UNIVERSITY of DENVER

COLORADO EVALUATION AND ACTION LAB

Does Concurrent Enrollment Improve College Access, Success, Time-To-Degree and Earnings?

A Quasi-Experimental Analysis of Colorado Students

TECHNICAL REPORT

Report Highlights:

This study shows Concurrent Enrollment to be highly effective in increasing college graduation for high school students in Colorado. The sample included students across different demographics and academic abilities. Compared to students who did not take college courses while in high school, students who took Concurrent Enrollment courses were more likely to: (1) Attend college within one year following high school graduation, (2) Earn a college degree on time or early, and (3) Have higher workforce earnings after five years.

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Report Number: 19-15B **Date:** September 2020

Acknowledgements

This report was funded via two separate funding agencies. The study assessing postsecondary outcomes (access, persistence, and completion of "any degree") was funded by a grant (R305H170049) from the Institute of Education Sciences (IES) of the U.S. Department of Education. The contents do not necessarily represent the policy of the Institute or the U.S. Department of Education, and readers should not assume endorsement by the federal government. The IES-funded study is registered with the Registry of Efficacy and Effectiveness Studies (1705.1v1).

In addition, the study assessing time-to-degree and wage outcomes was funded by a grant from the Colorado Evaluation and Action Lab at the University of Denver. The findings and conclusions reported here do not necessarily represent the official positions or policies of the funder or the University of Denver. The Lab-funded study is registered with the Open Science Framework (osf.io/cqm7t).

This research was conducted through a partnership between the Colorado Department of Higher Education (CDHE), Institute of Behavioral Science at the University of Colorado Boulder, Colorado Evaluation and Action Lab, APA Consulting, LLC and the National Center for Higher Education Management Systems (NCHEMS), with funding from the Institute of Education Sciences (R305H170049). The following individuals assisted with the research and provided feedback on drafts: Michael Vente, Dr. Lauren Ramsay, Dr. Kim Poast, and Maggie Yang of CDHE; Dr. Robert Reichardt of APA Consulting, LLC; and Dr. Rachel Christeson of NCHEMS; and Andy Tucker of the Colorado Department of Education. We also would like to acknowledge Dr. Beth Bean, Policy Director in the Office of Governor Jared Polis at the State of Colorado, who helped secure and launch the IES study while in her role as former Chief Strategy and Research Officer at CDHE. This report does not reflect the priorities of the Colorado Department of Higher Education (CDHE) or the Colorado Department of Education (CDE) for allocating funding or other resources. Any requests for funding or statutory changes will be developed in collaboration with the governor's office and communicated to the legislature through the regular budget and legislative processes.

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Suggested Citation

Buckley, P., Pendergast, P., Klopfenstein, K. (September 2020). Does Concurrent Enrollment improve college access, success, time-to-degree, and earnings? A quasi-experimental analysis of Colorado students. Technical report (Report No. 19-15B). Denver, CO: Colorado Evaluation and Action Lab at the University of Denver.

Executive Summary

The term dual enrollment refers to the broad array of programs available to high school students that allow them to take college-level courses for credit. Launched in the 2009-10 academic year, the Concurrent Enrollment Programs Act (C.R.S. §22-35-101 et seq.) created Colorado's present state-funded dual enrollment program, defined as "the simultaneous enrollment of a qualified student in a local education provider and in one or more postsecondary courses, including academic or career and technical education courses, which may include course work related to apprenticeship programs or internship programs, at an institution of higher education." High school students that participate in the state's Concurrent Enrollment program may enroll tuition-free in postsecondary courses and earn college credits that are transferable to any Colorado public university. We preregistered a protocol with the Registry of Efficacy and Effectiveness Studies (1705.1v1) and Open Science Framework (osf.io/cqm7t) before conducting analyses and used a two-stage, matched design to follow students who graduated from Colorado high schools between 2010-2011 and 2014-2015 to evaluate Colorado's Concurrent Enrollment program. Students' progress was tracked starting in 11th grade through their postsecondary education and into the labor force using data managed by several Colorado state agencies. The treatment was defined as 11th and 12th grade students who attempted Concurrent Enrollment credits while attending a high school with "ample" dual enrollment opportunities. Treatment students were compared to a business-as-usual comparison group of 11th and 12th grade students who did not attempt any dual enrollment credits while attending otherwise similar high schools offering "few" dual enrollment opportunities.

Outcomes show students who participated in Concurrent Enrollment enrolled in college within one year of their expected high school graduation at higher rates than students who did not take college classes in high school (*OR* = 3.06). Seventy-seven percent of students in the treatment group matriculated within one year of their expected high school graduation date compared to 52 percent of students in the comparison group. For students that matriculated within one year of their expected high school graduation, compared to control students, treatment students showed higher rates of persistence (*OR* = 1.30) and completion of "any" degree (*OR* = 2.08). For those who matriculated, 82 percent of students in the treatment group persisted from the fall of their first year to the fall of their second year compared to 77 percent of the control group. In addition, 37 percent of the treatment group that matriculated within one year of their expected high school graduation earned a credential compared to 22 percent of the control group.

Findings are also positive and in favor of the treatment group, with medium-to-large effect sizes detected for on time-completion, as measured by earning a two-year credential in two years (*OR* = 2.87) and earning a four-year degree in four years (*OR* = 1.61). For students who matriculated to college within one year of their expected high school graduation date, 13 percent of students in the treatment group earned a two-year degree or credential within two years compared to 5 percent of students in the control group. In addition, 26 percent of students in the treatment group earned a four-year degree in four years compared to 18 percent of students in the control group. Five years after their expected high school graduation date, treatment students had (on average) significantly higher earnings across four quarters compared to control students (*g* = .079; $15,767.45 in treatment vs. $14,377.98 in control).

