Dual Credit & Student Success:
The Effect of High School Dual Credit on Educational Outcomes at KCTCS

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Prepared by the Kentucky Council on Postsecondary Education

ICPE

About the Council on Postsecondary Education

The Council on Postsecondary Education is Kentucky's higher education coordinating agency committed to strengthening our workforce, economy and quality of life. We do this by guiding the continuous improvement and efficient operation of a high-quality, diverse and accessible system of postsecondary education.

Key responsibilities include:

- developing and implementing a strategic agenda for postsecondary education that includes measures of progress.
- producing and submitting a biennial budget request for adequate public funding of postsecondary education.
- determining tuition rates and admission criteria at public postsecondary institutions.
- collecting and distributing data about postsecondary education performance.
- ensuring the coordination and connectivity of technology among public institutions.
- licensing non-public postsecondary institutions to operate in the Commonwealth.

CONTENTS

EXECUTIVE SUMMARY

Dual credit programs are collaborations between secondary and postsecondary institutions that enable high school students to enroll in college courses and receive simultaneous academic or technical credit that counts toward high school and college completion.

Nationally and in Kentucky, dual credit participation is on the rise. The total number of high school students taking dual credit grew from 23,307 in 2014-15, to 40,821 students in 2019-20, an increase of 75%. The majority of dual credit courses are offered by Kentucky Community and Technical College System (KCTCS) institutions.

Last year, CPE published a report assessing the effects of high school dual credit participation on first-year GPA and persistence to a second year at Kentucky public universities. This report uses the same methodology to investigate the effects of dual credit on first-year GPA and credential completion at KCTCS. It analyzes the effects on students enrolled in a technical pathway (i.e., pursuing certificates or applied associate degrees) as well as in an academic pathway (i.e., pursuing associate degrees or transferring to a public university).

RESEARCH QUESTIONS

- **What are the effects of dual credit on KCTCS students' educational outcomes, as measured by the probability of earning a first-year college GPA of 3.0 or higher, completing a credential, or, for academic pathway students, transferring to a public university within three years?**

- **Do these effects vary by gender, race and income?**

PARTICIPANT CHARACTERISTICS

Prior to any impact analysis, differences in demographic characteristics and academic outcomes for dual credit participants and non-participants were explored. Among technical pathway students, 28% participated in dual credit in high school, while 72% did not. Dual credit participation was slightly higher among academic pathway students, with 34.6% taking dual credit courses in high school, while 65.4% did not. Overall, findings were similar for both sets of students, regardless of their pathway.

- **Dual credit participants were more likely to be female and white or Asian and less likely to be low-income, part of an underrepresented minority group (URM) or both URM and low-income.**

- **In fall 2017, more KCTCS students in the sample participated in dual credit than did not, perhaps due to the creation of the Kentucky dual credit scholarship a year earlier.**

- **West central and western Kentucky had significantly higher rates of dual credit participation compared to other geographic regions in the state.**

DUAL CREDIT EFFECTS

The rigorous quantitative methods used in this study provide empirical evidence of the effectiveness of dual credit as a general strategy for increasing academic outcomes at KCTCS for both technical and academic pathway students.

- ■ **Dual credit participants were more likely to earn a first-year college GPA of 3.0 or higher (on a 4.0 scale) than non-participants. Dual credit increased this probability by 4.4 percentage points for technical pathway students, and by 3.9 percentage points for academic pathway students.**

- ■ **Dual credit participants were more likely than non-participants to complete a college credential or, for academic pathway students, transfer to a public university within three years. Dual credit increased this probability by 9.2 percentage points for technical pathway students, and by 11.3 percentage points for academic pathway students.**

EFFECTS ON SUBGROUPS

To determine whether dual credit's effect varied across different subgroups of technical and academic pathway students, the analyses were disaggregated further by gender, URM, low-income, and both URM and low-income status for each outcome variable.

Likelihood of Earning a First-Year GPA of 3.0 or Higher

- ■ **Among KCTCS technical pathway students, dual credit increased the likelihood of earning a first-year GPA of at least 3.0 for male, white/Asian and non low-income students. No significant effects were detected for female, URM and low-income students.**

- ■ **Among KCTCS academic pathway students, dual credit increased the likelihood of earning a first-year GPA of at least a 3.0 for white/Asian and non low-income students. No significant effects were detected for male, female, URM and low-income students.**

Likelihood of Completing a Credential

- ■ **Among KCTCS students in both pathways, dual credit increased the likelihood of completing a credential (and transferring to a university, for academic pathway students) for every subgroup except URM students. The greatest effects were experienced by white/ Asian and non low- income students.**

INTRODUCTION

Dual credit is an arrangement whereby high school students take college-level courses and receive simultaneous academic or technical course credit satisfying both college and high school graduation requirements.
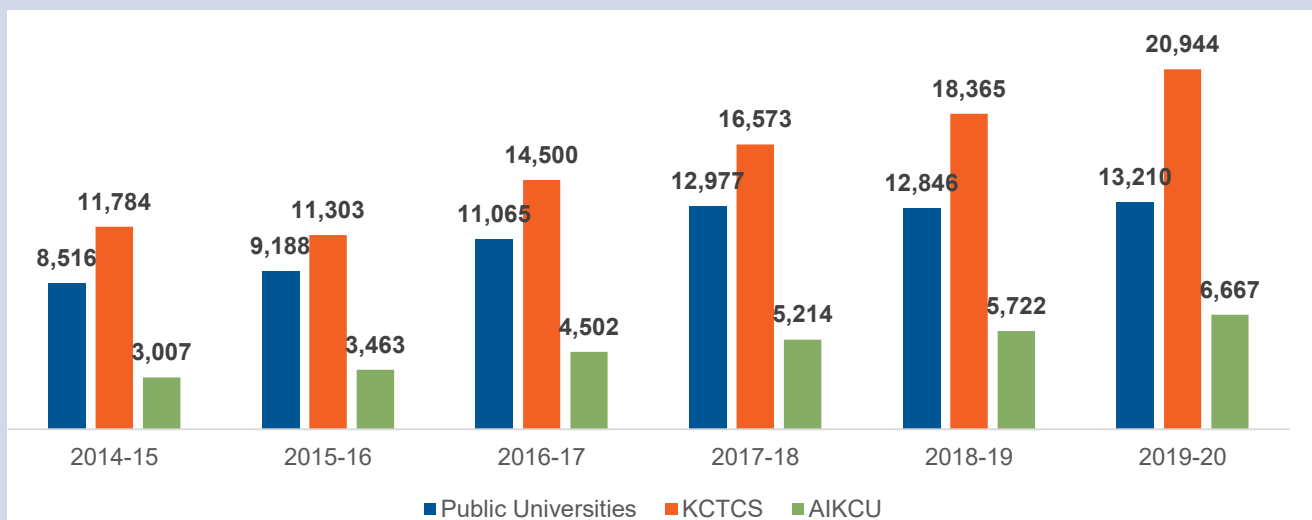
Across the country, the popularity of dual credit courses is on the rise.[1] Dual credit is provided through multiple avenues, including onsite at high schools, on college campuses, online, or a mix of online and in-person instruction. Recently, early college high schools have been gaining momentum; these high schools, often technical in nature, allow students to earn a high school diploma and associate degree (or two years of college credit) simultaneously.[2]

Following the national trend, Kentucky has experienced a dramatic rise in dual credit. The total number of high school students taking dual credit grew from 23,307 in 2014-15, to 40,821 students in 2019-20, an increase of 75% (see Figure 1). The majority of dual credit courses were offered by Kentucky Community and Technical College System (KCTCS) institutions.

As community colleges have increased dual credit offerings, they have experienced subsequent enrollment increases among high school graduates participating in these courses. For this reason, dual credit has become a key strategy for attracting recent high school graduates into community and technical colleges.[3] Nationally, 15 percent of students enrolled at community colleges in the fall of 2010 had recently participated in high school dual credit offered by a community college.[4]

Last year, CPE published a report assessing the effects of high school dual credit participation on first-year GPA and persistence to a second year at Kentucky public universities.[5] This report uses the same methodology to investigate the effects of dual credit on first-year GPA and credential completion at KCTCS, focusing on students enrolled in both technical and academic pathways. The next report will explore how variations in dual credit learning experiences could lead to different college and workforce outcomes.

Figure 1. Dual Credit Participation Across Institutions and Academic Years

Source: Kentucky Postsecondary Education Data System. This graph shows the number of high school students enrolled in dual credit courses at public universities, KCTCS or private institutions by academic year.

DUAL CREDIT INITIATIVES

Two initiatives have propelled dual credit participation in Kentucky. First, CPE approved a dual credit policy in June 2015, which took effect in the fall of 2016. The policy recommends that high school students should have access to a minimum of three general education and three career or technical dual credit courses over the course of their high school career. The policy also provides guiding principles and evidence-based practices to support and maintain the accessibility, quality, transferability and affordability of dual credit programs.

The second initiative is a dual credit scholarship established in June 2016, supported by Kentucky Lottery proceeds. This program allows high school juniors and seniors an opportunity to earn credit for two college courses at no cost. The Work Ready Kentucky Dual Credit Scholarship, established in 2018, expanded this benefit to include two Career and Technical Education (CTE) dual credit courses per year. Both initiatives aim to drive significant increases in dual credit hours taken and reduce barriers posed by tuition and fees.

DUAL CREDIT BENEFITS

Numerous policymakers, educators and researchers have found that dual credit leads to positive educational outcomes for community and technical college students. The following benefits emerged from a national literature review:

- **Enhancing college readiness.** Exposure to high school dual credit better prepares students for college. Studies found that community college students with prior dual credit enrollment were more likely to be college ready, meaning they were less likely to be placed in developmental (non credit-bearing) courses.[6]

- **Increasing college enrollment.** Evidence from previous studies supports the claim that high school students' participation in dual credit has a meaningful, positive effect on community and technical college enrollment. A 2014 study found that dual credit students were 34% more likely to enroll at a community and technical college than non-dual credit students.[7]

- **Strengthening academic performance.** Studies show that dual credit students earn higher GPAs at community and technical colleges than non-dual credit students.[8]

- **Improving college completion.** Previous studies found that community and technical college students who took dual credit in high school were more likely to complete a college credential than students who did not take dual credit.[9]

Although not an academic outcome, dual credit also has been shown to decrease college costs by shortening a student's time to degree. In Kentucky, a state dual credit scholarship guarantees students at least two free dual credit courses during high school. Beyond that, dual credit courses offered by Kentucky postsecondary institutions tend to be priced more competitively than regular college courses.

RESEARCH METHODOLOGY

The Dataset

This study used two longitudinal datasets complied from CPE's Kentucky Postsecondary Education Data System (KPEDS). Students from both datasets graduated from a Kentucky high school and enrolled full-time at a two-year public KCTCS institution for the first time in the fall of 2014, 2015, 2016 and 2017. The first dataset included 14,775 students who enrolled in a technical pathway at KCTCS (pursuing a certificate or applied associate degree), and the second dataset included 15,692 students who enrolled in an academic pathway (pursuing an associate degree or planning to transfer to a four-year program).

These longitudinal datasets include a rich array of high school and postsecondary variables. The independent variable being examined is dual credit participation. The outcome variables are first-year college GPA and credential completion (or successful transfer to a four-year public institution, for academic pathway students). Confounding variables include gender, income, race, geographic region, high school GPA, first-year college GPA (although an outcome variable, first-year GPA also was included as one of the confounding variables to predict credential completion), cohort year (year enrolled in college) and KCTCS institution attended. For a more detailed description of the measures and variables used, see Appendix A.

Analytic Strategies

The study first conducted descriptive analyses to examine the differences between dual credit participants and non-participants in terms of preexisting demographic characteristics (gender, URM and low-income status), academic outcomes (first-year GPA, credential completion or transfer), region of Kentucky (central, eastern, Lexington, Louisville, northern, southeast, west central and western), and cohort year participation (fall 2014, 2015, 2016 and 2017).

Next, binary logistic regression was used to examine the effects of dual credit on students' first-year GPA and credential completion. Both outcome variables were dichotomous. Regression analyses adjusted for the observed confounding variables in the models, which were found to be associated with the outcome variables suggested by previous theories and empirical studies.

