruction Mode

Limited variation was found in the relationship between student outcomes and dual credit by instruction mode. Dual-credit classes taught exclusively by computer produced the largest and statistically distinct effect on high school graduation rates. A three-SCH increase in average dual credit taught via computer was associated with a 23-percentage point increase in high school graduation rates as shown in Table 7.

No other mode of instruction produced a statistically unique effect size.

Dual-Credit Effects by Instruction Location

Limited variation was also found in the relationship between student outcomes and dual credit taught at different locations. As shown in Table 8, dual credit taught on a high school campus produced a negative, larger, and statistically distinct effect on associate degree completion by year six than dual credit taught at other locations. One interpretation for this could be that dual credit on a high school campus may have caused students to raise their college aspirations to university enrollment from community college enrollment thereby decreasing associate degree completion.

Discussion

Texas is pursuing a goal of raising the postsecondary attainment of 25- to 34-year-olds to 60 percent by 2030. To reach this goal, the state needs to increase its share of students enrolling and completing college. This study finds that dual credit is a systemic innovation that can help the state accomplish these objectives. (THECB, 2017).

Increases in dual-credit participation led to more timely completion of associate and bachelor's degrees and overall increases in associate, bachelor's and graduate degree attainment. Furthermore, the results of this study suggest that more dual credit is better. As school districts increase their average amount of dual credit earned up to 30 semester credit hours, the rates of college enrollment and degree completion continuously increase.

This study finds no evidence that dual credit produces a positive signal to university admission's offices of college readiness. Increases in college enrollment associated with dual-credit participation are driven by increases in college application rates, not admission rates.

This study also finds evidence to suggest that education leaders can increase dual-credit impacts on associate and bachelor's degree completion by prioritizing math, English, social sciences, foreign languages, science, and computer science dual credit. In contrast, the study finds that art, health, and "other" subjects only produced positive effects on associate degree completion but not bachelor's degree completion.

This study finds no evidence to suggest that instructors with doctoral degrees improve student outcomes more than those with only a master's degree. And, it finds no evidence to suggest that dual credit offered on a university or community college campus is more impactful on college enrollment patterns than dual credit on a high school campus. Impact on degree attainment was not fully identified due to data limitations discussed earlier.

Taken together, these findings suggest that districts can realize efficiencies in their dual-credit program by prioritizing core academic subjects, using instructors who hold a master's degree only, and locating dual-credit courses on their high school campuses.

School leaders often question which type of early college coursework is most likely to help prepare students to succeed in college, dual credit or AP. The findings suggest that if school leaders must choose between the two, dual credit offers greater benefits as students accumulate multiple credits. Furthermore, dual credit was the only college-prep curriculum to significantly improve outcomes for community college students seeking an associate degree–Texas's largest share of college students.

This study finds the most important difference between AP and dual credit is that increased levels of average dual credit are associated with larger increases in bachelor's degree completion rates than AP. This difference may be explained by AP credit not simultaneously representing college credit, unlike dual credit. To earn college credit, AP students must register for an AP test, pay for it, take the exam, and achieve a certain score. These four extra hurdles likely weaken the association between AP and improved postsecondary outcomes.

The findings of this study are affirmed by the existing research summarized in the literature review with one exception. This study finds that math dual credit does not produce effects on college access and degree completion greater than English or social science dual credit. Given the current push at the highest levels for STEM education, this finding that English and social science dual credit provides equal, and in some cases greater impact on student outcomes, is an important reminder not to forget the benefits of a strong humanities foundation.

In summary, dual credit is a systemic education innovation that integrates a historically fragmented education system to increase postsecondary achievement. The findings of this study provide evidence to policymakers to support high schools and colleges in expanding dual credit, increasing the amount of dual credit earned per student, and prioritizing dual-credit courses that produce the largest effects. Any policy capping dual-credit enrollment per student at less than 30 SCH should be rejected. To accomplish this agenda, school districts will need to overcome a shortage of teachers who are qualified to teach dual credit and institutions of higher education will need to embrace their role as partners with secondary education.

Appendix

Table 1. The Frequency of Declines in Dual-Credit Participation by School Districts Across Eleven Cohorts of High School Students

Declines	Frequency	Percent
0	90	8%
1	82	7%
2	98	8%
3	213	18%
4	318	27%
5	253	22%
6	100	9%
7	19	2%
8	0	0%
9	0	0%
10	0	0%
Total	1173	100%

Note: This study followed eleven cohorts of Texas public high school students starting in the year they entered high school. The study period was from 2001 to 2011. The above table describes the frequency of declines in dual-credit participation across time by 1173 school districts in the study population. Eighty eight school districts experienced no declines, while one experienced eight declines.