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Background

The term dual enrollment refers to the broad array of programs available to high school students that allow them to take college-level courses for credit. Dual enrollment creates multiple pathways to college by enabling high school students to take: (1) selected academic courses on college campuses; (2) college-led academic courses at their high school; or, (3) a hybrid of both (Puyear & Mills, 2001). In addition, some dual enrollment programs permit students to take post-secondary level career and technical education courses (Estacion, Cotner, D'Souza, Smith, & Borman, 2011). Bailey & Karp (2003) describe three types of dual enrollment programs: (1) stand-alone college courses available to high school students, referred to as a singleton program; (2) a comprehensive program that offers multiple college courses typically during the junior and senior year of high school; and (3) an enhanced comprehensive program that integrates college-level courses with support services. Dual enrollment students might participate in a singleton program or they could receive a more comprehensive program that, for some, leads to an associate's degree upon graduating from high school as is the model with early college high schools (Edmunds et al., 2012, 2017; Haxton et al., 2016; Song & Zeiser, 2019). The High School Longitudinal Study of 2009 (HSLS:09) is a nationally representative sample of more than 23,000 ninth graders surveyed in 2009 and again in 2016 (along with a review of high school transcript data collected in 2009 and 2013). According to these data, most students who took dual enrollment courses took them at their own high school (80 percent). Less common locations were at a college campus (17 percent), online (eight percent), and a high school other than the students' own (six percent) (Shivji & Wilson, 2019). Thus, most dually enrolled students do not experience a true college experience with high school students and college students in the same classroom. Nevertheless, dual enrollment instructors are required to meet the faculty qualifications for an adjunct community college instructor in most states.

Dual enrollment is unique to other credit-based postsecondary transition programs such as Advanced Placement (AP) and International Baccalaureate (IB) in that college credit is determined by a student's overall course grade. Students who pass the course receive college credit, whereas AP and IP programs require that students pass a standardized test to receive college credit. In addition, AP and IB provide course materials and guidelines for high schools to follow, whereas the curriculum used in dual enrollment, though the same as offered at a college, varies across programs.

Dual enrollment has been implemented in all fifty states over the past several decades (Plucker, Chien, & Zaman, 2006; Bailey, Hughes, & Karp, 2002), though it has recently risen in popularity. Between 2002-03 and 2010-11, concurrent enrollment programs grew over seven percent annually, with 12 percent growth seen in schools serving a high proportion of ethnic or racial minority students (Thomas, Marken, Gray, & Lewis, 2013). Based on data from the National Center for Education Statistics (NCES), Fink, Jenkins, & Yanagiura (2017) estimated that the number of high school dual enrollment students grew 67 percent from 2002 to 2010, to a total of nearly 1.4 million in the 2010-11 academic year, the most recent year for which NCES reported national data on dual enrollment students. Nationally, 15 percent of fall 2010 community college entrants were high school dual enrollment students; this proportion ranged from one percent in Georgia to 34 percent in Kentucky (Fink, Jenkins, & Yanagiura, 2017). These numbers have likely grown since then. Based on a review of 2019 legislative activity concerning dual enrollment access, at least 108 bills were introduced in 37 states and 36 were enacted across 23 states (Pompelia, 2020). Funding varies by state. That is, some states offer free (e.g., Florida), while others offer discounted (e.g., Texas and Utah) college tuition and fees for high school students who take college-level courses[1].

Colorado is currently one of the top states in the nation for concurrent enrollment participation with more than one in every three (i.e., 35 percent) 11th and 12th graders in public high schools in Colorado dually enrolled (Colorado Department of Higher Education & Colorado Department of Education, 2019). Colorado has 178 K-12 school districts serving 889,006 students, 45.5 percent of whom are minority and 41.8 percent of whom are eligible for free and reduced lunch (FRL; a proxy for low-income status). Colorado also has 28 public institutions of higher education, including thirteen four-year public institutions serving 254,981 students (34 percent of whom are minority) and fifteen two-year public institutions serving 88,505 students (41 percent of whom are minority).

Concurrent Enrollment (capitalized in all usages) refers only to Colorado's statewide programs created by House Bill 09-1319 and detailed in the Concurrent Enrollment Programs Act (C.R.S. §22-35-101 et seq.), defined as "the simultaneous enrollment of a qualified student in a local education provider and in one or more postsecondary courses, including academic or career and technical education courses, which may include course work related to apprenticeship programs or internship programs, at an institution of higher education." High school students that participate in the state's Concurrent Enrollment program may enroll tuition-free in postsecondary courses and earn college credits that are transferable to any Colorado public university. Since passage of this legislation in May 2009, dual enrollment has grown dramatically, from 9,349 Colorado high school students in 2010-11 to 45,787 students who participated in dual enrollment programs of any type in the 2017-2018 academic year (Colorado Department of Higher Education & Colorado Department of Education, 2019). In 2019, Colorado passed additional Concurrent Enrollment legislation (SB19-176), which requires that Concurrent Enrollment be offered at no tuition costs to qualified students (Pompelia, 2020). The present study serves to inform Colorado's understanding of the state's Concurrent Enrollment program in supporting college matriculation and persistence, as well as a driver of efficiency in getting to an on-time postsecondary credential and long-term improved earnings. This research expands on several earlier state-wide evaluations of Concurrent Enrollment in Colorado (Dickhoner, 2017; Jorgenson, 2013; Nash, 2015) and is (to our knowledge) the first to examine dual enrollment outcomes beyond postsecondary education and into the workforce. ***See Appendix A for a complete history of dual enrollment programs in Colorado.***

Methods

Research Questions

Confirmatory research tests a priori alternative hypotheses and exploratory research determines whether any interesting posteriori hypotheses might be generated from the data set (Jaeger & Halliday, 1998; Tukey, 1980). This study poses several questions, outlined below, and divided into exploratory and confirmatory research.