Four sets of interaction terms were tested through four separate binary logistic regression models. The interaction terms were: (a) dual credit and gender; (b) dual credit and URM status; (c) dual credit and low-income status; and (d) dual credit and both URM and low-income status.

In an ideal experimental setting, high school students would be randomly assigned to enroll or not to enroll in a dual credit course. The unbiased treatment effects of dual credit on students' postsecondary achievements would then be compared to the control group. However, dual credit opportunities are not randomly assigned but self-selected. Dual credit participation depends on the active choices of students and their parents and is influenced by academic performance, motivation, family economic status and available opportunities at a high school. In other words, if dual credit participants achieve higher grades than non-participants, it could be a function of higher motivation, better family support or other potentially unobserved differences between the two groups, not a function of the dual credit itself. In order to mitigate the selection bias, Propensity Score Matching (PSM) was used as a quasi-experimental approach to obtain better treatment effects.

Once the high school cohorts transitioned to a KCTCS institution, there were other potential variations that could account for differences in academic outcomes. There also were variations by cohort. In order to mitigate these, institution fixed effects and cohort fixed effects were included. A more detailed description of these analytic strategies is included in Appendix B.

RESEARCH QUESTIONS

This study uses rigorous quantitative methods to examine the impact of dual credit on students' postsecondary outcomes in both technical and academic pathways within Kentucky community and technical colleges. It aims to provide empirical evidence to inform policy making for dual credit programs statewide by answering the following questions:

- **What are the effects of dual credit on KCTCS students' educational outcomes, as measured by the probability of earning a first-year college GPA of 3.0 or higher, completing a credential, or, for academic pathway students, transferring to a public university within three years?**

- **Do these effects vary by gender, race and income?**

DUAL CREDIT PARTICIPATION

Prior to any impact analysis, the differences in demographic characteristics and academic outcomes for dual credit participants and non-participants were explored for two subsets of KCTCS students: students enrolled in a technical pathway (i.e., pursuing certificates or applied associate degrees) and students enrolled in an academic pathway (i.e., pursuing associate degrees or planning to transfer to a four-year program). Among technical pathway students, 28% participated in dual credit in high school, while 72% did not. Dual credit participation was slightly higher among academic pathway students, with 34.6% taking dual credit courses in high school, while 65.4% did not. Findings were similar for both sets of students, regardless of their pathway.

- ■ **Dual credit participants were more likely to be female and white or Asian and less likely to be low-income, part of an underrepresented minority group (URM) or both URM and low-income.**

- ■ **In fall 2017, more KCTCS students in the sample participated in dual credit than did not, perhaps due to the creation of the Kentucky dual credit scholarship a year earlier.**

- ■ **West central and western Kentucky had significantly higher rates of dual credit participation, compared to other geographic regions in the state.**

Figure 2. Characteristics of Dual Credit Participants and Non-Participants in the Study, by Credential Pathway

Variables	All Students (N=30,467)		Dual Credit Participants (N=9,570)		Dual Credit Non-Participants (N=20,897)	
	Technical Pathway (N=14,755)	Academic Pathway (N=15,692)	Technical Pathway (N=4,136)	Academic Pathway (N=5,434)	Technical Pathway (N=10,639)	Academic Pathway (N=10,258)
GENDER						
Male	59.1%	34.0%	55.0%	31.5%	60.6%	35.3%
Female	40.9%	66.0%	45.0%	68.5%	39.4%	64.7%
URM						
Yes	14.6%	15.1%	9.6%	9.8%	16.5%	17.9%
No	85.4%	84.9%	90.4%	90.2%	83.5%	82.1%
LOW-INCOME						
Yes	62.9%	66.5%	55.3%	58.0%	65.9%	71.0%
No	37.1%	33.5%	44.7%	42.0%	34.1%	29.0%
URM & LOW-INCOME						
Yes & Yes	11.0%	11.5%	6.8%	7.2%	12.6%	13.9%
Yes & No	3.6%	2.7%	2.7%	2.6%	4.0%	4.1%
No & Yes	51.9%	48.4%	48.4%	50.8%	53.3%	57.1%
No & No	33.5%	42.1%	42.1%	39.4%	30.1%	24.9%
FIRST-YEAR GPA						
<3.0	63.4%	63.5%	56.4%	54.2%	65.9%	68.4%
≥3.0	36.6%	36.5%	43.6%	45.8%	34.1%	31.6%
CREDENTIAL COMPLETION						
Yes	34.9%	36.3%	47.7%	45.8%	30.0%	29.5%
No	65.1%	63.7%	52.3%	54.2%	70.0%	70.5%
COHORT YEAR						
Fall 2014	31.9%	20.8%	29.2%	20.3%	33.0%	21.1%
Fall 2015	23.0%	26.3%	23.6%	24.7%	22.7%	27.2%
Fall 2016	21.8%	25.6%	20.5%	24.4%	22.4%	26.2%
Fall 2017	23.3%	27.3%	26.7%	30.6%	21.9%	25.5%
GEOGRAPHIC REGION						
Central KY	4.3%	3.7%	2.2%	2.4%	5.1%	4.4%
Eastern KY	16.3%	14.5%	16.1%	14.7%	16.4%	14.3%
Greater Lexington	13.7%	11.7%	8.6%	8.5%	15.5%	13.5%
Greater Louisville	13.0%	10.1%	4.5%	3.7%	16.0%	13.5%
Northern KY	5.0%	4.3%	3.0%	2.1%	5.7%	5.5%
Southeastern KY	14.1%	21.5%	12.1%	19.1%	14.8%	22.7%
West Central KY	19.1%	19.4%	26.5%	24.5%	16.5%	16.7%
Western KY	14.5%	14.8%	27.0%	25.0%	10.0%	9.4%

Dual credit students are all individuals who enrolled in at least one dual credit course in high school.
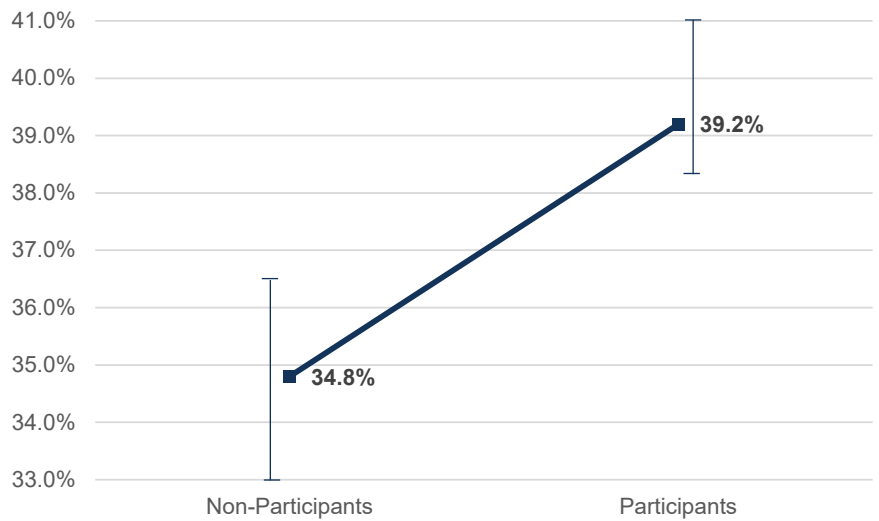
EFFECTS OF DUAL CREDIT

Using rigorous quantitative methods, this study provides empirical evidence of the effectiveness of dual credit as a general strategy for increasing academic outcomes at KCTCS for both technical and academic pathway students. Key findings include:

> ■ **Dual credit participants were more likely to earn a first-year college GPA of 3.0 or higher (on a 4.0 scale) than non-participants. Dual credit increased this probability by 4.4 percentage points for technical pathway students, and by 3.9 percentage points for academic pathway students.**

The study predicted the average probability of earning a first-year college GPA of 3.0 or higher for dual credit participants and non-participants enrolled in a technical pathway at KCTCS. The probability of dual credit participants earning at least a 3.0 GPA was 39.2%, compared to 34.8% for non-participants, a difference of 4.4 percentage points. For a more detailed explanation of the analytic strategies used to obtain this result, see Appendix C.

Vertical lines represent 95% confidence intervals. Values: Non-participants (33.0%-36.5%) and participants (38.4%-41%).
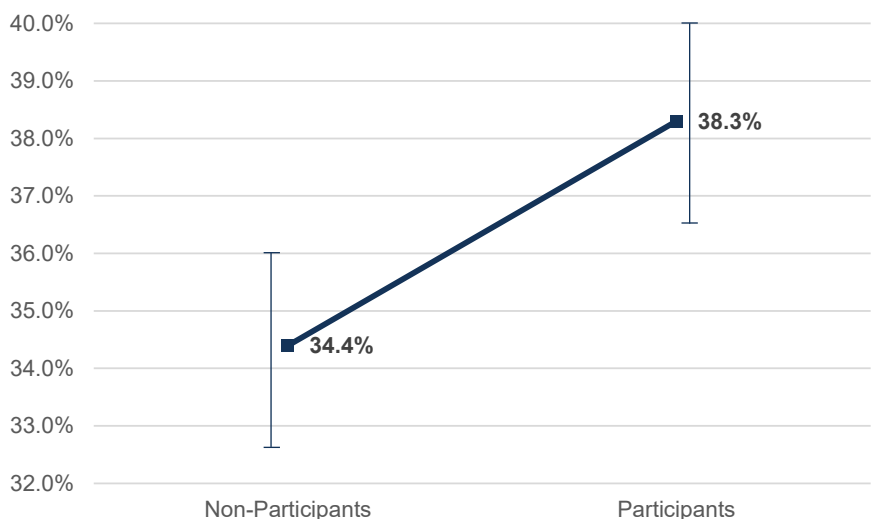
Probability of Earning at Least a 3.0 GPA Among KCTCS Technical Pathway Students

The study predicted the average probability of achieving a first-year college GPA of 3.0 or higher for dual credit participants and non-participants enrolled in an academic pathway at KCTCS. The probability of dual credit participants earning at least a 3.0 GPA was 38.3%, compared to 34.4% for non-participants, a difference of 3.9 percentage points. For a more detailed analysis, see Appendix D.

Vertical lines represent 95% confidence intervals. Values: Non-participants (32.7%-36.0%) and participants (36.6%-40.0%).

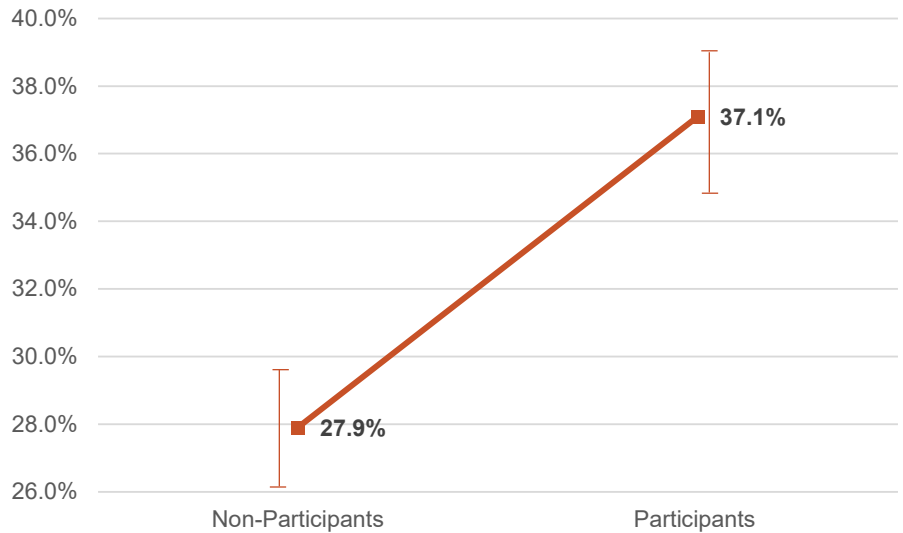**Probability of Earning at Least a 3.0 GPA Among KCTCS Academic Pathway Students**

> ■ **Dual credit participants were more likely than non-participants to complete a college credential or, for academic pathway students, transfer to a public university within three years. Dual credit increased this probability by 9.2 percentage points for technical pathway students, and by 11.3 percentage points for academic pathway students.**

The study predicted the average probability of earning a credential within three years for dual credit participants and non-participants enrolled in a technical pathway at KCTCS. The probability of credential completion for dual credit participants was 37.1%, compared to 27.9% for non-participants, a difference of 9.2 percentage points. For a more detailed explanation of the analytic strategies used to obtain this result, see Appendix C.