Table 2. Descriptive Statistics of School Districts, Observantions pooled across 11 cohorts

	N	Mean	SD	Min	Max
White	12,021	0.57	0.30	0.00	1.00
Hispanic	12,021	0.31	0.29	0.00	1.00
Black	12,021	0.10	0.16	0.00	1.00
Asian	12,021	0.01	0.03	0.00	0.68
Other	12,021	0.01	0.02	0.00	0.34
Immigrant	12,021	0.00	0.01	0.00	0.86
Federal Reduced Lunch Participation	12,021	0.09	0.07	0.00	1.00
Federal Free Lunch Participation	12,021	0.37	0.21	0.00	1.00
Federal Food Assistance Participation	12,021	0.03	0.12	0.00	1.00
Reading 8th grade Z-score	12,021	-0.02	0.38	-4.15	2.55
Math 8th grade Z-score	12,021	-0.07	0.41	-3.80	2.72
Dual Credit Participation	12,021	0.18	0.17	0.00	1.00
AP Participation	12,021	0.48	0.58	0.00	8.14
Avg Math Dual Credit	12,021	0.05	0.11	0.00	1.97
Avg English Dual Credit	12,021	0.15	0.21	0.00	4.00
Avg Science Dual Credit	12,021	0.01	0.05	0.00	1.13
Avg Social Science Dual Credit	12,021	0.22	0.31	0.00	4.06
Avg Foreign Language Dual Credit	12,021	0.01	0.05	0.00	1.25
Avg Health Dual Credit	12,021	0.00	0.03	0.00	1.58
Avg Art Dual Credit	12,021	0.01	0.03	0.00	0.77
Avg Computer Science Dual Credit	12,021	0.00	0.02	0.00	0.81
Avg Other Dual Credit	12,021	0.00	0.01	0.00	0.39
Avg Master's-degreed-instructor Dual Credit	2,212	0.18	0.32	0.00	2.72
Avg Doctoral-degreed-instructor Dual Credit	2,212	0.01	0.05	0.00	1.06
Avg Face-to-face Dual Credit	2,212	0.62	0.80	0.00	6.14
Avg Blended Dual Credit	2,212	0.34	0.69	0.00	11.06
Avg Video Dual Credit	2,212	0.19	0.54	0.00	5.73
Avg Computer-based Dual Credit	2,212	0.00	0.02	0.00	0.64
Avg High-school-located Dual Credit	2,072	0.02	0.16	0.00	3.43
Avg Community-College-located Dual Credit	2,186	0.50	0.93	0.00	7.42
Avg University-located Dual Credit	2,212	0.37	0.77	0.00	11.67
Avg Other-located Dual Credit	2,212	0.28	0.52	0.00	6.60

Note: DC stands for Dual Credit. The drop in observations of variables describing instructors' highest degree held, location, and teaching mode represents a data limitation. The Texas Higher Education Coordinating Board began collecting these variables in 2012.

Table 3.
School-District Fixed Effects Regression Results Relating Changes in Dual Credit (DC) and Advanced Placement (AP) Participation to Student Outcomes

	DC	AP	Baseline Estimate			
Student Outcomes	Coeff/(SE)	Coeff/(SE)	Mean/(SD)	**Obs**	**ISD's**	**Rho**
High School Grad Rate Year 4	0.066	**0.123**	0.729	12,021	1,173	0.93
	(0.011)***	**(0.011)*****	(0.164)			
Univ App Rate Year 5	0.100	**0.160**	0.260	12,021	1,173	0.90
	(0.014)***	**(0.015)*****	(0.195)			
Univ Admit Rate Year 5	0.096	0.117	0.221	12,021	1,173	0.89
	(0.015)***	(0.013)***	(0.210)			
Univ Enroll Rate Year 5	0.082	0.079	0.200	12,021	1,173	0.89
	(0.010)***	(0.009)***	(0.146)			
Comm College Enroll Rate Year 5	0.023	**0.064**	0.309	12,021	1,173	0.90
	(0.012)*	**(0.011)*****	(0.176)			
Associates Grad Rate Year 6	**0.021**	-0.002	0.008	10,916	1,166	0.71
	(0.004)***	(0.004)	(0.049)			
Associates Grad Rate Year 8	0.018	0.005	0.033	8,708	1,140	0.81
	(0.005)***	(0.004)	(0.051)			
Bachelor's Grad Rate Year 8	**0.051**	0.029	0.070	8,708	1,140	0.84
	(0.005)***	(0.004)***	(0.055)			
Bachelor's Grad Rate Year 10	0.056	**0.097**	0.155	6,535	1,122	0.88
	(0.009)***	**(0.009)*****	(0.071)			
Bachelor's Grad Rate Year 12	0.063	**0.115**	0.180	4,344	1,115	0.90
	(0.014)***	**(0.012)*****	(0.083)			
Graduate Degree Grad Rate Year 12	0.008	**0.024**	0.022	4,344	1,115	0.71
	(0.004)**	**(0.004)*****	(0.021)			
Graduate Degree Grad Rate Year 13	0.003	**0.029**	0.028	3,250	1,107	0.76
	(0.004)	**(0.006)*****	(0.022)			

Note: The above results were produced by a school-district fixed effects regression model using school district-level panel data with probability weights that equal a disstrist's average student population as a percent of the total average statewide population of students. ISD's represents the number of unique school districts. Obs represents total number of pooled observations. Standard errors were clustered by school district. Dual credit (DC) and Advanced Placement (AP) represent the percent of students earning at least one DC and AP credit per cohort per school district, respectively. Baseline estimates represent the average of expected outcomes when participation n dual credit is zero. For all models, the hypothesis that coeifficients were jointly equal to zero could be rejected with a p-value less than 0.001. Bolded effects were statistically distinct from a majority of the other effect sizes based on a two-tailed t-test and a p-value of less than 0.05.