To assess college access and success, before conducting any analyses we preregistered with the Registry of Efficacy and Effectiveness Studies (1705.1v1) the following confirmatory research questions: (1) Is

[1] For information on how different states fund dual enrollment policies, see: (1) Who is primarily responsible for paying tuition: http://ecs.force.com/mbdata/MBQuest2RTanw?Rep=DE1904; (2) How state funds participating high schools: http://ecs.force.com/mbdata/MBQuest2RTanw?Rep=DE1910; and (3) How state funds participating postsecondary institutions: http://ecs.force.com/mbdata/MBQuest2RTanw?Rep=DE1911.

participation in Concurrent Enrollment related to college access, as measured by matriculation to college one year post-expected date of high school graduation and (2) college credits attempted one year post-expected date of high school graduation? (3) For students who matriculate to college within one year of their expected high school graduation date, is participation in Concurrent Enrollment related to college success, as measured by persistence from year 1 to year 2 and (4) completion of any postsecondary credential? Our exploratory research questions focused on moderation effects of student characteristics on these same questions: Do the relationships between participation in Concurrent Enrollment and college access and success vary for students from different backgrounds? Are these relationships stronger for students from low-income families? For non-white/non-Asian students?

Confirmatory questions related to on-time completion and earnings were preregistered with the Open Science Framework (osf.io/cqm7t) prior to conducting analyses. The sample for this set of questions focused on students who matriculated to college within one year of their expected high school graduation date and included the following: (1) What is the impact of Concurrent Enrollment on earning a credential within two years of expected high school graduation, for those who enrolled immediately in two-year colleges? (2) What is the impact of Concurrent Enrollment on earning a four-year degree within four years of expected high school graduation date, for those who enrolled in a four-year college immediately or transferred from a two-year school within two years? (3) What is the impact of Concurrent Enrollment on earnings five years after expected high school graduation date? Exploratory questions interacted condition by race, income, gender, and achievement level and then examined each confirmatory outcome. The earnings confirmatory research question also included degree attainment as a moderator. Additional exploratory questions included: (4) What is the impact of Concurrent Enrollment on earning a four-year degree within three years of expected high school graduation date, for those who enrolled in a four-year college immediately or transferred from a two-year school within two years? How does this differ by race, income, gender, achievement level, and credential/degree attainment?

Sample

This project uses a retrospective, quasi-experimental design (QED) relying on secondary analysis of historical data. We conducted a cohort-based longitudinal study that follows 11th grade students who had an expected high school graduation date between 2010-2011 and 2014-2015. Cohorts were deemed eligible for inclusion in the study based on the school year in which students were in 11th grade. Though the 2009 legislation made all high school students eligible to participate in Concurrent Enrollment courses in grades 9 through 12, most dual enrollment courses in Colorado are offered to 11th and 12th grade students. Statewide, 35 percent of all 11th and 12th graders in public high schools in Colorado participated in dual enrollment in 2017-2018 (Colorado Department of Higher Education & Colorado Department of Education, 2019). Given the data available for the period of the present study, five cohorts were constructed – starting when students were in 11th grade and defined by their expected high school graduation year. Table 1 presents the study's cohorts.

Table 1: Cohorts

Cohort	11th Grade School Year	12th Grade School Year (Expected HS Graduation)
1: Cohort 2011	2009 – 2010	2010 – 2011
2: Cohort 2012	2010 – 2011	2011 – 2012
3: Cohort 2013	2011 – 2012	2012 – 2013
4: Cohort 2014	2012 – 2013	2013 – 2014
5: Cohort 2015	2013 – 2014	2014 – 2015

Note: HS – High School

Research Design

While randomly assigning subjects to condition is the most effective approach for eliminating selection bias (Shadish, Cook, & Campbell, 2002), efforts to do so are limited by many forces, including widespread availability and the ethical and political issues associated with granting some schools and students access while denying others (May et al., 2015). Given the real-world challenges of randomly assigning participants to condition with a universal policy (such as the one we were evaluating), alternatively we employ a quasi-experimental design study using multiple statistical techniques to adjust for pre-existing differences between students who participated in Concurrent Enrollment and students who did not take any dual enrollment courses while in high school. To address both selection bias and differences in opportunity due to the inequitable availability of dual enrollment at different types of schools, we follow a 2-stage matching design that included, first, crude matching at the school level and, second, propensity score matching (PSM; Rosenbaum, 2010; Rosenbaum & Rubin, 1983) at the student level.

Matching Process

We decided that it was important, *a priori*, for any matching strategy to account for the fact that some schools offer greater opportunity for dual enrollment than others, and that this opportunity impacts not only the likelihood of students selecting into the treatment, but also schools' likelihood of fostering beneficial college and postsecondary outcomes for students. Therefore, we defined a school-level treatment group for schools offering "ample" dual enrollment opportunities than those that offer "few". Groups were identified at the school-level using the state median number of dual enrollment credits attempted per enrolled student in 2008-09 (the baseline year), with "ample" opportunities represented by schools at or above the state median and "few" reflecting schools below the state median[2]. At the student level, treatment was defined as attempting any Concurrent Enrollment credits in the 11th or 12th grade while attending a school with "ample" dual enrollment opportunities. Treatment students were compared to a business-as-usual comparison group of 11th and 12th grade students who did not attempt any dual enrollment credits while attending otherwise similar high schools offering "few" dual enrollment opportunities. Baseline equivalence at both the school and student levels was established using Hedges *g* (with pooled standard deviations) for continuous variables and Cox's *d* for dichotomous measures, as

[2] The state median number of dual enrollment hours attempted per-capita (i.e., per student) in 2008-09 (the baseline year) was 0.1841, calculated by determining the mean number of dual enrollment hours earned (total dual enrollment hours attempted in 2008-09 divided by the school sample size in 2008-09) per school (n = 292 schools), and then determining the median of these 292 schools.

recommended by the What Works Clearinghouse (WWC) Version 4.1 Standards Handbook for reviewing education studies (USDOE, 2020). All data management and analyses were performed using R version 3.3.1 (R Core Team, 2017), with the R package “MatchIt” (Ho et al., 2011) used for both stages of the matching process. Distance measures were calculated using logistic regression for most variables rather than exact matching on covariates (with some exceptions noted below).