Vertical lines represent 95% confidence intervals. Values: Non-participants (26.1%-29.8%) and participants (35.0%-39.1%).
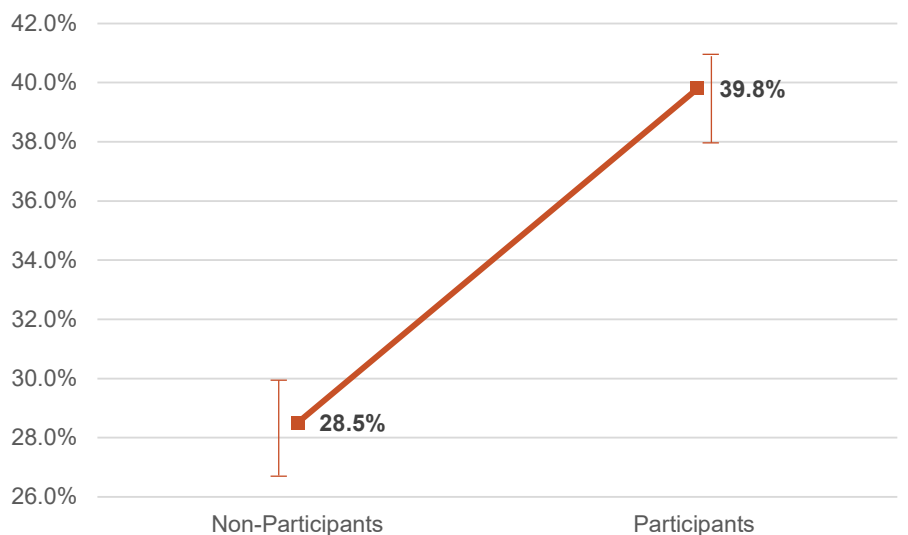
Probability of Credential Completion within Three Years Among KCTCS Technical Pathway Students

The study predicted the average probability of earning a credential or transferring to a public university within three years for dual credit participants and non-participants enrolled in an academic pathway at KCTCS. The probability of credential completion or transfer for dual credit participants was 39.8%, compared to 28.5% for non-participants, a difference of 11.3 percentage points. For a more detailed explanation of the analytic strategies used to obtain this result, see Appendix D.

Vertical lines represent 95% confidence intervals. Values: Non-participants (26.9%-30.0%) and participants (38.0%-41.5%).

Probability of Credential Completion or Transfer within Three Years Among KCTCS Academic Pathway Students
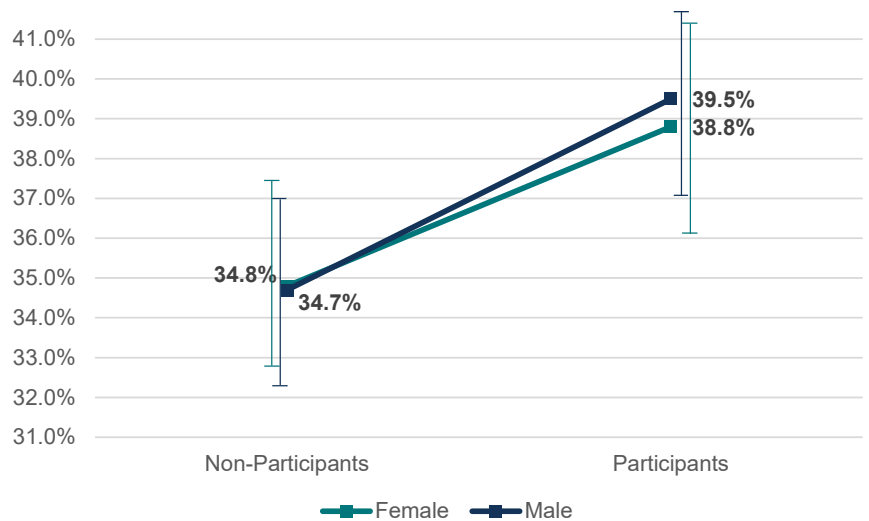
EFFECTS ON SUBGROUPS
Enrolled in a Technical Pathway: GPA

To examine whether the effects of dual credit varied across different subgroups of KCTCS students enrolled in a technical pathway, the analyses were disaggregated further by gender, race and income. Four sets of interaction terms (gender, URM, low-income and both URM and low-income status) were tested through five separate binary logistic regression models to determine the effect of dual credit on first-year GPA (for more detail, see Appendix E). Key findings follow:

> ■ **Among technical pathway students, dual credit had a positive effect on first-year GPA of male participants only. No significant effect was detected for female participants.**
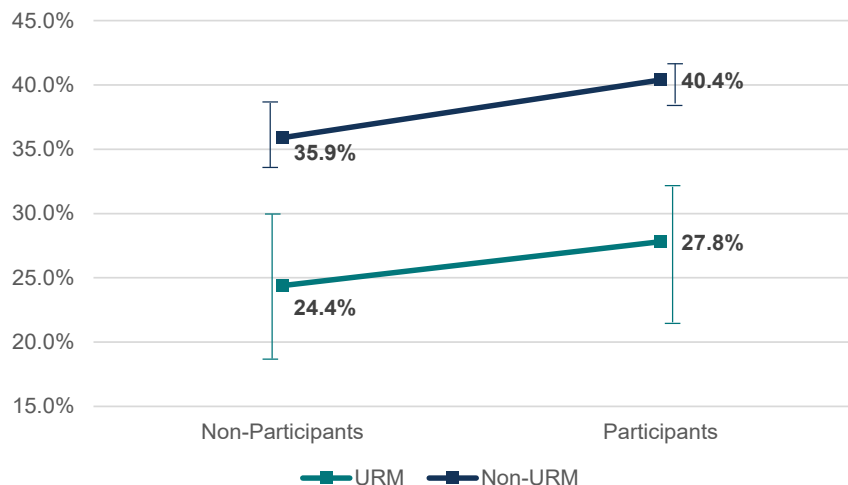
Male dual credit participants were 4.8 percentage points more likely to earn at least a 3.0 GPA during the first year of college than male non-participants (a 39.5% chance for participants, compared to a 34.7% chance for non-participants). Although female dual credit participants did show an increased likelihood of earning a 3.0 or higher than non-participants, the difference of 4 percentage points was not statistically significant. With or without dual credit, no statistically significant gaps were found between male and female students in terms of first-year GPA.

Vertical lines represent 95% confidence intervals. Values: Female non-participants (32.9%-37.6%) and female participants (36.1%-41.5%). Male non-participants (32.4%-37.0%) and male participants (37.1%-41.9%).

> ■ **Among technical pathway students, dual credit had a positive effect on first-year GPA of white and Asian students only. No significant effect was detected for URM students.**

White and Asian dual credit participants were 4.5 percentage points more likely to earn at least a 3.0 GPA during the first year of college than white/ Asian non-participants (40.4% for participants versus 35.9% for non-participants). Although URM dual credit participants did show an increased likelihood of earning a 3.0 or higher, the difference of 3.4 percentage points was not statistically significant. White/Asian students were more likely to earn at least a 3.0 first-year GPA than URM students, with or without dual credit. The gap between the two groups was 11.5 percentage points without dual credit, and 12.6 percentage points with dual credit.

Vertical lines represent 95% confidence intervals. Values: URM non-participants (18.9%-30.0%) and URM participants (22.6%-33.1%). Non-URM non-participants (34.0%-37.8%) and non-URM participants (38.5%-42.3%).

■ **Among technical pathway students, dual credit had a positive effect on first-year GPA of non low-income students only. No significant effect was detected for low-income students.**

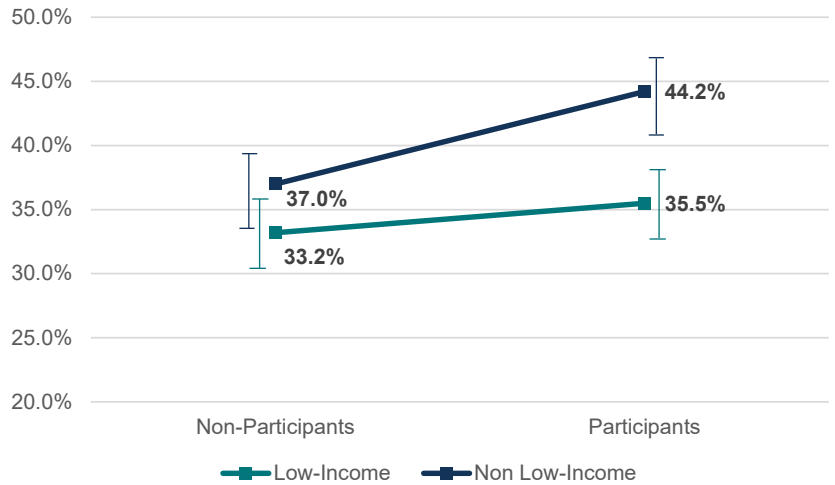Non low-income dual credit participants were 7.2 percentage points more likely to earn at least a 3.0 GPA in the first year of college than non low-income non-participants (44.2% for participants versus 37% for non-participants). Although low-income participants did show an increased likelihood of earning a 3.0 or higher, the difference of 2.3 percentage points was not statistically significant. The GPA gap between low-income and non low-income dual credit participants was 8.7 percentage points; the gap between non-participants was not statistically significant.

Vertical lines represent 95% confidence intervals. Values: low-income non-participants (30-9%-35.6%) and low-income participants (33.1%-37.8%). Non low-income non-participants (34.3%-39.7%) and non low-income participants (41.4%-47.0%).

■ **Taking into account both race and income, dual credit had a positive effect on first-year GPA of white and Asian, non low-income technical pathway students only.**

Among all four noted subgroups related to URM and low-income status enrolled in a technical pathway, dual credit had a positive effect on the first-year GPA of non low-income, white and Asian students only. They were 7.4 percentage points more likely to earn a first-year GPA of 3.0 or higher than similar non-participants. The increases for the other three subgroups (URM and low-income, URM and non-low income, and white/Asian and low-income) were not statistically significant.
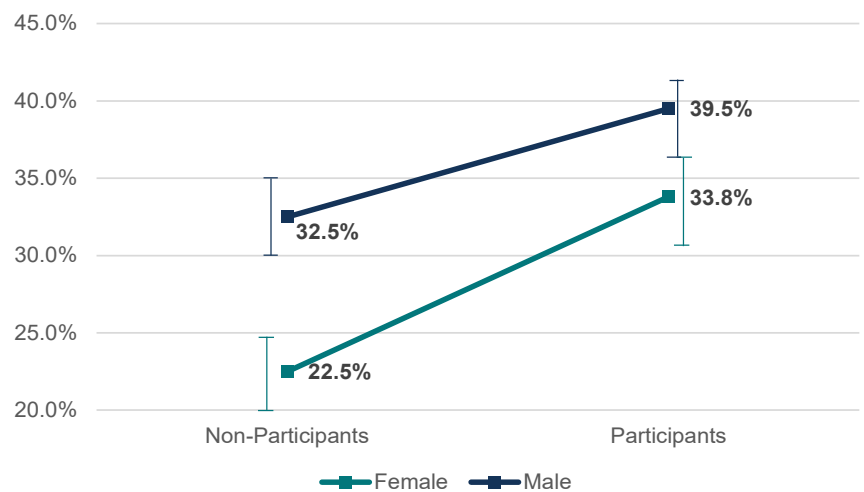
EFFECTS ON SUBGROUPS
Enrolled in a Technical Pathway: Completion

To examine whether the effects of dual credit varied across different subgroups of KCTCS students enrolled in a technical pathway, the analyses were disaggregated further by gender, race and income. Four sets of interaction terms (gender, URM, low-income and both URM and low-income status) were tested through five separate binary logistic regression models to determine the likely effect of dual credit on credential completion within three years. For more detail, see Appendix F. Key findings follow:

> ■ **Among technical pathway students, dual credit had a positive effect on credential completion for both female and male participants, with a slightly greater effect for females.**

Female dual credit participants were 11.3 percentage points more likely to complete a credential within three years than female non-participants, while male dual credit participants were 7.0 percentage points more likely to complete a credential than male non-participants. Both increases were statistically significant. With or without dual credit, male students were more likely to complete within three years than female participants. Dual credit significantly narrowed this completion gap, from a 10.0 percentage-point gap without dual credit to a 5.7 percentage-point gap with dual credit.