P-value thresholds were represented at the following levels: <.001 ***, <.05**, <.1*.

Table 4.
School-District Fixed Effects Regression Results Relating Changes in Average Dual Credit (DC) and Advanced Placement (AP) Credit Earned in Quadratic Functional Form to Student Outcomes

	DC	DC X DC	AP	AP X AP	Constant			
Student Outcomes	Coeff/(SE)	Coeff/(SE)	Coeff/(SE)	Coeff/(SE)	Coeff/(SE)	**Obs**	**ISD's**	**Rho**
High School Grad Rate Year 4	0.0284	-0.0052	0.0468	-0.0098	0.6865	12,021	1,173	0.93
	(0.005)***	(0.001)***	(0.007)***	(0.001)***	(0.013)***			
Univ App Rate Year 5	0.0406	-0.0024	0.0474	-0.0049	0.2333	12,021	1,173	0.91
	(0.004)***	(0.001)**	(0.008)***	(0.002)***	(0.015)***			
Univ Admit Rate Year 5	0.0383	-0.0023	0.0289	-0.002	0.2216	12,021	1,173	0.90
	(0.005)***	(0.001)**	(0.008)***	(0.002)	(0.015)***			
Univ Enroll Rate Year 5	0.0342	-0.0015	0.0281	-0.0042	0.2216	12,021	1,173	0.90
	(0.004)***	(0.001)*	(0.005)***	(0.001)***	(0.011)***			
Comm College Enroll Rate Year 5	0.0022	-0.002	0.025	-0.0053	0.2918	12,021	1,173	0.90
	(0.004)	(0.001)*	(0.005)***	(0.001)***	(0.01)***			
Associates Grad Rate Year 6	0.0066	0.0041	0.001	-0.0006	0.0063	10,916	1,166	0.72
	(0.002)***	(0.001)***	(0.001)	(0.000)**	(0.003)**			
Associates Grad Rate Year 8	0.0049	0.0031	0.0038	-0.0015	0.0249	8,708	1,140	0.81
	(0.004)	(0.002)	(0.002)**	(0.000)***	(0.004)***			
Bachelor's Grad Rate Year 8	0.0196	0.0025	0.0108	-0.0009	0.0897	8,708	1,140	0.83
	(0.002)***	(0.001)*	(0.002)***	(0.001)	(0.005)***			
Bachelor's Grad Rate Year 10	0.0268	0.0035	0.0333	-0.0048	0.1765	6,535	1,122	0.88
	(0.005)***	(0.003)	(0.004)***	(0.001)***	(0.008)***			
Bachelor's Grad Rate Year 12	0.0364	0.002	0.043	-0.0085	0.1905	4,344	1,115	0.90
	(0.007)***	(0.004)	(0.007)***	(0.003)***	(0.009)***			
Graduate Degree Grad Rate Year 12	0.0058	0.0004	0.0111	-0.0019	0.0221	4,344	1,115	0.70
	(0.003)**	(0.002)	(0.002)***	(0.001)***	(0.003)***			
Graduate Degree Grad Rate Year 13	0.004	0.0009	0.0131	-0.0025	0.0289	3,250	1,107	0.76
	(0.004)	(0.003)	(0.002)***	(0.001)***	(0.004)***			

Note: ISD's represents the number of unique school districts. Obs represents total number of pooled observations. The above results were produced by a school-district fixed effects regression model using school district level panel data with probability weights that equal a distrist's average student population as a percent of the average annual total statewide population of students. Standard errors were clustered by school district. Dual credit (DC) and Advanced Placement (AP) represent average amounts of DC and AP credit earned per cohort per school district, respectively. Baseline estimates represent the average of expected outcomes when participation n dual credit is zero. For all models, the hypothesis that coeifficients were jointly equal to zero could be rejected with a p-value less than 0.001.

P-value thresholds were represented at the following levels: <.001 ***, <.05**, <.1*.