In the first step of the matching process, dual-enrollment rich schools were crudely matched to their nearest neighbor, dual-enrollment poor schools on: a) proportion of students qualified for free- or reduced-price lunch (FRL), b) state-mandated average ninth grade reading achievement test scores reported by the Colorado Department of Education (CDE), and c) college-going rates, which are calculated by the Colorado Department of Higher Education and represent the percent of students who enrolled in college the fall after graduating from high school. In addition, high schools were exactly matched on urbanicity (urban/suburban vs. rural) since urbanicity strongly predicts dual enrollment offerings. That is, in Colorado, rural schools lean heavily on Concurrent Enrollment because they do not have the student numbers to support alternative programs like Advanced Placement (AP) and International Baccalaureate (IB). Given this structural difference between rural and non-rural schools, we matched dual enrollment rich rural schools only with dual enrollment poor rural schools, and dual enrollment rich non-rural schools only with dual enrollment poor non-rural schools. From the initial sample of 292 eligible schools (see Figure 2), 172 matched schools were retained (86 dual enrollment rich, 86 dual enrollment poor).

We also determined *a-priori* that, if baseline equivalence was not achieved between all students attempting Concurrent Enrollment credits at the matched dual enrollment rich schools (treatment students) and all students who did not attempt dual enrollment credits at the matched dual enrollment poor schools (comparison students), we would use a second stage of one-to-one, nearest neighbor propensity score matching (PSM) without replacement (yielding equal control and treatment student group sizes) to match students across conditions by cohort, FRL qualification, ninth grade reading achievement state-mandated test scores reported by CDE, minority status, and English language learner (ELL) status. Consistent with What Works Clearinghouse (WWC) standards as outlined in the *Transition to College Review Protocol* (USDOE, 2019), we used a cutoff of better than 0.25 standard deviations for baseline equivalence on ninth grade standardized reading scores and FRL qualification for each matched sample. All matching variables were also included as controls in analytic models to capture residual sources of observable variation remaining between the study groups. Tables 3 and 4 (presented in the Results section) display the baseline equivalence statistics for all samples in section 3 (i.e., results).

Because there remained sizeable baseline differences in student standardized test scores after school-level matching ($g = 0.35$), we proceeded with student-level matching for those enrolled in the remaining schools on: a) ninth grade state standardized reading test score; b) FRL qualification (1 = FRL, 0 = not FRL); c) Under-represented minority status (1 = all others; 0 = white or Asian); d) English language learner (ELL) status (1 = ELL, 0 = not ELL); and, e) school-level propensity scores from the previous matching model. While the sample was already restricted to comparable schools during the school-level match, the retained schools still displayed a range of propensity scores. School-level propensity scores were thus included in the student-level match so that students were matched not only to similar students, but to students with similar school-level characteristics that determined access and opportunity for treatment, without requiring that they could only be matched to similar students in their school’s exact matched pair. Additionally, students were exactly matched on their expected high school graduation cohort to minimize the risk of unequal exposure (i.e., time available to attain each outcome) driving any group differences. In the samples assessing on-time degree attainment and earnings, we also examined whether students were roughly equivalent at baseline on gender (1 = female, 0 = male) and included gender as an additional matching covariate when further matching was needed.

We excluded treatment and potential comparison youth with missing data on the key matching variables. Furthermore, if baseline equivalence was not achieved on key matching variables in the full analytic sample, treatment youth with the least similar matched comparisons available were omitted from the sample until baseline equivalence was achieved. For each outcome, we re-assessed the baseline equivalence of the analytic samples and proceeded with drawing a new, matched sample from the full, eligible population of students enrolled in the matched schools only if baseline equivalence was not maintained. If it was maintained, we simply proceeded to the next analysis with a subsample of students from the previous matched sample that were also eligible for the new outcome analysis, using listwise deletion to remove participants if outcome variables were missing. Most commonly, this occurred when there was insufficient follow-up data for later cohorts to attain the outcome (such as 4-year degree attainment or earnings).

In summary, treatment and comparison students were never drawn from the same school, and many potential treatment and comparison students were not included in our analytic samples because of design decisions. By selecting comparison students from schools offering "few" dual enrollment opportunities, and only retaining treatment students that attended schools with "ample" opportunities for dual enrollment, we tried to minimize the potential confound of comparison students self-selecting out of dual enrollment courses. Nonetheless, we acknowledge that these improvements in internal validity, which are rare in studies using PSM, come at some cost to external validity through the loss of a substantial portion of the baseline sample.

Inclusion and Exclusion Criteria

The evaluation-specific inclusion criteria were as follows: (1) The record had to be linked to a school with 2008-09 baseline school-level data, meaning the school was in operation in 2008-2009, the study baseline year. This is the year prior to establishment of Concurrent Enrollment via HB 09-1319. (2) The record had to be linked to a traditional school in which individuals earned a high school degree (or GED), typically done in four years (that is, the expected high school graduation date was in four years) because this is how most students experience dual enrollment education in Colorado. The definition of "traditional school" included charter and innovation schools that offered high school degrees. And, (3) The record had to be linked to a school with a sample size of 11th and 12th grade students that included 70 or more students (per school), as "treatment" was defined first at the school level and then at the student level and we needed a minimum number of students who were eligible to take dual enrollment courses.

Whole schools or subsets of students within schools were excluded when they were associated with three types of credit transition programs separate from Colorado's state-funded Concurrent Enrollment program:

- *Early college high schools*: Students can attend a Colorado state board-approved high school that, through partnerships with institutions of higher education, enable them to earn 60 credits and an associate degree (or a specified number of college credits). We decided to focus on dual credit programs offered through traditional high schools because that is how most students experience dual enrollment in Colorado. As such, early colleges are exempt from Colorado's Concurrent Enrollment act and excluded from this study.

- *ASCENT (Accelerating Students through Concurrent ENrollmenT)*: Students who have completed at least 12 credit hours of postsecondary coursework prior to completion of their 12th grade year may be eligible for the ASCENT Program. They remain students in their high school for one year following their 12th grade year, and the school receives ASCENT-specific per-pupil state funding that it uses to pay their college tuition at the resident community college rate. Students receive their high-school diplomas at the end of their ASCENT year. We excluded ASCENT students (though not the high schools they attend) because this is not the way most students in Colorado experience dual enrollment.