Vertical lines represent 95% confidence intervals. Values: male non-participants (30.0%-35.0%) and male participants (36.8%-42.2%). Female non-participants (20.0%-24.9%) and female participants (31.0%-36.8%).

> ■ **Among technical pathway students, dual credit had a positive effect on credential completion for white and Asian students only. No significant effect was detected for URM students.**

White and Asian dual credit participants were 9.4 percentage points more likely to complete a credential within three years than white/Asian non-participants (37.4% for participants versus 28% for non-participants). Although URM dual credit participants did show an increased likelihood of credential completion, the difference of 6.7 percentage points was not statistically significant. The gap between the two groups was not statistically significant, with or without dual credit.
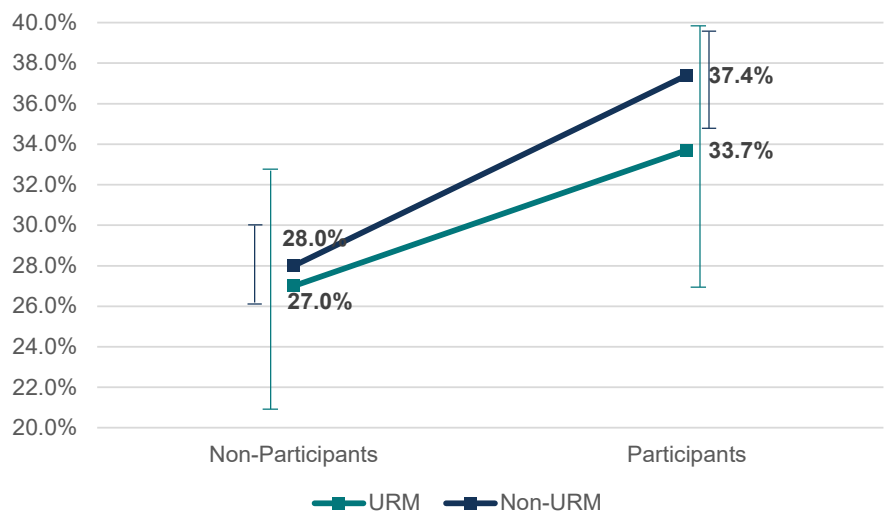
Vertical lines represent 95% confidence intervals. Values: URM non-participants (21.1%-32.8%) and URM participants (27.5%-39.9%). Non-URM non-participants (26.1%-30.0%) and non-URM participants (35.3%-39.6%).

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- **Among technical pathway students, dual credit had a positive effect on credential completion for both low-income and non low-income participants, with a slightly greater effect for low-income participants.**
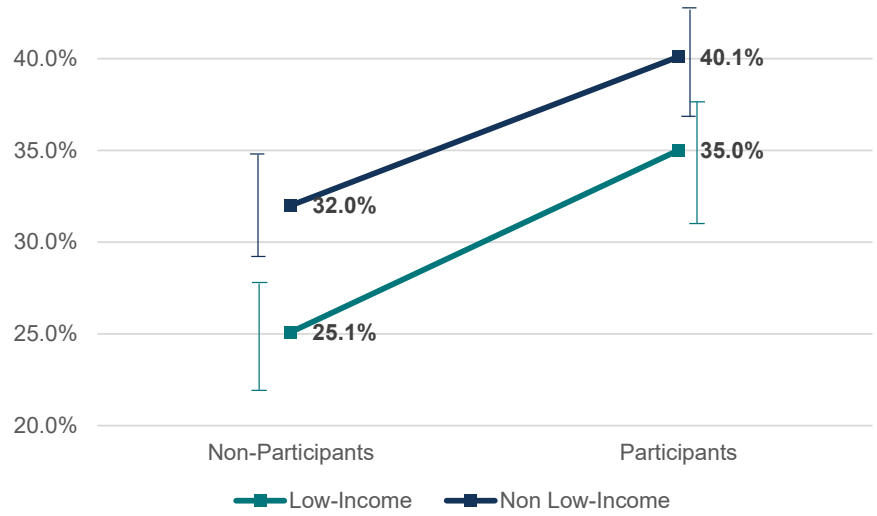
Low-income dual credit participants were 9.9 percentage points more likely to complete a credential within three years than low-income non-participants (35.0% for participants versus 25.1% for non-participants). Non low-income participants were 8.1 percentage points more likely to complete a credential than non low-income non-participants (40.1% for participants versus 32.0% for non-participants). The GPA gap between low-income and non low-income non-participants was 8.7 percentage points; the gap between dual credit participants was not statistically significant.

Vertical lines represent 95% confidence intervals. Values: low-income non-participants (22.8%-27.3%) and low-income participants (32.3%-37.6%). Non low-income non-participants (29.1%-34.9%) and non low-income participants (37.1%-43.1%).

- **Taking into account both race and income, dual credit had a positive effect on credential completion for white and Asian students enrolled in a technical pathway, regardless of income.**

Among all four noted subgroups related to URM and low-income status, dual credit had a positive effect on credential completion for white and Asian students of all incomes. Low-income white/Asian dual credit participants were 10.5 percentage points more likely to complete a credential at any KCTCS institution within three years than low-income, white/Asian non-participants. Non low-income, white/Asian dual credit participants were 8.0 percentage points more likely to complete a credential within three years than non low-income, white/Asian non-participants. Both increases were statistically significant. Dual credit had no significant effect on credential completion for low-income URM students and non low-income URM students.
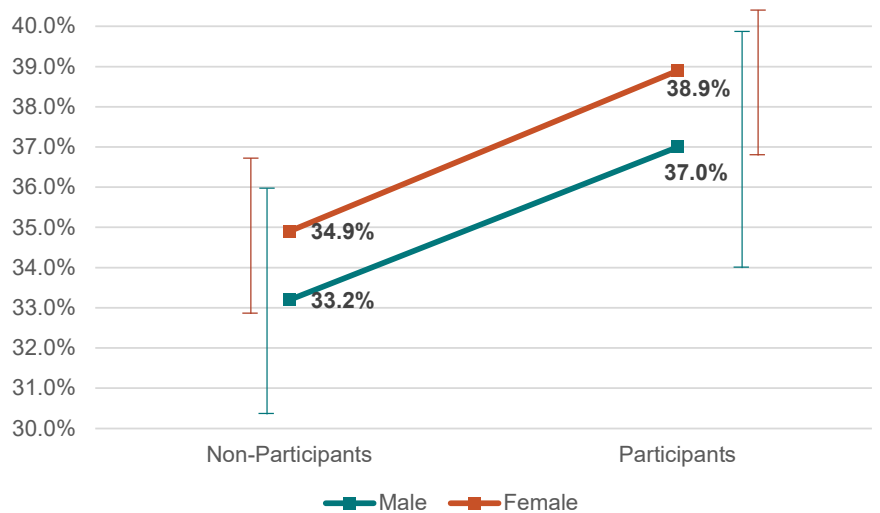
EFFECTS ON SUBGROUPS
Enrolled in an Academic Pathway: GPA

To examine whether the effects of dual credit varied across different subgroups of KCTCS students enrolled in an academic pathway, the analyses were disaggregated further by gender, race and income. Four sets of interaction terms (gender, URM, low-income and both URM and low-income status) were tested through five separate binary logistic regression models to determine dual credit's effect on first-year college GPA. For more detail, see Appendix G. Key findings follow:

■ **Among academic pathway students, dual credit increased the likelihood of earning a first-year GPA of 3.0 or higher for both female and male students, but neither increase was statistically significant.**
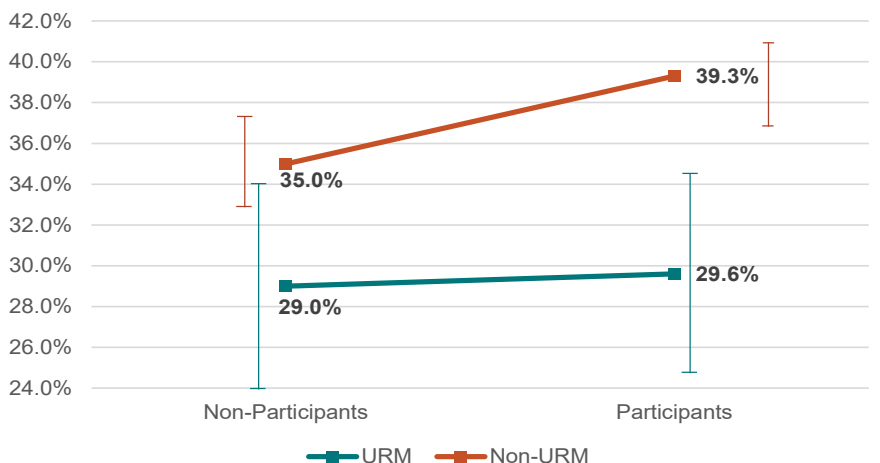
Female dual credit participants were 4.0 percentage points more likely to earn at least a 3.0 GPA during their first year of college than female non-participants (a 38.9% chance for participants, compared to a 34.9% chance for non-participants). Male dual credit participants were 3.8 percentage points more likely to earn at least a 3.0 GPA in the first year of college than male non-participants (a 37.0% chance for participants, compared to a 33.2% chance for non-participants). However, neither increase was statistically significant.

Vertical lines represent 95% confidence intervals. Values: Female non-participants (32.9%-36.8%) and female participants (36.9%-40.9%). Male non-participants (30.4%-36.0%) and male participants (34.0%-39.9%).

■ **Among academic pathway students, dual credit increased the likelihood of earning a first-year GPA of 3.0 or higher for white and Asian students only. No significant effect was detected for URM students.**

White and Asian dual credit participants were 4.3 percentage points more likely to earn at least a 3.0 GPA during their first year of college than white/Asian non-participants (39.3% versus 35.0%). Although URM dual credit participants did show an increased likelihood of earning a 3.0 or higher, the difference of 0.6 of a percentage point was not statistically significant. White/Asian students were more likely to earn at least a 3.0 first-year GPA than URM students, with or without dual credit. Among non-participants, the gap was not statistically significant, but among dual credit participants, the gap was 9.7 percentage points.

Vertical lines represent 95% confidence intervals. Values: URM non-participants (24.0%-34.0%) and URM participants (24.9%-34.3%). Non-URM non-participants (33.3%-36.7%) and non-URM participants (37.5%-41.1%).

- **Among academic pathway students, dual credit increased the likelihood of earning a first-year GPA of 3.0 or higher for non low-income students only. No significant effect was detected for low-income students.**

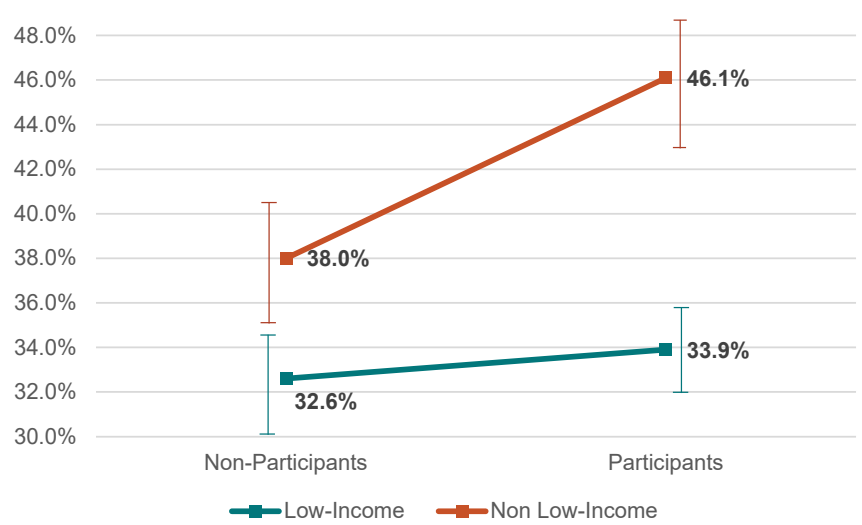Non low-income dual credit participants were 8.1 percentage points more likely to earn at least a 3.0 GPA in their first year of college than non low-income non-participants (46.1% versus 38.0%). Although low-income participants did show an increased likelihood of earning a 3.0 or higher, the difference of 1.3 percentage points was not statistically significant. Non low-income students were much more likely to earn a first-year GPA of 3.0 or higher than low-income students, with or without dual credit. Dual credit participation widened that gap from 5.4 percentage points to 12.2 percentage points.