Table 5.
School-District Fixed Effects Regression Results Relating Student Outcomes to Changes in Average Dual Credit (DC) and Advanced Placement (AP) Credit Earned by Course Subject

Student Outcomes	Math	English	Science	Social Science	Foreign Languages	Health	Art	Computer Science	Other	Baseline Estimate	Obs	ISD's	Rho
	Coeff/(SE)	Coeff/(SE)	Coeff/(SE)	Coeff/(SE)	Coeff/(SE)	Coeff/(SE)	Coeff/(SE)	Coeff/(SE)	Coeff/(SE)	Mean/(SD)			
High School Grad Rate Year 4	**-0.034**	0.018	0.014	**0.019**	**0.085**	0.038	0.040	-0.033	-0.027	0.733	10,993	1,170	0.94
	(0.014)**	(0.009)**	(0.029)	**(0.006)*****	**(0.034)****	(0.030)	(0.045)	(0.080)	(0.072)	(0.10)			
Univ App Rate Year 5	0.001	**0.040**	-0.013	**0.034**	**0.087**	0.034	0.121	0.065	-0.128	0.263	10,993	1,170	0.91
	(0.014)	**(0.008)*****	(0.033)	**(0.006)*****	**(0.032)*****	(0.038)	(0.081)	(0.134)	(0.126)	(0.10)			
Univ Admit Rate Year 5	-0.003	**0.039**	-0.036	**0.038**	**0.078**	0.053	0.062	0.006	0.002	0.224	10,993	1,170	0.90
	(0.014)	**(0.008)*****	(0.034)	**(0.007)*****	**(0.027)*****	(0.037)	(0.058)	(0.076)	(0.143)	(0.10)			
Univ Enroll Rate Year 5	0.012	**0.026**	0.024	**0.036**	0.055	0.024	0.041	0.006	0.026	0.202	10,993	1,170	0.90
	(0.018)	**(0.010)****	(0.043)	**(0.007)*****	(0.025)**	(0.029)	(0.033)	(0.068)	(0.085)	(0.10)			
Comm College Enroll Rate Year 5	-0.023	0.013	-0.022	-0.007	0.018	-0.017	-0.013	0.114	-0.035	0.312	10,993	1,170	0.90
	(0.014)	(0.009)	(0.031)	(0.006)	(0.022)	(0.031)	(0.035)	(0.054)**	(0.082)	(0.10)			
Associates Grad Rate Year 6	**0.008**	**0.013**	**0.033**	**0.005**	**0.034**	**0.047**	**0.094**	0.038	**0.142**	0.008	9,888	1,163	0.73
	(0.004)*	**(0.004)*****	**(0.014)****	**(0.002)****	**(0.019)***	**(0.025)***	**(0.023)*****	(0.047)	**(0.059)****	(0.05)			
Associates Grad Rate Year 8	0.006	**0.026**	0.016	-0.002	0.021	0.008	0.029	0.041	0.292	0.033	7,680	1,137	0.82
	(0.007)	**(0.005)*****	(0.013)	(0.003)	(0.02)	(0.014)	(0.032)	(0.040)	(0.221)	(0.04)			
Bachelor's Grad Rate Year 8	**0.020**	**0.033**	0.018	**0.022**	**0.034**	**-0.043**	-0.001	**0.053**	0.004	0.070	7,680	1,137	0.85
	(0.008)**	**(0.004)*****	(0.016)	**(0.003)*****	**(0.012)*****	**(0.017)****	(0.018)	**(0.018)*****	(0.095)	(0.03)			
Bachelor's Grad Rate Year 10	0.017	**0.045**	0.041	**0.026**	0.034	**-0.072**	0.014	**0.114**	0.145	0.155	5,507	1,119	0.90
	(0.013)	**(0.008)*****	(0.022)*	**(0.006)*****	(0.032)	**(0.024)*****	(0.053)	**(0.057)****	(0.139)	(0.05)			
Bachelor's Grad Rate Year 12	**0.041**	**0.046**	0.056	**0.033**	0.044	-0.059	0.040	0.099	0.121	0.179	3,316	1,112	0.92
	(0.018)**	**(0.010)*****	(0.036)	**(0.007)*****	(0.037)	(0.034)*	(0.088)	(0.116)	(0.364)	(0.04)			
Graduate Degree Grad Rate Year 12	0.013	0.008	0.000	0.005	-0.007	0.016	-0.010	-0.024	-0.002	0.022	3,316	1,112	0.78
	(0.009)	(0.005)	(0.012)	(0.003)*	(0.014)	(0.019)	(0.024)	(0.030)	(0.052)	(0.02)			
Graduate Degree Grad Rate Year 13	0.012	0.000	-0.010	0.008	0.006	0.008	-0.039	-0.055	-0.109	0.028	2,222	1,102	0.83
	(0.014)	(0.007)	(0.019)	(0.004)*	(0.018)	(0.021)	(0.046)	(0.047)	(0.121)	(0.02)			

Note: ISD's represents the number of unique school districts. Obs represents total number of pooled observations. The above results were produced by a school-district fixed effects regression model using school district level panel data with probability weights that equal a distrist's average student population as a percent of the average annual total statewide population of students. Standard errors were clustered by school district. Dual credit (DC) and Advanced Placement (AP) represent the percent of students earning at least one DC and AP credit per cohort per school district, respectively. Baseline estimates represent the average of expected outcomes when participation n dual credit is zero. For all models, the hypothesis that coeifficients were jointly equal to zero could be rejected with a p-value less than 0.001. Bolded effects were statistically distinct from a majority of the other effect sizes based on a two-tailed t-test and a p-value of less than 0.05.