- *"Other" high school dual enrollment program:* Students taking a dual enrollment course outside Colorado's state-funded Concurrent Enrollment program. Programs identified by the state of Colorado as "other" dual enrollment are administered directly by postsecondary institutions and do not fall under the state's statutory definition of Concurrent Enrollment. Students can receive college-level credit through these other programs, but they and their families may be required to pay for courses. Additionally, these completed courses are not required to transfer and/or apply to programs of study at other Colorado public institutions of higher education (Colorado Department of Higher Education, & Colorado Department of Education, 2019). As such, we exclude these students (although not the high schools they attend).

Data Sources

Matching, independent, and dependent variables were measured using administrative data that originated from four sources: (1) Colorado Department of Education (CDE) provided student-level demographic and 9th grade achievement data. School-level data from CDE were used to identify comparison schools. (2) Colorado Department of Higher Education (CDHE) provided student-level Concurrent Enrollment course-taking information as well as matriculation and completion for in-state colleges and universities. (3) National Student Clearinghouse (NSC) provided student-level matriculation and completion data for out-of-state colleges and universities. And (4) Colorado Department of Labor and Employment (CDLE) provided student-level quarterly earnings through their unemployment insurance data. This work was made possible by integrating data from CDE, CDHE, and CDLE under CDHE's statutory authority from CRS 22-35-112 mandating the annual Concurrent Enrollment report, CRS 23-1-113 mandating the annual Postsecondary Progress and Success of High School Graduates report, and CRS 23-1-135 mandating the annual Return on Investment report.

In correspondence with ethical standards for research, this research protocol has been reviewed and approved by the University of Colorado at Boulder's Institutional Review Board (IRB). CDHE linked all data sets and provided researchers from the University of Colorado Boulder with masked student-level data sets. The de-identified electronic data linking student-level secondary with postsecondary and wage records supplied by CDHE were stored on an encrypted server at CU Boulder using password protected computers accessible only to CU Boulder authors. Student data were strictly confidential. That is, this research used existing student data files, but this information was recorded, managed and provided in such a manner that all personally identifiable information related to data collected for students could not be identified, directly or indirectly, through identifiers. Upon completion of this study, the data is to be destroyed pursuant to the study authors' IRB requirements.

Cohorts and Outcome Measures

We examined a total of seven confirmatory questions among four groups of dependent variables in this study related to college matriculation, persistence, earning any degree, on-time completion (i.e., earning a 2-year degree in two years or a 4-year degree in four years), and earnings. Table 2 describes how these outcomes were analyzed using different numbers of cohorts based on the length of required follow-up period.

Table 2: Confirmatory Outcomes Assessed by Cohort

Cohort (EHSG Year)	***Matriculation*** within 1 YR of EHSG	***Credits Attempted*** within 1 YR of EHSG	Matriculate within 1 YR of EHSG: (1) ***persistence*** YR1-YR2, (2) ***"Any" Degree***	On-time completion: Matriculate within 1 YR of EHSG, ***2 YR Degree in 2 YRs***	On-time completion: Matriculate to College within 1 YR of EHSG, ***4 YR Degree in 4 YRs***	***Earnings*** within 5 years of EHSG
2011	X	X	X	X	X	X
2012	X	X	X	X	X	X
2013	X	X	X	X	--	X
2014	X	X	X	X	--	--
2015	X	X	--	--	--	--

Note: EHSG – Expected high school graduation date. RQ – Research Question.

Postsecondary data encompass academic year (AY) 2011-12 though AY 2015- 2016. Earnings data encompass calendar year (CY) 2011 through CY 2018.

Matriculation and College Credits Attempted

We coded the first outcome, college matriculation, as a binary variable that indicated whether students (a) enrolled in college within one year (during summer or fall immediately following graduation, or spring of the year after), of expected high school graduation date during the observation period, or (b) did not enroll in college within one year of expected high school graduation date during the observation period. In addition, we coded college access as a continuous variable that captured the number of college credits that students attempted in their first year after expected high school graduation. While credits earned may be a more ideal measure, fewer of our data providers supplied data on the credits that were earned rather than attempted. For the subset that did provide both, there was a significant, moderate correlation ($r = 0.55$) between earned and attempted credits. Since some students did not matriculate within a year of high school graduation, and therefore did not attempt any college credits, they received a "zero" for college credits attempted, though we also conducted and report on the findings for an exploratory analysis in which non-matriculaters were dropped instead, as a robustness check (not pre-registered). In addition, some students matriculated within a year of expected high school graduation date but went to a college out-of-state, in which outcomes were assessed using the National Student Clearinghouse (NSC) dataset. We had to drop these students, as the NSC database does not collect information on college credits attempted.

College Success: Persistence and Completion of Any Degree

We measured college success several ways. Samples for both research questions included only students who matriculated to college within one year of their expected high school graduation during the observation period. First, we coded college success as a binary variable indicating whether students *persisted from year 1 to year 2* (enrolling in the fall of year 2 after enrolling in the summer, fall, or spring of year 1) versus those who did not persist from year 1 to year 2. Students who earned a credential (typically a certificate) prior to year 2 and did not enroll in fall of year 2 are excluded from this analysis. The second college success measure was *whether students completed any certificate, associate, or bachelor degree* versus no certificate, associate or bachelor degree.