Vertical lines represent 95% confidence intervals. Values: low-income non-participants (30.5%-34.7%) and low-income participants (32.0%-35.9%). Non low-income non-participants (35.4%-40.6%) and non low-income participants (43.2%-48.9%).

- **Taking into account both race and income, dual credit had a positive effect on first-year GPA of white and Asian, non low-income academic pathway students only.**

Among all four noted subgroups related to URM and low-income status enrolled in an academic pathway, dual credit had a positive effect on the first-year GPA of non low-income, white and Asian students only. They were 8.0 percentage points more likely to earn a first-year GPA of at least 3.0 or than similar non-participants. The increases for the other three subgroups (URM and low-income, URM and non low-income, and white/Asian and low-income) were not statistically significant.
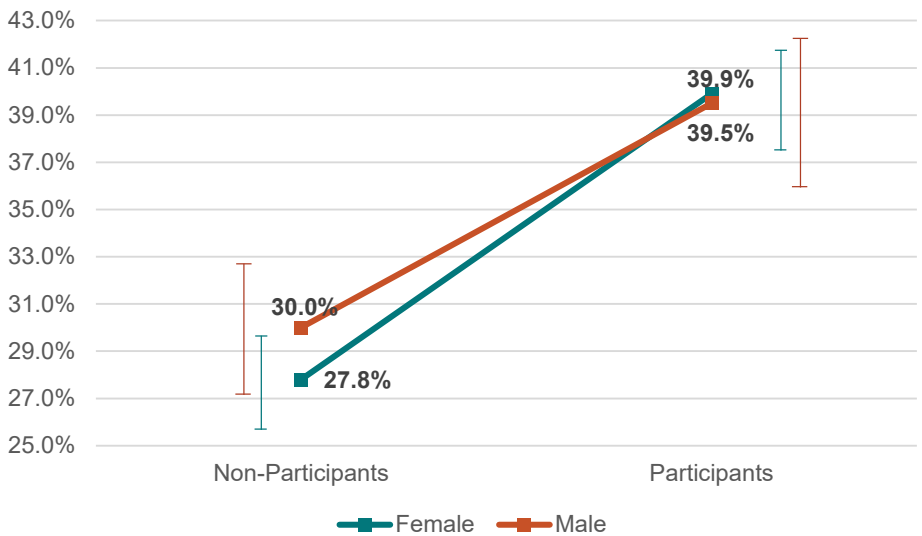
EFFECTS ON SUBGROUPS
Enrolled in an Academic Pathway: Completion

To examine whether the effects of dual credit varied across different subgroups of KCTCS students enrolled in an academic pathway, the analyses were disaggregated further by gender, race and income. Four sets of interaction terms (gender, URM, low-income and both URM and low-income status) were tested through five separate binary logistic regression models to determine dual credit's effect on completing a credential or transferring to a public university within three years. For more detail, see Appendix H. Key findings follow:

■ **Among academic pathway students, dual credit had a positive effect on credential completion or successful transfer for both female and male participants, with a greater effect for females.**

Female dual credit participants were 12.1 percentage points more likely to complete a credential or transfer within three years than female non-participants, while male dual credit participants were 9.5 percentage points more likely to complete a credential or transfer than male non-participants. Both increases were statistically significant. Without dual credit, male students were slightly more likely to complete or transfer within three years than females. Dual credit significantly narrowed this completion gap, from a 2.2 percentage-point gap to a 0.4 percentage-point gap.

Vertical lines represent 95% confidence intervals. Values: male non-participants (27.2%-32.8%) and male participants (36.3%-42.6%). Female non-participants (25.9%-29.6%) and female participants (37.8%-41.9%).

■ **Among academic pathway students, dual credit had a positive effect on credential completion or transfer for white and Asian students only. No significant effect was detected for URM students.**

White and Asian dual credit participants were 11.6 percentage points more likely to complete a credential or transfer within three years than white/Asian non-participants (40.2% versus 28.6%). Although URM dual credit participants did show an increased likelihood of credential completion, the difference of 9.1 percentage points was not statistically significant. The gap between the two groups was not statistically significant, with or without dual credit.
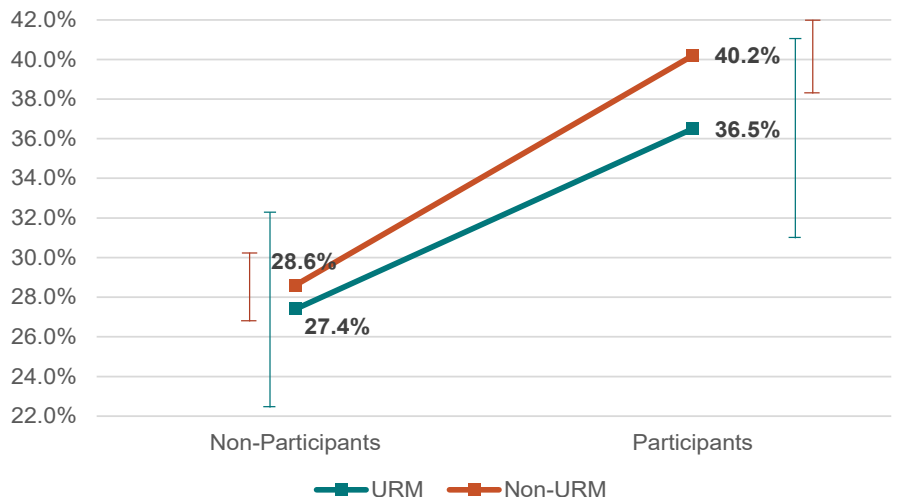
Vertical lines represent 95% confidence intervals. Values: URM non-participants (22.6%-32.2%) and URM participants (31.3%-41.6%). Non-URM non-participants (26.9%-30.2%) and non-URM participants (38.3%-42.0%).

■ **Among academic pathway students, dual credit had a positive effect on credential completion or transfer for both low-income and non low-income students, with a slightly greater effect for non low-income participants.**

Non low-income dual credit participants were 13.4 percentage points more likely to complete a credential or transfer within three years than non low-income non-participants (44.4% versus 31.0%). Low-income participants were 10.0 percentage points more likely to complete a credential or transfer than low-income non-participants (37.1% versus 27.1%). Both increases were statistically significant.

Vertical lines represent 95% confidence intervals. Values: low-income non-participants (25.2%-29.0%) and low-income participants (35.0%-39.2%). Non low-income non-participants (28.4%-33.6%) and non low-income participants (41.6%-47.3%).

■ **Taking into account both race and income, dual credit had a positive effect on credential completion or transfer of white and Asian academic pathway students, both low-income and non low-income.**

Among all four noted subgroups enrolled in an acdemic pathway, dual credit had a positive effect on completion or transfer of white/Asian students of all incomes. Low-income, white/Asian dual credit participants were 10.3 percentage points more likely than low-income, white/Asian non-participants to complete a credential at any KCTCS institution or transfer to a university within three years. Non low-income, white/Asian dual credit participants were 13.4 percentage points more likely to complete a credential or transfer to a university within three years than similar non-participants. Both increases were statistically significant. Dual credit had no significant effect on credential completion or transfer for URM students, whether low-income or not.

FOR FUTURE STUDY

Overall, this study demonstrates that dual credit participation has a positive effect on college academic performance and completion for community and technical college students in the state of Kentucky. However, the effect on low-income and underrepresented minority students was smaller than the average effect. While low-income and URM students saw some increase in likely credential completion due to dual credit participation, there was no significant effect on their first-year grade-point average. In other words, the knowledge and skills gained from high school dual credit participation did not translate into higher grades in college. This finding suggests the need for more rigorous dual credit experiences for low-income and minority students, with greater academic supports, to prepare them for the academic challenges of a college setting.

Additional research is needed to address some of the limitations of this study and expand the depth and breadth of our understanding of the effects of dual credit on postsecondary outcomes.

- **Include additional demographic characteristics and variables.** Restrictions in the available longitudinal dataset limited the number of demographic characteristics that could be included in the matching model to predict the likelihood of enrolling in dual credit. Because prior academic performance and motivation are key predictors of dual credit enrollment, additional research would match students within each high school using eighth-grade GPA or other characteristics as a measure of academic motivation. A next step is to merge CPE's dataset with KDE's dataset to obtain better estimates of the causal relationship between high school dual credit and postsecondary achievement.

- **Survey dual credit students, teachers and other stakeholders.** It would be useful to better understand the perceptions and experiences of stakeholders who are involved in dual credit, such as students, instructors, advisors and school administrators. To facilitate this, surveys could be designed and administered, and focus groups and individual interviews could be conducted.

- **Explore the effects of dual credit on learning and workforce outcomes.** Future studies will explore how variations in dual credit programs (e.g., by intensity/duration and type) lead to different learning outcomes (e.g., college enrollment and completion) or workforce outcomes (e.g., career readiness and earnings).

In conclusion, additional qualitative and quantitative research will help us gain further insights into the accessibility, transferability, affordability and quality of dual credit programs and their effect on academic and career achievement. Through these approaches, CPE will gain a more complete picture of dual credit programs and participants in Kentucky.

APPENDICES

APPENDIX A

MEASURES

Independent Variable:

Dual credit. This variable indicates whether a student enrolled in a course for which he or she received both high school and college credit.

Outcome Variables:

First-year GPA. This variable was calculated based on the average GPA of all the courses a student took during his or her first year of college, exluding the grades earned in remedial courses. The variable was classified into two categories: GPA less than 3.0 and GPA greater than or equal to 3.0.

Credential Completion. For technical pathway students, this variable indicated whether or not a student completed a postsecondary credential from any KCTCS campus within three years. For academic pathway students, this variable indicated whether or not a student completed a postsecondary credential from any KCTCS campus within three years or successfully transferred to a public four-year institution within three years.

Confounding Variables:

Underrepresented minority (URM). This variable indicates whether students categorized themselves as (a) Hispanic or Latinx, (b) American Indian or Alaska Native, (c) Black or African American, (d) Native Hawaiian or Other Pacific Islander, or (e) Two or more Races.

Low-income. This variable indicates whether or not students received any Pell Grant at entry or during specific semesters (varies depending on the specific metric).

Gender. This variable indicates whether students categorized themselves as (a) female or (b) male.

High school GPA. This variable indicates the average GPA of all of the courses a student took during high school.

First-year GPA. This variable is one of the outcome variables. It was included in the models as one of the confounding variables to predict credential completion.

Cohort year. This variable indicates the cohort year when students first enrolled at a KCTCS institution in Kentucky, including fall 2014, 2015, 2016 and 2017.

Institution name. This variable indicates the KCTCS institution in Kentucky where students were enrolled during the cohort years of fall 2014, 2015, 2016 and 2017. They include: Ashland Community and Technical College, Big Sandy Community and Technical College, Bluegrass Community and Technical College, Elizabethtown Community and Technical College, Gateway Community and Technical College, Hazard Community and Technical College, Henderson Community College, Hopkinsville Community College, Jefferson Community and Technical College, Madisonville Community College, Maysville Community and Technical College, Owensboro Community and Technical College, Somerset Community College, Southcentral Community and Technical College, Southeast Community and Technical College, West Kentucky Community and Technical College.