P-value thresholds were represented at the following levels: <.001 ***, <.05**, <.1*.

Table 6.
School-District Fixed Effects Regression Results Relating Changes in Average Dual Credit (DC) and Advanced Placement (AP) Earned by to Student Outcomes

Student Outcomes	Master-degreed Instructor Coeff/(SE)	Doctoral-degreed Instructor Coeff/(SE)	Baseline Estimate Mean/(SD)	Obs	ISD's	Rho
High School Grad Rate Year 4	0.015 (0.010)	0.059 (0.046)	0.794 (0.08)	2,212	1,115	0.95
Univ App Rate Year 5	0.036 (0.012)***	0.053 (0.095)	0.298 (0.11)	2,212	1,115	0.95
Univ Admit Rate Year 5	0.039 (0.012)***	0.031 (0.079)	0.245 (0.10)	2,212	1,115	0.94
Univ Enroll Rate Year 5	0.047 (0.010)***	0.033 (0.052)	0.214 (0.09)	2,212	1,115	0.94
Comm College Enroll Rate Year 5	-0.005 (0.011)	0.020 (0.063)	0.316 (0.09)	2,212	1,115	0.92
Associates Grad Rate Year 6	0.017 (0.006)***	0.042 (0.035)	0.010 (0.05)	2,212	1,115	0.87

Note: ISD's represents the number of unique school districts. Obs represents total number of pooled observations. The above results were produced by a school-district fixed effects regression model using school district level panel data with probability weights that equal a distrist's average student population as a percent of the average annual total statewide population of students. Standard errors were clustered by school district. Master-degreed Instructor and Doctoral-degreed Instrutor represent the average dual credit earned in classes instructed by teachers with Master's and doctoral degrees, respectively. Baseline estimates represent the average of expected outcomes when participation n dual credit is zero. For all models, the hypothesis that coeifficients were jointly equal to zero could be rejected with a p-value less than 0.001.

P-value thresholds were represented at the following levels: <.001 ***, <.05**, <.1*.

Table 7.
School-District Fixed Effects Regression Results Relating Changes in Average Dual Credit (DC) and Advanced Placement (AP) Earned by Instruction Mode to Student Outcomes

	Face-to-face	Blended Learning	Video	Computer	Baseline Estimate			
Student Outcomes	Coeff/(SE)	Coeff/(SE)	Coeff/(SE)	Coeff/(SE)	Mean/(SD)	**Obs**	**ISD's**	**Rho**
High School Grad Rate Year 4	0.01	0.01	0.03	**0.23**	0.79	2,212	1,115	0.94
	(0.006)	(0.007)**	(0.011)***	**(0.060)*****	(0.16)			
Univ App Rate Year 5	0.02	0.03	0.04	0.04	0.29	2,212	1,115	0.95
	(0.004)***	(0.008)***	(0.012)***	(0.092)	(0.12)			
Univ Admit Rate Year 5	0.02	0.03	0.03	0.01	0.24	2,212	1,115	0.94
	(0.004)***	(0.009)***	(0.011)***	(0.083)	(0.11)			
Univ Enroll Rate Year 5	0.02	0.03	0.04	-0.06	0.21	2,212	1,115	0.94
	(0.004)***	(0.008)***	(0.011)***	(0.114)	(0.11)			
Comm College Enroll Rate Year 5	-0.01	0.01	0.01	0.10	0.32	2,212	1,115	0.92
	(0.006)	(0.008)	(0.014)	(0.086)	(0.15)			
Associates Grad Rate Year 6	0.01	-0.01	0.01	0.00	0.01	2,212	1,115	0.87
	(0.002)***	(0.003)**	(0.005)	(0.016)	(0.06)			

Note: ISD's represents the number of unique school districts. Obs represents total number of pooled observations. The above results were produced by a school-district fixed effects regression model using school district level panel data with probability weights that equal a distrist's average student population as a percent of the average annual total statewide population of students. Standard errors were clustered by school district. Master-degreed Instructor and Doctoral-degreed Instrutor represent the average dual credit earned in classes instructed by teachers with Master's and doctoral degrees, respectively. Baseline estimates represent the average of expected outcomes when participation in dual credit is zero. For all models, the hypothesis that coeifficients were jointly equal to zero could be rejected with a p-value less than 0.001. Bolded effects were statistically distinct from a majority of the other effect sizes based on a two-tailed t-test and a p-value of less than 0.05.

P-value thresholds were represented at the following levels: <.001 ***, <.05**, <.1*.