Time-To-Degree

Several factors were considered in examining time-to-degree outcomes. That is, students enroll in public two-year community colleges to pursue a variety of goals. Some want to learn specific skills but not necessarily earn a credential. Others may want to obtain an industry-recognized certificate, take remedial courses to prepare for further postsecondary education, or take courses to prepare for transfer to a four-year college or university. In short, the goal for many community college students is not an associate degree, and many who earn an associate degree will seek four-year degrees. Thus, time-to-degree was assessed as a binary variable (yes/no) using different samples, each analyzed with a separate model: (1) *Earning a credential within two years of expected high school graduation date*. This sample included students who initially enrolled in a 2-year institution and excluded students who started at a 2-year college and transferred to a 4-year institution within two years of their expected high school graduation date. Students earning any certificate or associate degree within two years were classified as “yes”, while those who did not were “no”. (2) *Earning a four-year degree within four years of expected high school graduation date*. This sample included students who initially enrolled in a 4-year institution as well as those who enrolled in a 2-year college and transferred to a 4-year institution within two years of their expected high school graduation date. In addition, the sample included those who initially enrolled in a 2-year college, earned a credential, and then enrolled immediately in a 4-year institution. Students who earned a 4-year degree within four years of their expected high school graduation were coded as “yes”, and those who did not were “no.”

Earnings

Both the Colorado Department of Higher Education (CDHE) and Colorado Department of Labor and Employment (CDLE) data sets provide social security numbers (SSN), which allows the departments to link data and examine earnings for students who attended a postsecondary institution in Colorado. However, the Colorado Department of Education (CDE) data set does not contain SSN. Thus, given the availability of data for the present study, the only opportunity to identify earnings outcomes for secondary students was for cases in which the student matriculated to college. For this reason, the earnings analysis was limited to students who attempted at least one postsecondary course within a year of their expected high school graduation. Also, the sample evaluating earnings only included students with an SSN found in the CDLE unemployment insurance (UI) database, which requires them to have been employed in Colorado. The UI data, however, does not include all Coloradans in the labor force, omitting some in agricultural employment, military and federal civilian employment, railroad employment and those who are self-employed. *Earnings five years after students’ expected high school graduation date* was treated as a continuous variable. Quarterly data were summed for the fifth calendar year after a student’s expected high school graduation date. For example, for students whose expected high school graduation date was May 2012, their earnings were summed from Q1 2017 to Q4 2017. We chose to use fifth year earnings because it gives sufficient time for students to graduate from both 2-year and 4-year programs on time and return to the workforce.

Analysis Model

We assessed each of the seven confirmatory questions using multi-level, or mixed effects, regression models. Mixed effects logistic regression models were used to estimate the odds of binary outcomes, with linear regression used to model continuous outcomes, while allowing us to simultaneously adjust for school-level clustering (by including random intercepts for high schools) and student-level characteristics. Student-level controls included English language learner (ELL) status, urbanicity, income (FRL, free/reduced lunch), ethnicity, and ninth grade reading scores in all models. Models assessing "any" credential attainment further included cohort (using 2011 as reference category) and tests for on-time degree attainment and earnings included controls for both cohort (2011 referent) and gender (with female as the referent). We used the Bonferroni method of adjustment for multiple comparisons when running the confirmatory models. The basic analytic model was as follows.

$$Y_{ij} = \gamma_{00} + \gamma_{10}(PRE_{ij}) + \gamma_{20}(ELL_{ij}) + \gamma_{30}(Urbanicity_j) + \gamma_{40}(FRL_{ij}) + \gamma_{50}(Ethnicity_{ij}) + \gamma_{60}(Treatment_{ij}) + u_j + e_{ij}$$

Where:

- Y_{jj} = the outcome for student *i* in school *j*
- PRE_{ij} is the student ninth grade reading standardized test score
- ELL_{ij} is 1 if student *i* in school *j* is an English Language Learner, 0 otherwise
- $Urbanicity_j$ is 1 if students belonging to school *j* attended a rural school in 11th grade, 0 otherwise
- FRL_{ij} is 1 if student *i* in school *j* is low income (as measured by Free or Reduced Lunch price status), 0 otherwise
- $Ethnicity_{ij}$ is 1 if student *i* in school *j* is non-Asian or non-White, 0 otherwise
- $Treatment_{ij}$ is 1 if student *i* in school *j* is in treatment, 0 otherwise

And:

- γ_{00} is the student-level intercept
- γ_{10} is the effect of student level pretest, which is fixed at level 2
- γ_{20} is the effect of ELL status, which is fixed at level 2
- γ_{30} is the effect of Urbanicity, which is fixed at level 2
- γ_{40} is the effect of FRL qualification, which is fixed at level 2
- γ_{50} is the effect of Ethnicity, which is fixed at level 2
- γ_{60} is the treatment effect, which is fixed at level 2
- Together, $\gamma_{00} + u_j$ represents the random intercept for school membership
- e_{ij} is the error associated with student *i* in school *j*, with mean 0 and conditional variance σ^2_e
- u_j is the error associated with school *j*, with mean 0 and conditional variance σ^2_u
- σ^2_e is the unexplained variation at level 1
- σ^2_u u is the unexplained variation at level 2

In addition, for each confirmatory analysis we calculated marginal effects to ease with interpretation. For binary outcomes, these marginal effects give the predicted probability of the outcome for both treatment and comparison students while holding all other covariates (FRL qualification, minority status, ELL status, ninth grade reading achievement, and school-level urbanicity, as well as student cohort and gender, if appropriate) constant at their means. With continuous outcomes, the marginal effects display the predicted level of the outcome (i.e. number of credits attempted or earnings in dollars) with all covariates at their means for the treatment and comparison group.

We ran separate, exploratory tests for moderating factors of treatment effects by including interaction terms between Concurrent Enrollment participation and (1) race/ethnicity; (2) free-and-reduced lunch (FRL; income) status; and (3) ninth grade reading test scores. We ran the same set of exploratory analyses for the outcomes assessed among those who matriculated to college within one year of expected high school graduation (on-time degree completion and earnings), but also tested potential moderation effects of gender on both outcomes and credential/degree attainment on the earnings outcome.