ATTRIBUTES OF THE VARIABLES

Variable Name	Type	Categories
Independent Variable		
Dual Credit	Binary	(a) Yes (b) No
Outcome Variables		
Credential Completion/ Transfer	Binary	(a) Yes (b) No
First-Year GPA	Binary	(a) GPA < 3.0 (b) GPA $\geq$ 3.0
	Continuous	Points range on a 4.0 scale
Confounding Variables		
Underrepresented Minority	Binary	(a) Yes (b) No
Gender	Binary	(a) Yes (b) No
Low-Income	Binary	(a) Yes (b) No
High School GPA	Continuous	Points range on a 4.0 scale
First-Year College GPA	Continuous	Points range on a 4.0 scale
Cohort Year	Categorical	Fall 2014 Fall 2015 Fall 2016 Fall 2017
Institution	Categorical	Ashland CTC Big Sandy CTC Bluegrass CTC Elizabethtown CTC Gateway CTC Hazard CTC Henderson CC Hopkinsville CC Jefferson CTC Madisonville CC Maysville CTC Owensboro CTC Somerset CC Southcentral CTC Southeast CTC West KY CTC

APPENDIX B

ANALYTIC STRATEGIES

This study first conducted descriptive analyses to examine the differences in preexisting demographic characteristics (gender, URM, low-income), academic outcomes (first-year GPA, credential completion), region (central, east, Lexington, Louisville, north, southeast, west central and west), and cohort year participation (fall 2014, 2015, 2016 and 2017) between dual credit and non-dual credit students.

Binary logistic regression was used to examine the effect of dual credit on students' first-year GPA and credential completion. Both outcome variables were dichotomous. Regression analyses adjusted for the observed confounding variables in the models. The confounding variables were found to be associated with the study's outcome variables suggested by both theories and previous empirical studies.

The two datasets used for this study included full-time, first-time students from sixteen different KCTCS campuses across four cohorts, regardless of whether a student had a dual credit experience or in which sector the dual credit experience occurred. However, there are variations in first-year GPA and in the proportion of credential completions across institutions due to differences in each campus. Additionally, there are variations by cohort. Without accounting for the differences between campuses and cohorts, the estimate of the effect of dual credit on first-year GPA and credential completion might be biased. In order to mitigate these potential biases, campus fixed effects and cohort fixed effects were included to account for the variations across campuses and by cohort.

In order to explore whether the effects of dual credit varied across different subgroups of students, the analyses were disaggregated further by student race, gender and low-income status. These estimates were calculated by introducing interactions of the student subgroup with the dual credit indicator in the analysis models. Five sets of interaction terms were tested through five separate binary logistic regression models. The interaction terms are: (a) dual credit and gender, (b) dual credit and URM status, (c) dual credit and low-income status, (d) dual credit and both URM and low-income status.

In an ideal experimental setting, high school students would be randomly assigned either to enroll or not to enroll in a dual credit course. The unbiased treatment effects of dual credit on students' postsecondary achievements would then be calculated. However, in Kentucky, dual credit is not randomly assigned, but self-selected. Choosing to apply for a dual credit course depends on the active choices of students and their parents. These choices typically depend on student academic performance, motivation, family financial situation, and available dual credit opportunities in high schools. For example, if students with higher eighth-grade GPAs or stronger motivation apply for dual credit courses, then the postsecondary performances of these students might appear better than non-dual credit students because of potentially unobserved background differences between the two groups. In order to mitigate the selection bias, we employed Propensity Score Matching (PSM) as a quasi-experimental approach attempting to obtain better treatment effects.

Given the availability of longitudinal data, student demographic characteristics for this study included gender, race, low-income status, cohort year, and geographic region in the matching model to predict students' likelihood of enrolling in a dual credit course. Ideally, students would be matched within each high school using their eighth-grade GPA and a measure of their motivation. Thus, due to this limitation, PSM was used as a trial on the preferred logistic regression models to predict first-year GPA and credential completion.

For all logistic regression analysis results, both Odds Ratio (OR) and Marginal Effects at the Means (MEM) were calculated and recorded. Compared with the OR, the MEM presents the differences in probabilities while holding other confounding variables at their means. Therefore, MEM can provide a clearer interpretation of the magnitude of the effect of dual credit on first-year GPA and credential completion by isolating these outcome variables without effect from other factors. Adjusted Predictions at the Means (APM) were also computed and reported to provide the average predicted probabilities while holding other confounding variables at their means.

All analyses were conducted using Stata SE/14.0 statistical software.

THE EFFECT OF DUAL CREDIT ON FIRST-YEAR GPA -Technical Pathway Students

Overall, dual credit had a positive impact on students' first-year GPA across all of the models, as shown in the table below. After controlling for the covariates and including the institution and cohort fixed effects, the results after PSM in model 5 indicate that dual credit students were 1.210 times more likely than students who did not enroll in dual credit to obtain a first-year GPA equal to or greater than 3.0 on a 4.0 scale.

	Before PSM				After PSM
	Model 1	Model 2	Model 3	Model 4	Model 5
Dual Credit (Marginal Effects at the Means)	0.095*** (0.008)	0.033*** (0.011)	0.032*** (0.011)	0.029*** (0.011)	0.044*** (0.014)
Dual Credit (Odds Ratio)	1.493*** (0.058)	1.156*** (0.051)	1.149*** (0.061)	1.181*** (0.067)	1.210*** (0.068)
[1]Covariates	NO	YES	YES	YES	YES
Cohort Fixed Effects	NO	NO	YES	YES	YES
Institution Fixed Effects	NO	NO	NO	YES	YES
Observations	13,947	11,933	11,933	11,933	6,417
Pseudo R^2	0.006	0.053	0.055	0.064	0.071
Log-likelihood	-9110.479	-7428.114	-7407.762	-7336.371	-3979.487
AIC	18224.959	14868.229	14833.525	14720.741	8006.973
BIC	18240.045	14912.551	14900.008	14898.030	8169.374

Note. [1]Covariates included gender, URM, low-income and high school GPA. Robust standard errors are in parentheses.

*$P \leq .05$. **$P \leq .01$. ***$P \leq .001$.

AVERAGE PREDICTED PROBABILITY OF OBTAINING A FIRST-YEAR GPA EQUAL TO OR GREATER THAN 3.0 - Technical Pathway Students

The following table presents the average predicted probability of obtaining a first-year GPA equal to or greater than 3.0 for both dual credit and non-dual credit students after holding other confounding variables at their means. After PSM, the average predicted probability of dual credit students earning a first-year GPA equal to or greater than 3.0 was 39.2%, compared to 34.8% for non-participants. A difference of 4.4 percentage points was statistically significant (p<0.001).

	Before PSM				After PSM
	Model 1	Model 2	Model 3	Model 4	Model 5
Dual Credit	0.436 (0.008)	0.377 (0.009)	0.376 (0.009)	0.379 (0.009)	0.392 (0.009)
95% Confidence Intervals	[0.420, 0.452]	[0.360, 0.395]	[0.358, 0.393]	[0.360, 0.397]	[0.384, 0.410]
Non-Dual Credit	0.0341 (0.005)	0.344 (0.005)	0.344 (0.005)	0.340 (0.005)	0.348 (0.009)
95% Confidence Intervals	[0.332, 0.350]	[0.334, 0.354]	[0.333, 0.354]	[0.330, 0.351]	[0.330, 0.365]

Note. 95% Confidence Intervals were reported.
Robust standard errors are in parentheses.

THE EFFECT OF DUAL CREDIT ON CREDENTIAL COMPLETION -Technical Pathway Students

Overall, dual credit had a positive effect on students' credential completion within three years across all of the models, as shown in the table below. After controlling all the covariates and including the institution and cohort fixed effects, the results after PSM in model 5 indicate that dual credit students were 1.521 times more likely than students who did not enroll in dual credit to complete a cedential at any KCTCS institution within three years.

	Before PSM				After PSM
	Model 1	Model 2	Model 3	Model 4	Model 5
Dual Credit (Marginal Effects at the Means)	0.177*** (0.009)	0.123*** (0.011)	0.124*** (0.010)	0.076*** (0.011)	0.092*** (0.013)
Dual Credit (Odds Ratio)	2.219*** (0.080)	1.833*** (0.088)	1.840*** (0.089)	1.480*** (0.078)	1.521*** (0.093)
[1]Covariates	NO	YES	YES	YES	YES
Cohort Fixed Effects	NO	NO	YES	YES	YES
Institution Fixed Effects	NO	NO	NO	YES	YES
Observations	14,775	13,746	13,746	13,746	7,339
Pseudo R^2	0.021	0.275	0.282	0.316	0.307
Log-likelihood	-9357.303	-6451.279	-6387.271	-6082.488	-3428.351
AIC	18718.607	12914.559	12792.542	12212.976	6904.703
BIC	18733.808	12959.730	12860.299	12393.660	7070.326

Note. [1]Covariates included gender, URM, low-income and high school GPA.
Robust standard errors are in parentheses.

*$P \le .05$. **$P \le .01$. ***$P \le .001$.

AVERAGE PREDICTED PROBABILITY OF COMPLETING A CREDENTIAL AT ANY KCTCS INSTITUTION WITHIN THREE YEARS - Technical Pathway Students

The following table presents the average predicted probability of completing a credential at any KCTCS institution within three years for both dual credit and non-dual credit students after holding other confounding variables at their means. After PSM, the likelihood of completing a credential within three years for dual credit participants was 37.1%, compared to 27.9% for non-participants. The difference of 9.2 percentage points was statistically significant.

	Before PSM				After PSM
	Model 1	Model 2	Model 3	Model 4	Model 5
Dual Credit	0.477 (0.008)	0.351 (0.010)	0.350 (0.010)	0.302 (0.010)	0.371 (0.010)
95% Confidence Intervals	[0.461, 0.492]	[0.332, 0.370]	[0.331, 0.369]	[0.283, 0.321]	[0.350, 0.391]
Non-Dual Credit	0.304 (0.005)	0.228 (0.005)	0.226 (0.005)	0.226 (0.005)	0.279 (0.009)
95% Confidence Intervals	[0.291, 0.308]	[0.218, 0.238]	[0.216, 0.237]	[0.215, 0.237]	[0.261, 0.298]

Note. 95% Confidence Intervals were reported.
Robust standard errors are in parentheses.

APPENDIX D

THE EFFECT OF DUAL CREDIT ON FIRST-YEAR GPA - Academic Pathway Students

Overall, dual credit had a positive effect on students' first year GPA for all the models shown in the table below. After controlling for the covariates and including the institution and cohort fixed effects, the results after PSM indicate that dual credit students were 1.186 times more likely than non-dual credit students to earn a first-year GPA equal to or greater than 3.0 on a 4.0 scale.

	Before PSM				After PSM
	Model 1	Model 2	Model 3	Model 4	Model 5
Dual Credit (Marginal Effects at the Means)	0.142*** (0.008)	0.049*** (0.009)	0.044*** (0.009)	0.046*** (0.010)	0.039*** (0.012)
Dual Credit (Odds Ratio)	1.828*** (0.064)	1.242*** (0.051)	1.217*** (0.050)	1.226*** (0.054)	1.186*** (0.062)
[1]Covariates	NO	YES	YES	YES	YES
Cohort Fixed Effects	NO	NO	YES	YES	YES
Institution Fixed Effects	NO	NO	NO	YES	YES
Observations	15,254	13,199	13,199	11,933	8,353
Pseudo R^2	0.015	0.102	0.105	0.118	0.124
Log-likelihood	-9864.875	-7793.727	-7768.821	-7648.562	-4914.621
AIC	19733.751	15599.454	15555.642	15345.123	9877.242
BIC	19749.016	15644.381	15623.033	15524.833	10045.971

Note. [1]*Covariates included gender, URM, low-income and high school GPA.*
Robust standard errors are in parentheses.

*$P \leq .05$. **$P \leq .01$. ***$P \leq .001$.

AVERAGE PREDICTED PROBABILITY OF OBTAINING A FIRST-YEAR GPA EQUAL TO OR GREATER THAN 3.0 - Academic Pathway Students

The following table presents the average predicted probability of obtaining a first-year GPA equal to or greater than 3.0 for both dual credit participants and non-participants after holding other confounding variables at their means. The average predicted probability of dual credit participants earning a first-year GPA equal to or greater than 3.0 was 38.3%, compared to 34.4% for non-participants. The difference of 3.9 percentage points was statistically significant.