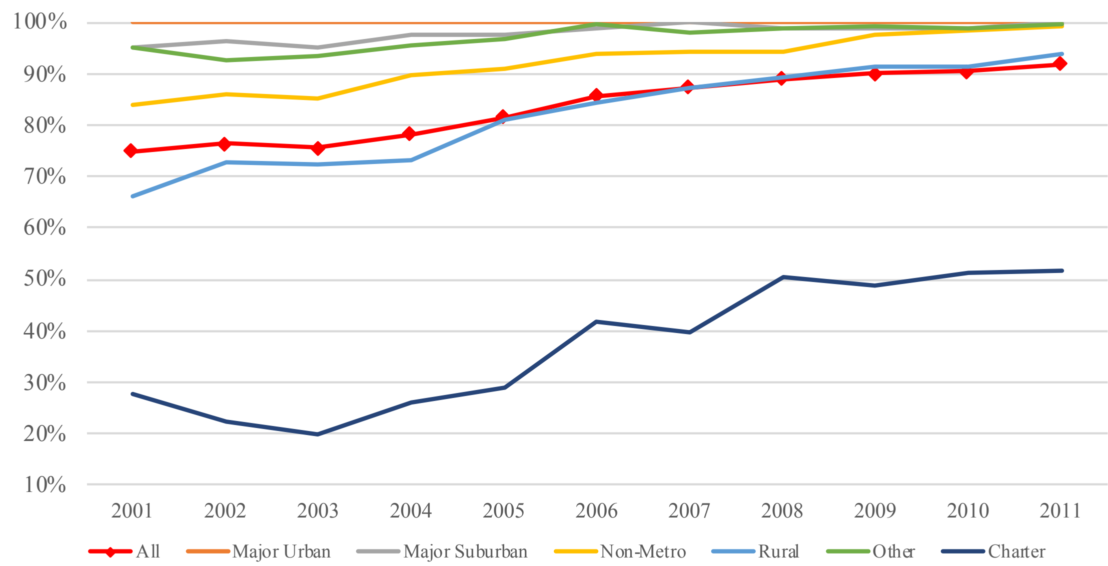
Table 8.
School-District Fixed Effects Regression Results Relating Changes in Average Dual Credit (DC) and Advanced Placement (AP) Earned by Instruction Location to Student Outcomes

Student Outcomes	University Campus Coeff/(SE)	Community College Campus Coeff/(SE)	High School Campus Coeff/(SE)	Other Sites Coeff/(SE)	Baseline Estimate Mean/(SD)	Obs	ISD's	Rho
High School Grad Rate Year 4	0.038	0.007	0.000	0.006	0.79	2,068	1,060	0.90
	(0.020)*	(0.004)	(0.007)	(0.006)	(0.10)			
Univ App Rate Year 5	-0.003	0.011	0.017	0.020	0.30	2,068	1,060	0.95
	(0.014)	(0.003)***	(0.004)***	(0.005)***	(0.09)			
Univ Admit Rate Year 5	-0.011	0.008	0.014	0.020	0.25	2,068	1,060	0.94
	(0.012)	(0.003)***	(0.004)***	(0.005)***	(0.08)			
Univ Enroll Rate Year 5	0.014	0.013	0.015	0.023	0.21	2,068	1,060	0.93
	(0.012)	(0.003)***	(0.004)***	(0.005)***	(0.08)			
Comm College Enroll Rate Year 5	0.031	-0.009	-0.004	0.001	0.32	2,068	1,060	0.91
	(0.022)	(0.004)**	(0.005)	(0.006)	(0.11)			
Associates Grad Rate Year 6	0.008	0.010	**-0.004**	0.002	0.01	2,068	1,060	0.89
	(0.004)*	(0.002)***	**(0.002)******	(0.002)	(0.04)			

Note: ISD's represents the number of unique school districts. Obs represents total number of pooled observations. The above results were produced by a school-district fixed effects regression model using school district level panel data with probability weights that equal a distrist's average student population as a percent of the average annual total statewide population of students. Standard errors were clustered by school district. The four dual credit locations represent the average dual credit earned in dual credit classes located at a university, community college, high school, and other sites, respectively. Baseline estimates represent the average of expected outcomes when participation n dual credit is zero. Bolded effects were statistically distinct from a majority of the other effect sizes based on a two-tailed t-test and a p-value of less than 0.05.

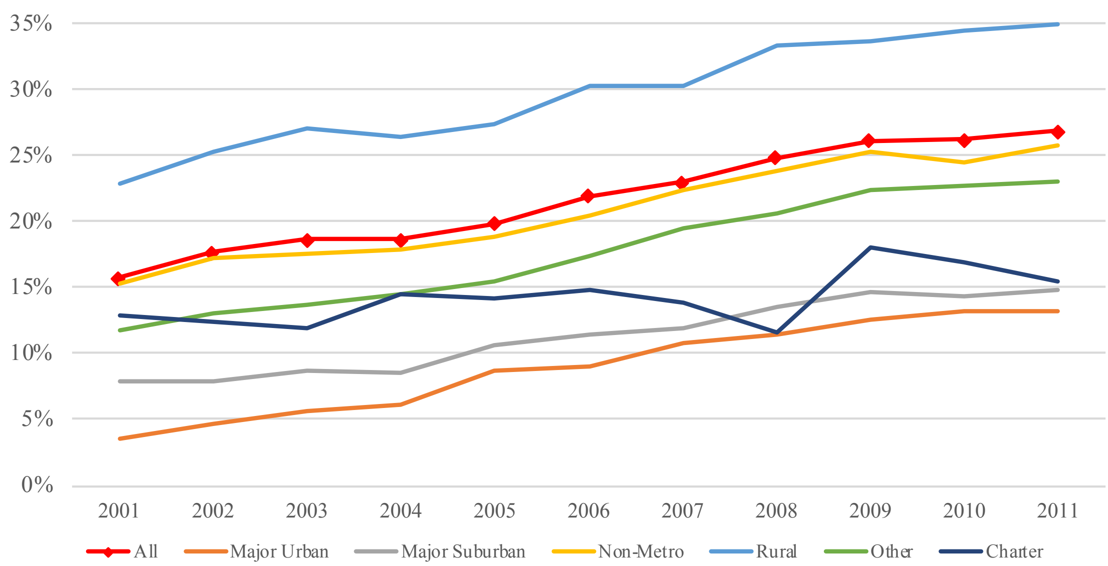
P-value thresholds were represented at the following levels: <.001 ***, <.05**, <.1*.