Results

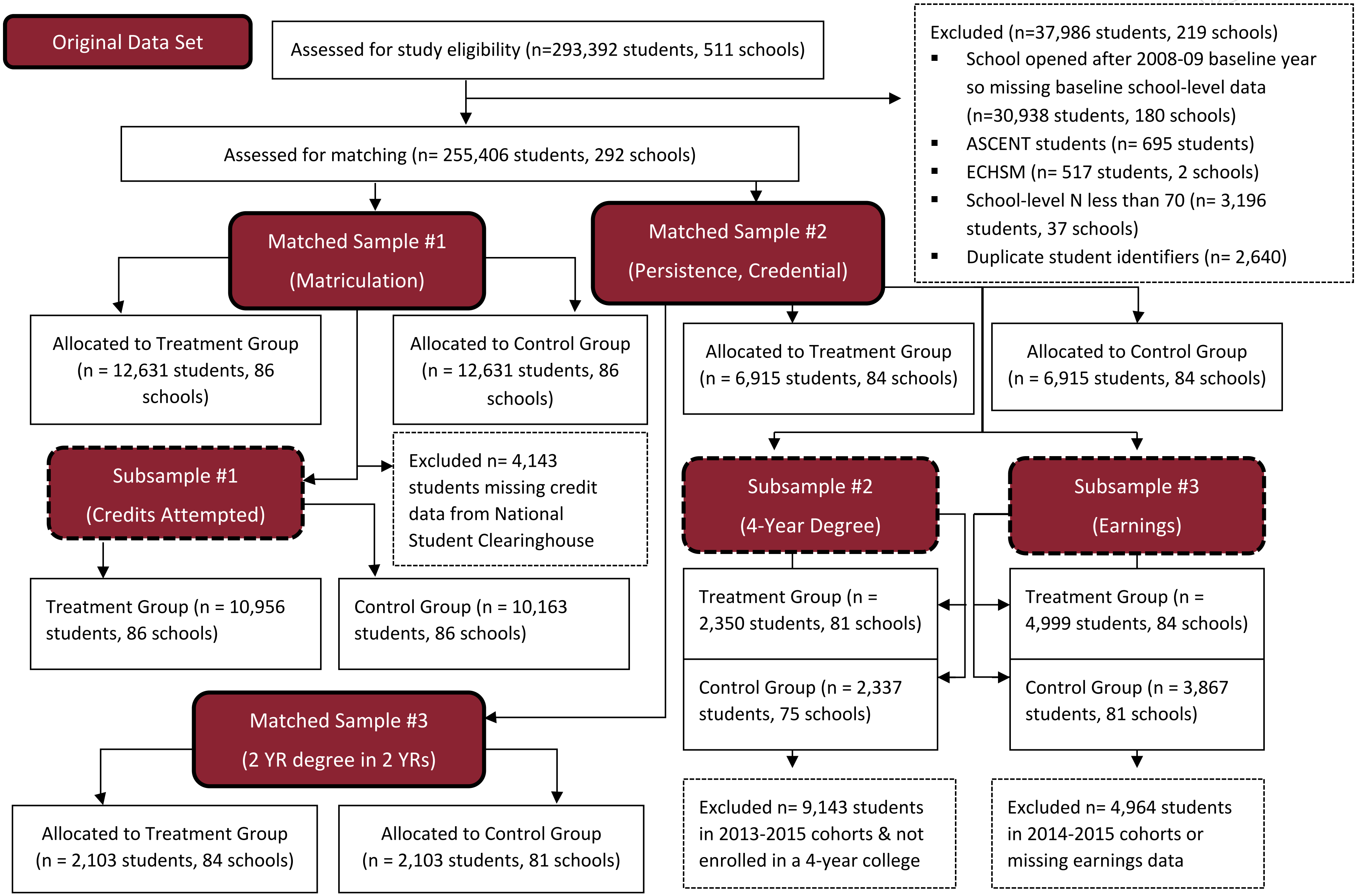
Samples, Descriptives, and Baseline Equivalence

Figure 2 displays the flow of students and schools through each of the various analytic samples using an adapted CONSORT diagram for randomized trials (Schulz, Altman, & Moher, 2010). The initial student-level data set linking secondary to postsecondary and earnings records included 293,392 students nested within 511 schools. A total of 37,986 students and 219 schools failed to meet inclusion criteria and were dropped prior to any matching. This number includes 695 ASCENT students (i.e., students who attended high school in 5 years) and 362 students nested within two early college high schools "approved" while the study period was ongoing, 3,196 students in 37 schools with school-level sample sizes less than 70 across cohorts, and 2,640 student duplicate observations where identifiers appeared in more than one school during their 11th grade year and only one was chosen at random and retained. The remainder and majority of exclusions (30,938 students in 180 schools) lacked school-level data at baseline. As such, 255,406 students in 292 schools were eligible for matching and inclusion in the evaluation.

In all, there are six different samples used to assess outcomes across the seven confirmatory analyses. Table 3 reports descriptive statistics and baseline equivalence for the initial, eligible sample, as well as for the analysis samples used to evaluate matriculation, attempted credits, college persistence, and "any" credential completion. Table 4 reports these same statistics for outcome related to on-time degree attainment and earnings. "Matched Sample" refers to an analytic sample of students who met inclusion criteria for the research question and were retained in the sample after using propensity score matching at the school and student levels, as described in section 2.3.1 above. Samples designated "Subsample" are comprised of a subset of students matched in an earlier, related analysis sample who were also eligible for a different outcome analysis and retained baseline equivalence without needing further matching. An easy way to differentiate these samples at a glance is that the matched samples contain balanced numbers of treatment and control students, while this is not guaranteed for subsamples.

For the first and largest matched sample used to assess treatment impacts on matriculation, of 255,406 students eligible for matching, 25,262 were retained, 12,631 students per condition nested in 172 schools (86 per condition). From these, a subsample of 21,119 students in 172 schools were used to assess credits attempted who met eligibility criteria for that analysis (noting that National Student Clearinghouse used to track students who matriculated out-of-state does not collect college credit data). A second matched sample of 13,830 students (6,915 per condition) in 168 schools (84 per condition) who matriculated to college within one year of their expected high school graduation date were drawn from the initial, eligible sample of 255,406 to examine college persistence and completion. From these, a second (n=4,687) and

Figure 1: Flow chart adapted from the CONSORT diagram for randomized trials (Schulz, Altman, & Moher, 2010).