	Before PSM				After PSM
	Model 1	Model 2	Model 3	Model 4	Model 5
Dual Credit	0.458 (0.007)	0.368 (0.008)	0.364 (0.008)	0.362 (0.008)	0.383 (0.009)
95% Confidence Intervals	[0.444, 0.471]	[0.352, 0.383]	[0.349, 0.380]	[0.346, 0.378]	[0.366, 0.400]
Non-Dual Credit	0.316 (0.005)	0.319 (0.005)	0.320 (0.005)	0.316 (0.006)	0.344 (0.008)
95% Confidence Intervals	[0.307, 0.325]	[0.308, 0.330]	[0.310, 0.331]	[0.305, 0.327]	[0.327, 0.360]

Note. 95% Confidence Intervals were reported.
Robust standard errors are in parentheses.

THE EFFECT OF DUAL CREDIT ON CREDENTIAL COMPLETION OR TRANSFER -
Academic Pathway Students

Overall, dual credit had a positive effect on academic pathway students' likelihood of completing a postsecondary credential from any KCTCS institution within three years or transferring to a four-year public institution within three years. After controlling all the covariates and including the cohort and institution fixed effects, the results on the matched sample indicated that dual credit students were 1.660 times more likely to complete or transfer than non-participants.

	Before PSM				After PSM
	Model 1	Model 2	Model 3	Model 4	Model 5
Dual Credit (Marginal Effects at the Means)	0.196*** (0.008)	0.126*** (0.009)	0.127*** (0.009)	0.110*** (0.011)	0.113*** (0.012)
Dual Credit (Odds Ratio)	2.300*** (0.080)	1.786*** (0.074)	1.792*** (0.074)	1.670*** (0.075)	1.660*** (0.087)
[1]Covariates	NO	YES	YES	YES	YES
Cohort Fixed Effects	NO	NO	YES	YES	YES
Institution Fixed Effects	NO	NO	NO	YES	YES
Observations	15,692	15,153	15,153	15,153	7,339
Pseudo R^2	0.028	0.248	0.248	0.262	0.265
Log-likelihood	-9991.239	-7532.030	-7529.239	-7386.882	-4705.433
AIC	19986.478	15076.061	15076.478	14821.764	9458.866
BIC	20001.800	15121.816	15145.112	15004.787	9630.587

Note. [1]*Covariates included gender, URM, low-income and high school GPA.*
Robust standard errors are in parentheses.

*$P \leq .05.$ **$P \leq .01.$ ***$P \leq .001.$*

AVERAGE PREDICTED PROBABILITY OF COMPLETING A CREDENTIAL AT ANY KCTCS INSTITUTION WITHIN THREE YEARS OR TRANSFERRING - Academic Pathway Students

The following table presents the average predicted probability of completing a credential from KCTCS or transferring to a public four-year institution within three years. On average, dual credit participants had a 39.8% chance of completion or transfer, while non-participants had a 28.5% chance. The difference of 11.3 percentage points was statistically significant.

	Before PSM				After PSM
	Model 1	Model 2	Model 3	Model 4	Model 5
Dual Credit	0.491 (0.007)	0.387 (0.008)	0.387 (0.008)	0.372 (0.008)	0.398 (0.009)
95% Confidence Intervals	[0.478, 0.504]	[0.371, 0.403]	[0.372, 0.403]	[0.355, 0.388]	[0.380, 0.415]
Non-Dual Credit	0.295 (0.005)	0.261 (0.005)	0.261 (0.005)	0.262 (0.006)	0.285 (0.008)
95% Confidence Intervals	[0.287, 0.304]	[0.251, 0.272]	[0.250, 0.271]	[0.251, 0.272]	[0.269, 0.300]

Note. 95% Confidence Intervals were reported.
Robust standard errors are in parentheses.

APPENDIX E

AVERAGE PREDICTED PROBABILITY OF EARNING A FIRST-YEAR GPA EQUAL TO OR GREATER THAN 3.0 ACROSS SUBGROUPS - Technical Pathway Students

Gender

Overall, dual credit had a positive effect on first-year GPA for male students only. Male dual credit participants were more likely to earn a first-year GPA equal to or greater than 3.0 than male non-participants. The average predicted probability of males earning a first-year GPA equal to or greater than 3.0 with and without dual credit was 39.5% and 34.7%, respectively. The statistically significant difference between dual credit participants and non-participants was 4.8 percentage points. The predicted probability of females earning a first-year GPA equal to or greater than 3.0 with and without dual credit was 38.8% and 34.8%, respectively. However, the difference of 4.0 percentage points was not statistically significant. There was no effect of dual credit on first-year GPA found for female students. Additionally, with or without dual credit, no statistically significant gaps in first-year GPA were found between female and male students.

Subgroup	Non-Dual Credit	Dual Credit	Difference
Model 1: Interaction between dual credit and gender			
Gender			
Female	0.348 (0.014)	0.388 (0.014)	0.040
95% Confidence Intervals	[0.329, 0.376]	[0.361, 0.415]	
Male	0.347 (0.012)	0.395 (0.012)	0.048*
95% Confidence Intervals	[0.324, 0.370]	[0.371, 0.419]	
Difference	0.001	0.007	

Race

Dual credit had a positive effect on first-year GPA only for white/Asian students. No effect was detected for URM students. White/Asian dual credit participants were 4.5 percentage points more likely to earn a first-year GPA equal to or greater than 3.0 than white/Asian non-participants. On average, a white/Asian dual credit non-participant had a 35.9% chance of earning at least a 3.0 GPA, while an otherwise comparable white/Asian participant had a 40.4% chance. Although a dual credit URM participant had a 3.4 percentage-point increase in the probability of earning at least a 3.0 GPA, the increase was not statistically significant.

Additionally, white/Asian students were more likely tthan URM students to earn a first-year GPA equal to or greater than 3.0, with or without dual credit. Both gaps were statistically significant. Without dual credit, the gap between the two groups was 11.5 percentage points. With dual credit, the gap increased to 12.6 percentage points. Dual credit slightly widened the gap in first-year GPA between white/Asian and URM students.

Subgroup	Non-Dual Credit	Dual Credit	Difference
Model 2: Interaction between dual credit and race			
URM			
Yes	0.244 (0.028)	0.278 (0.027)	0.034
95% Confidence Intervals	[0.189, 0.300]	[0.226, 0.331]	
No	0.359 (0.010)	0.404 (0.010)	0.045*
95% Confidence Intervals	[0.340, 0.378]	[0.385, 0.423]	
Difference	0.115*	0.126*	

Income

Dual credit had a positive impact on first-year GPA for non low-income students. The average predicted probability of earning a first-year GPA equal to or greater than 3.0 for non low-income dual credit participants and non-participants was 44.2% and 37.0%, respectively. Non low-income dual credit participants were 7.2 percentage points more likely to earn a first-year GPA of at least 3.0 than non low-income non-participants. Dual credit had no significant effect on the first-year GPA of low-income students. With or without dual credit, the study found that non low-income students were more likely to earn at least a 3.0 GPA than low-income students. With dual credit, the gap between the two groups was 8.7 percentage points, which was statistically significant. The gap without dual credit was not statistically significant.

Subgroup	Non-Dual Credit	Dual Credit	Difference
Model 3: Interaction between dual credit and income			
Low-Income			
Yes	0.332 (0.012)	0.355 (0.012)	0.023
95% Confidence Invervals	[0.309, 0.356]	[0.331, 0.378]	
No	0.370 (0.015)	0.442 (0.014)	0.072*
95% Confidence Intervals	[0.343, 0.397]	[0.414, 0.470]	
Difference	0.038	0.087*	

Income and Race

Among all four noted subgroups related to URM and low-income status, dual credit had a positive effect on first-year GPA for non low-income, white/Asian students only. Non low-income white/Asian dual credit participants were 7.4 percentage points more likely to earn a first-year GPA of at least 3.0 than non low-income white/Asian non-participants. The increases for the other three subgroups were not statistically significant.

Subgroup	Non-Dual Credit	Dual Credit	Difference
Model 4: Interaction between dual credit, race and income			
URM & Low-Income			
No & No	0.383 (0.014)	0.457 (0.015)	0.074*
95% Confidence Intervals	[0.354, 0.411]	[0.428, 0.489]	
No & Yes	0.343 (0.013)	0.364 (0.013)	0.021
95% Confidence Intervals	[0.318, 0.368]	[0.339, 0.388]	
Yes & No	0.251 (0.048)	0.285 (0.051)	0.034
95% Confidence Intervals	[0.156, 0.346]	[0.185, 0.384]	
Yes & Yes	0.236 (0.034)	0.265 (0.034)	0.029
95% Confidence Intervals	[0.170, 0.302]	[0.205, 0.325]	

Note. For all tables, covariates included gender, URM, low-income and high school GPA. The analyses included cohort and institution fixed effects.
Robust standard errors are in parentheses.

*P ≤ .05.

APPENDIX F

AVERAGE PREDICTED PROBABILITY OF COMPLETING A CREDENTIAL AT ANY KCTCS CAMPUS WITHIN THREE YEARS ACROSS SUBGROUPS - Technical Pathway Students

Gender

Dual credit had positive effects on credential completion for both male and female students. Dual credit had a greater effect on the completion of female students than of male students. Female dual credit participants were 11.3 percentage points more likely to complete a credential within three years than female non-participants, while the gap for male participants and non-participants was 7.0 percentage points. Both gaps were statistically significant.

With or without dual credit, male students were more likely than female students to complete a credential within three years. The average predicted probability of completing a credential within three years for male participants and non-participants was 39.5% and 32.5%, respectively. For female students, the probability was 33.8% for participants and 22.5% for non-participants. Dual credit significantly narrowed the gap between male and female students, from 10.0 percentage points to 5.7 percentage points. In addition, the gap between male and female students with dual credit was no longer statistically significant.

Subgroup	Non-Dual Credit	Dual Credit	Difference
Model 1: Interaction between dual credit and gender			
Gender			
Female	0.225 (0.012)	0.338 (0.014)	0.113*
95% Confidence Intervals	[0.200, 0.249]	[0.310, 0.368]	
Male	0.325 (0.013)	0.395 (0.013)	0.070*
95% Confidence Intervals	[0.300, 0.350]	[0.368, 0.422]	
Difference	0.100*	0.057	

Race

Dual credit had a positive effect on credential completion for white/Asian students only. There was no effect found for URM students. White/Asian dual credit participants were 9.4 percentage points more likely to complete a credential from any KCTCS campus within three years than white/Asian non-participants. On average, a white/Asian participant had a 37.4% chance of completing a credential, while an otherwise comparable white/Asian non-participant had a 28.0% chance of completing a credential. Although dual credit URM participants were 6.7 percentage points more likely to complete a credential than non-participants, the increase was not statistically significant. Additionally, with or without dual credit, the gap between URM and white/Asian students was not statistically significant.

Subgroup	Non-Dual Credit	Dual Credit	Difference
Model 2: Interaction between dual credit and race			
URM			
Yes	0.270 (0.030)	0.337 (0.032)	0.067
95% Confidence Intervals	[0.211, 0.328]	[0.275, 0.399]	
No	0.280 (0.010)	0.374 (0.010)	0.094*
95% Confidence Intervals	[0.261, 0.300]	[0.353, 0.396]	
Difference	0.010	0.037	

Income

Dual credit had a positive impact on credential completion for both low-income and non low-income students. On average, low-income dual credit participants were 9.9 percentage points more likely to complete a credential at any KCTCS campus within three years than low-income non-participants. Non low-income dual credit participants were 8.1 percentage points more likely to complete than non-participants. Thus, dual credit had a greater effect on the credential completion of low-income students than of non low-income students.

With or without dual credit, non low-income students were more likely than low-income students to complete a credential within three years. The average predicted probability of completing a credential within three years for non low-income participants and non-participants was 40.1% and 32.0%, respectively. By comparison, the predicted probability for low-income participants and non-participants was 35.0% and 25.1%. Dual credit significantly narrowed the gap between non low-income and low-income students, from 7.1 percentage points to 5.1 percentage points. In addition, the gap between the two groups was no longer statistically significant.