Figure 1. Adoption of Dual-Credit Policy by Type of School District



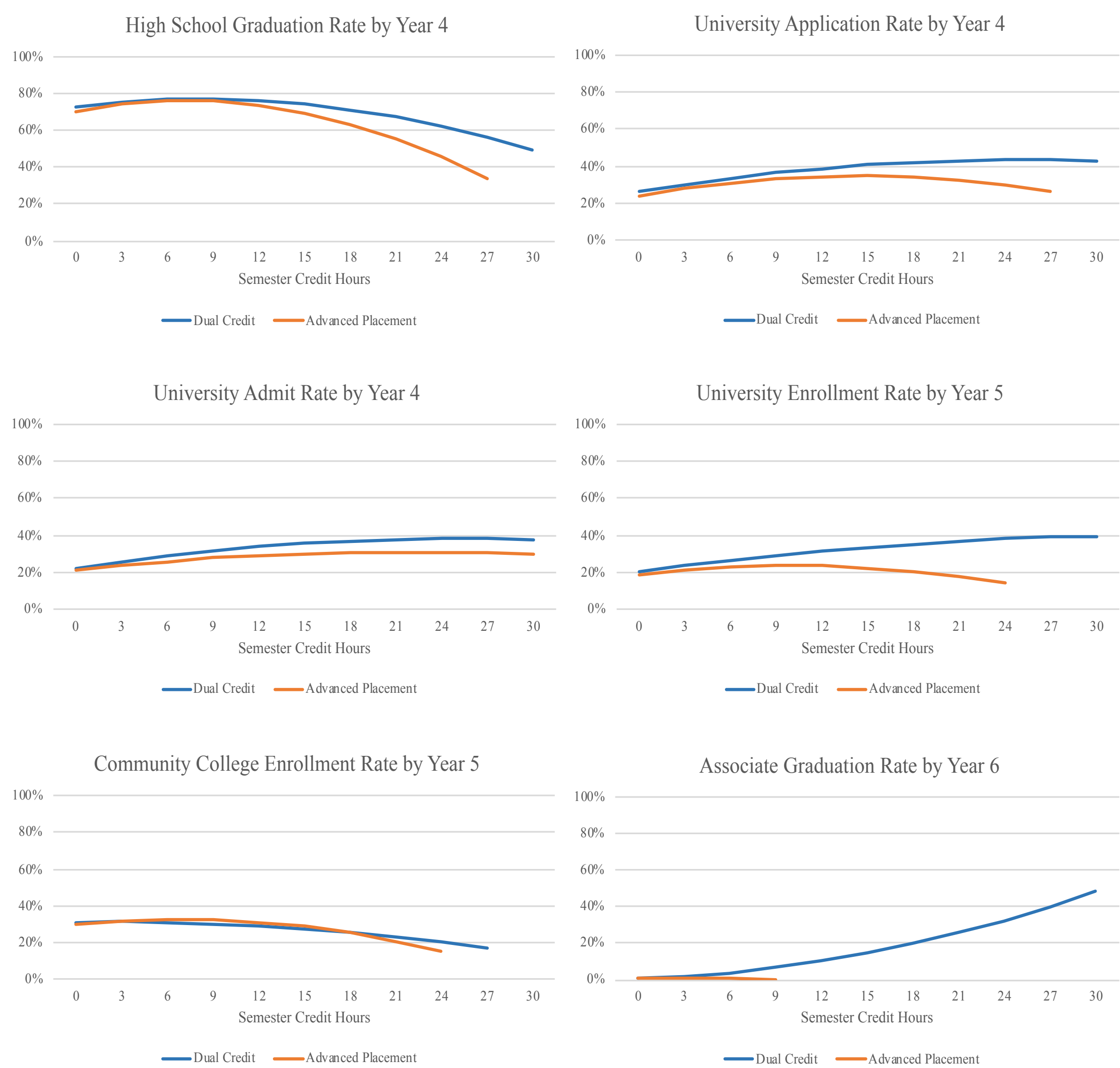
Note: Categories of school districts are defined by the Texas Education Agency. The horizontal axis represents the 9th-grade-entering year of each cohort analyzed.