Subgroup	Non-Dual Credit	Dual Credit	Difference
Model 3: Interaction between dual credit and income			
Low-Income			
Yes	0.251 (0.011)	0.350 (0.013)	0.099*
95% Confidence Invervals	[0.228, 0.273]	[0.323, 0.376]	
No	0.320 (0.015)	0.401 (0.015)	0.081*
95% Confidence Intervals	[0.291, 0.349]	[0.371, 0.431]	
Difference	0.069*	0.051	

Income and Race

Among all four noted subgroups related to URM and low-income status, dual credit had a positive effect on credential completion for both low-income and non low-income white/Asian students. Low-income white/Asian dual credit participants were 10.5 percentage points more likely than low-income white/Asian non-participants to complete a credential at any KCTCS institution within three years. Non low-income white/Asian dual credit participants were 8.0 percentage points more likely to complete a credential than non low-income, white/Asian non-participants. Both increases were statistically significant. Dual credit had no effect on low-income and non low-income URM students.

Subgroup	Non-Dual Credit	Dual Credit	Difference
Model 4: Interaction between dual credit, race and income			
URM & Low-Income			
No & No	0.324 (0.015)	0.404 (0.016)	0.080*
95% Confidence Intervals	[0.294, 0.354]	[0.373, 0.434]	
No & Yes	0.250 (0.012)	0.355 (0.014)	0.105*
95% Confidence Intervals	[0.226, 0.273]	[0.327, 0.383]	
Yes & No	0.280 (0.053)	0.381 (0.060)	0.101
95% Confidence Intervals	[0.176, 0.383]	[0.263, 0.500]	
Yes & Yes	0.257 (0.035)	0.307 (0.034)	0.050
95% Confidence Intervals	[0.188, 0.326]	[0.237, 0.378]	

Note. For all tables, covariates included gender, URM, low-income and high school GPA. The analyses included cohort and institution fixed effects.
Robust standard errors are in parentheses.

$*P \leq .05$.

APPENDIX G

AVERAGE PREDICTED PROBABILITY OF EARNING A FIRST-YEAR GPA EQUAL TO OR GREATER THAN 3.0 ACROSS SUBGROUPS - Academic Pathway Students

Gender

Although both female and male dual credit participants were more likely to earn a first-year GPA equal to or greater than 3.0 than non-participants, the increases were not statistically significant. On average, the predicted probability of females earning a first-year GPA equal to or greater than 3.0 was 38.9% for dual credit participants and 34.9% for non-participants. The probability of males earning a first-year GPA of at least 3.0 was 37.0% for participants and 33.2% for non-participants.

Additionally, female students were more likely than male students to obtain a first-year GPA equal to or greater than 3.0, with or without dual credit. However, since the differences were not statistically significant, dual credit had no effect on the first-year GPA of males or females.

Subgroup	Non-Dual Credit	Dual Credit	Difference
Model 1: Interaction between dual credit and gender			
Gender			
Female	0.349 (0.010)	0.389 (0.010)	0.040
95% Confidence Intervals	[0.329, 0.368]	[0.369, 0.409]	
Male	0.332 (0.015)	0.370 (0.015)	0.038
95% Confidence Intervals	[0.304, 0.360]	[0.340, 0.399]	
Difference	0.017	0.019	

Race

Dual credit had a positive impact on the first-year GPA of white/Asian students only. No effect was found for URM students. White/Asian dual credit participants were 4.3 percentage points more likely to earn a first-year GPA equal to or greater than 3.0 than white/Asian non-participants. The average predicted probability of white/Asian dual credit participants was 39.5%, compared to 35.0% for white/Asian non-participants. Although dual credit increased the probability of URM students earning a first-year GPA of at least 3.0, the 0.6 of a percentage-point difference was not statistically significant.

White/Asian students were more likely than URM students to earn a first-year GPA equal to or greater than 3.0, with or without dual credit. The gap between non-participants was not statistically significant; between participants, the 9.7 percentage-point difference was statistically significant.

Subgroup	Non-Dual Credit	Dual Credit	Difference
Model 2: Interaction between dual credit and race			
URM			
Yes	0.290 (0.025)	0.296 (0.024)	0.006
95% Confidence Intervals	[0.240, 0.340]	[0.249, 0.343]	
No	0.350 (0.009)	0.393 (0.009)	0.043*
95% Confidence Intervals	[0.333, 0.367]	[0.375, 0.411]	
Difference	0.060	0.097*	

Income

Dual credit had a positive impact on the first-year GPA of non low-income students only. No effect was found for low-income students. Non-low-income dual credit participants were 8.1 percentage points more likely to earn a first-year GPA equal to or greater than 3.0 than non-low-income non-participants. On average, a non-low-income non-participant had a 38.0% chance of earning a first-year GPA of at least 3.0, while a non-low-income participant had a 46.1% chance. Although dual credit increased the chance of earning a 3.0 or higher for low-income participants, the increase of 1.3 percentage points wa not statistically significant.

Additionally, students from non low-income families were more likely to earn a first-year GPA of 3.0 or higher than students from low-income families, with or without dual credit. Both gaps were found to be statistically significant. Without dual credit, the gap was 5.4 percentage points; with dual credit, the gap increased to 12.2 percentage points. Dual credit widened the gap in first-year GPA between low-income and non low-income students.

Subgroup	Non-Dual Credit	Dual Credit	Difference
Model 3: Interaction between dual credit and income			
Low-Income			
Yes	0.326 (0.011)	0.339 (0.010)	0.013
95% Confidence Intervals	[0.305, 0.347]	[0.320, 0.359]	
No	0.380 (0.013)	0.461 (0.014)	0.081*
95% Confidence Intervals	[0.354, 0.406]	[0.432, 0.489]	
Difference	0.054*	0.122*	

Income and Race

Among all four noted subgroups related to URM and low-income status, dual credit had a positive effect on the first-year GPA of non low-income, white/Asian students only. Non low-income white/Asian dual credit participants were 8.0 percentage points more likely than non low-income white/Asian non-participants to earn a first-year GPA of at least 3.0. The differences between dual credit participants and non-participants for the other three subgroups were not statistically significant.

Subgroup	Non-Dual Credit	Dual Credit	Difference
Model 4: Interaction between dual credit, race and income			
URM & Low-Income			
No & No	0.388 (0.014)	0.468 (0.015)	0.080*
95% Confidence Intervals	[0.361, 0.415]	[0.439, 0.497]	
No & Yes	0.332 (0.011)	0.350 (0.011)	0.028
95% Confidence Intervals	[0.310, 0.354]	[0.329, 0.371]	
Yes & No	0.310 (0.046)	0.407 (0.055)	0.097
95% Confidence Intervals	[0.219, 0.400]	[0.300, 0.514]	
Yes & Yes	0.276 (0.030)	0.250 (0.025)	0.026
95% Confidence Intervals	[0.217, 0.334]	[0.201, 0.300]	

Note. For all tables, covariates included gender, URM, low-income, college underpreparedness and first-year GPA. The analyses included cohort and institution fixed effects.
Robust standard errors are in parentheses. 95% Confidence Intervals were reported.

$P \leq .05$.

APPENDIX H

AVERAGE PREDICTED PROBABILITY OF COMPLETING A CREDENTIAL AT ANY KCTCS CAMPUS OR TRANSFERRING WITHIN THREE YEARS ACROSS SUBGROUPS - Academic Pathway Students

Gender

Dual credit had a positive impact on credential completion or transfer to a four-year institution within three years for both male and female students. Dual credit had a greater effect on female students than male students. Female dual credit participants were 12.1 percentage points more likely to complete a credential or transfer than female non-participants, while the gap between male dual credit participants and non-participants was 9.5 percentage points. Both gaps were statistically significant.

Without dual credit, male students were slightly more likely than female students to complete a credential or transfer to a four-year public institution within three years. However, with dual credit, female students had a similar likelihood to male students. The average predicted probability of completing a credential or transferring for female dual credit participants and non-participants was 39.9% and 27.8%, respectively. For male students, the average predicted probability was 39.5% for participants and 30.0% for non-participants. Dual credit significantly narrowed the gap between male and female students, from 2.2 percentage points to 0.4 percentage points. Neither gap was statistically significant.

Subgroup	Non-Dual Credit	Dual Credit	Difference
Model 1: Interaction between dual credit and gender			
Gender			
Female	0.278 (0.009)	0.399 (0.010)	0.121*
95% Confidence Intervals	[0.259, 0.296]	[0.378, 0.419]	
Male	0.300 (0.014)	0.395 (0.016)	0.095*
95% Confidence Intervals	[0.272, 0.328]	[0.363, 0.426]	
Difference	0.022	0.004	

Race

Dual credit had a positive effect on credential completion or successful transfer within three years for white/Asian students only. There was no effect for URM students. White/Asian dual credit participants were 11.6 percentage points more likely to cmplete a credential or transfer within three years than white/Asian non-participants. On average, a white/Asian dual credit participant had a 40.2% chance of completion or transfer, compared to a 28.6% chance for an otherwise comparable white/Asian non-participant. With or without dual credit, white/Asian students had a greater likelihood of completion or transfer, but neither gap was statistically significant.

Subgroup	Non-Dual Credit	Dual Credit	Difference
Model 2: Interaction between dual credit and race			
URM			
Yes	0.274 (0.025)	0.365 (0.026)	0.091
95% Confidence Intervals	[0.226, 0.322]	[0.313, 0.416]	
No	0.286 (0.008)	0.402 (0.009)	0.116*
95% Confidence Intervals	[0.269, 0.302]	[0.383, 0.420]	
Difference	0.005	0.037	

Income

Dual credit had a positive effect on credential completion or successful transfer with three years for both low-income and non low-income students. On average, low-income dual credit participants were 10.0 percentage points more likely to complete a credential at any KCTCS institution or transfer to a public four-year institution than low-income non-participants. The gap between non low-income dual credit participants and non-participants was 13.4 percentage points. Dual credit had a greater effect for non low-income students than for low-income students.

With or without dual credit, non low-income students were more likely to complete a credential or transfer. The average predicted probability of completion or transfer for non low-income students was 44.4% with dual credit and 31.0% without dual credit. The average predicted probability of completion or transfer for low-income students was 37.1% with dual credit and 27.1% without dual credit. Without dual credit, the gap of 3.9 percentage points between low-income and non low-income students was not statistically significant. With dual credit, the gap of 7.3 percentage points was statistically significant.

Subgroup	Non-Dual Credit	Dual Credit	Difference
Model 3: Interaction between dual credit and income			
Low-Income			
Yes	0.271 (0.011)	0.371 (0.013)	0.100*
95% Confidence Intervals	[0.252, 0.290]	[0.350, 0.392]	
No	0.310 (0.015)	0.444 (0.015)	0.134*
95% Confidence Intervals	[0.284, 0.336]	[0.416, 0.473]	
Difference	0.039	0.073*	

Income and Race

Among all four noted subgroups related to URM and low-income status, dual credit had a positive effect on credential completion or transfer for both low-income and non low-income white/Asian students. Low-income white/Asian dual credit participants were 10.3 percentage points more likely than low-income, white/Asian non-participants to complete a credential at any KCTCS campus or transfer to a public four-year institution within three years. Non low-income white/Asian dual credit participants were 13.4 percentage points more likely than similar non-participants to complete or transfer. Both increases were statistically significant. Dual credit had no effect on low-income and non low-income URM students.

Subgroup	Non-Dual Credit	Dual Credit	Difference
Model 4: Interaction between dual credit, race and income			
URM & Low-Income			
No & No	0.316 (0.014)	0.450 (0.015)	0.134*
95% Confidence Intervals	[0.289, 0.343]	[0.421, 0.480]	
No & Yes	0.270 (0.010)	0.373 (0.012)	0.103*
95% Confidence Intervals	[0.249, 0.290]	[0.351, 0.396]	
Yes & No	0.244 (0.042)	0.374 (0.052)	0.130
95% Confidence Intervals	[0.162, 0.325]	[0.272, 0.477]	
Yes & Yes	0.284 (0.030)	0.352 (0.030)	0.068
95% Confidence Intervals	[0.226, 0.342]	[0.294, 0.411]	

Note. For all tables, covariates included gender, URM, low-income, college underpreparedness and first-year GPA. The analyses included cohort and institution fixed effects.
Robust standard errors are in parentheses. 95% Confidence Intervals were reported.

$*P \leq .05$.

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