Figure 2. Student Participation in Dual Credit at Dual-Credit School Districts by Type of School District



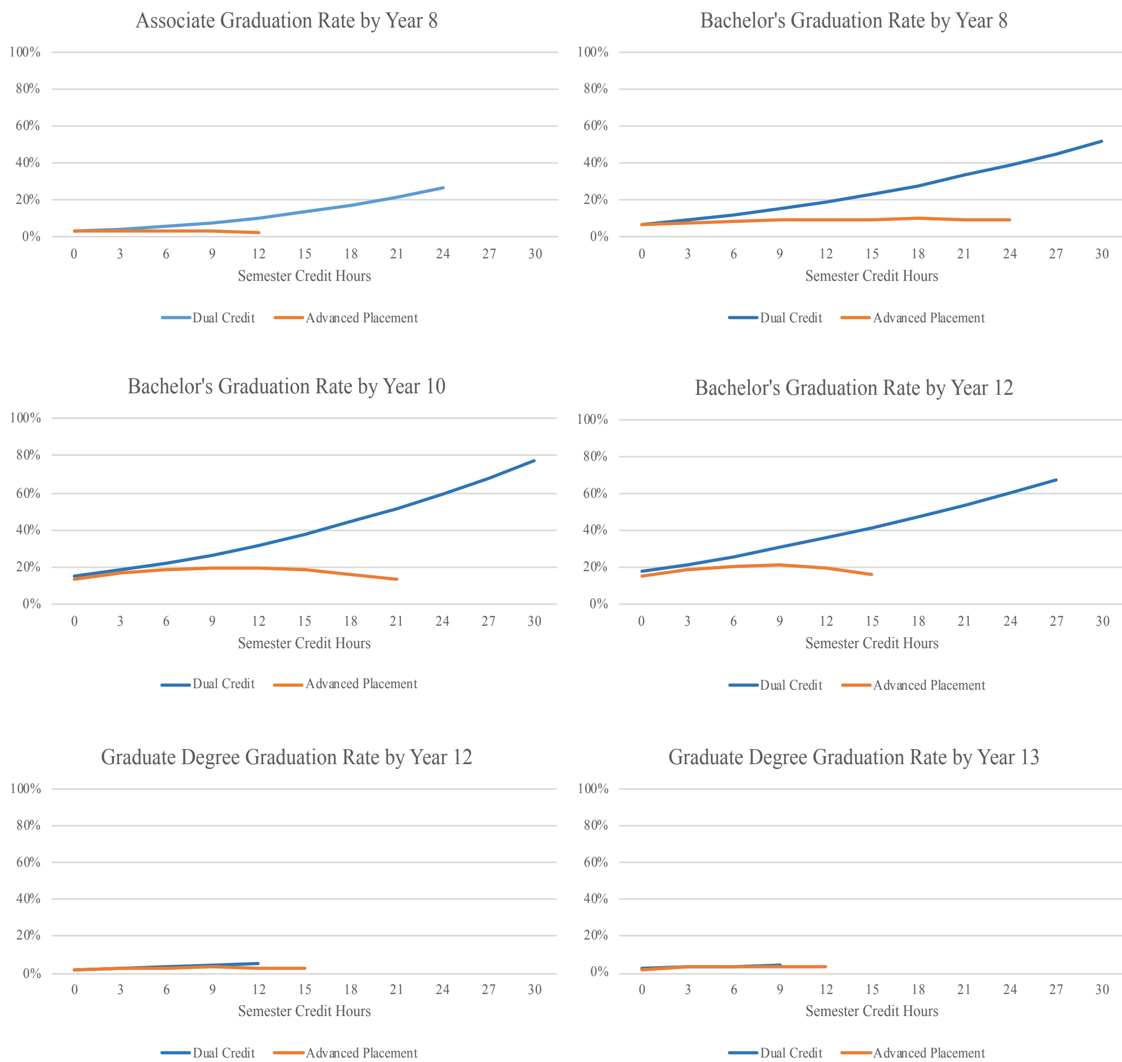
Note: Categories of school districts are defined by the Texas Education Agency. The horizontal axis represents the 9th-grade-entering year of each cohort analyzed.

Figure 3. Change in Student Outcomes by Increasing Levels of Average Credit Earned in Dual Credit, CTE Dual Credit, and AP (measured in semester credit hours)



Note: Estimates are derived from a school district fixed effects regression model using school-district level panel data. Relationships are graphed if they are statistically significant based on a two-sided t-test with a p-value of less than 0.05.

Figure 3 Continued. Change in Student Outcomes by Increasing Levels of Average Credit Earned in Dual Credit, CTE Dual Credit, and AP (measured in semester credit hours)



Note: Estimates are derived from a school district fixed effects regression model using school-district level panel data. Relationships are graphed if they are statistically significant based on a two-sided t-test with a p-value of less than 0.05.

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