Note: ASCENT – Accelerating Students through Concurrent ENrollmenT; ECHSM – Early College High School Model. "Matched Sample" refers to the analytic sample of students who met inclusion criteria for the research question and were retained in the sample after using propensity score matching at the student level.

Table 3: Baseline Equivalence of Initial and Matched Samples

	Initial Sample - Excluding Ineligible Schools and Students				Matched Sample 1 - Matriculation				Subsample of Matched Sample 1 - Credits Attempted[a]				Matched Sample 2 - Year 1 to Year 2 Persistance, "Any" Credential			
	Overall	Treatment	Control	Trt vs. Cnt	Overall	Treatment	Control	Trt vs. Cnt	Overall	Treatment	Control	Trt vs. Cnt	Overall	Treatment	Control	Trt vs. Cnt
Baseline Characteristics	Mean (SD)	Mean (SD)	Mean (SD)	Effect Size	Mean (SD)	Mean (SD)	Mean (SD)	Effect Size	Mean (SD)	Mean (SD)	Mean (SD)	Effect Size	Mean (SD)	Mean (SD)	Mean (SD)	Effect Size
School Level																
% FRL	0.30	0.35	0.25	0.29	0.35	0.41	0.30	0.29	0.35	0.41	0.30	0.29	0.35	0.41	0.29	0.32
College-Going Rate	0.55	0.56	0.54	0.05	0.54	0.55	0.53	0.05	0.54	0.55	0.53	0.05	0.55	0.56	0.55	0.02
Urban	0.55	0.35	0.76	-1.07	0.59	0.59	0.59	0.00	0.59	0.59	0.59	0.00	0.60	0.58	0.61	0.08
Test Score Average	665.67	666.22	665.13	0.05	664.82	664.70	664.95	0.01	664.82	664.70	664.95	0.01	665.59	665.14	666.04	0.04
	(22.69)	(16.58)	(27.52)		(21.72)	(19.27)	(24.04)		(21.72)	(19.27)	(24.04)		(21.50)	(19.27)	(23.62)	
Student Level																
Race/Ethnic Minority	0.34	0.40	0.39	0.03	0.40	0.40	0.40	0.00	0.43	0.42	0.43	-0.02	0.34	0.36	0.33	0.08
FRL Status	0.30	0.37	0.34	0.08	0.38	0.37	0.38	0.03	0.41	0.40	0.42	-0.05	0.32	0.33	0.32	0.03
ELL Status	0.07	0.04	0.07	-0.36	0.05	0.04	0.05	0.14	0.05	0.05	0.05	0.00	0.03	0.03	0.03	0.00
Test Score	666.03	677.01	660.78	0.35	676.21	677.01	675.41	0.04	672.22	674.58	669.67	0.12	683.48	683.87	683.08	0.02
	(49.99)	(39.68)	(51.36)		(42.37)	(39.68)	(44.89)		(41.48)	(39.54)	(43.33)		(39.14)	(36.65)	(41.47)	
Cohort																
2010-2011	0.20	0.17	0.20	-0.12	0.17	0.17	0.17	0.00	0.17	0.17	0.17	0.00	0.23	0.23	0.23	0.00
2011-2012	0.20	0.19	0.20	-0.04	0.19	0.19	0.19	0.00	0.20	0.20	0.19	0.04	0.25	0.25	0.25	0.00
2012-2013	0.20	0.20	0.20	0.00	0.20	0.20	0.20	0.00	0.19	0.19	0.19	0.00	0.25	0.25	0.25	0.00
2013-2014	0.20	0.21	0.20	0.04	0.21	0.21	0.21	0.00	0.21	0.21	0.21	0.00	0.27	0.27	0.27	0.00
2014-2015	0.20	0.23	0.20	0.11	0.23	0.23	0.23	0.00	0.23	0.23	0.23	0.00				
School N	292	146	146		172	86	86		172	86	86		168	84	84	
Student N	255406	12631	118111		25262	12631	12631		21119	10956	10163		13830	6915	6915	

Notes. "Matched Sample 1" refers to the analytic sample of students who met inclusion criteria for the matriculation research question and were retained in the sample after propensity score matching at the school and then student level. "Matched Sample 2" refers to the analytic sample of students who matriculated to college within one year of expected high school graduation, met inclusion criteria for the credits attempted research question, and were retained in the sample after propensity score matching at the student level. Urban (1 = rural; 0 = urban/suburban); ELL – English Language Learner (ELL = 1, non-ELL = 0); FRL – Free & Reduced Lunch, a proxy for low-income (FRL = 1, non-FRL =0); Minority (White/Asian = 0; All other = 1).

[a] This analysis includes the same matched sample used to assess matriculation (n=25,262) but drops students with National Student Clearinghouse data (n=4,143) due to a lack of information on attempted credits. Data were not re-matched because baseline equivalence was maintained.

Table 4: Baseline Equivalence of Initial and Matched Samples

	Matched Sample 3 - 2-Year Degree in 2 Years				Subsample of Matched Sample 2 - 4 Year Degree in 4 Years*				Subsample of Matched Sample 2 - Earnings 5 Years Post-Expected HS Grad+			
	Overall	Treatment	Control	Trt vs. Cnt	Overall	Treatment	Control	Trt vs. Cnt	Overall	Treatment	Control	Trt vs. Cnt
Baseline Characteristics	Mean (SD)	Mean (SD)	Mean (SD)	Effect Size	Mean (SD)	Mean (SD)	Mean (SD)	Effect Size	Mean (SD)	Mean (SD)	Mean (SD)	Effect Size
School Level												
% FRL	0.35	0.41	0.29	0.32	0.35	0.41	0.28	0.35	0.35	0.41	0.29	0.32
College-Going Rate	0.55	0.56	0.55	0.02	0.58	0.57	0.58	-0.02	0.56	0.56	0.56	0.00
Urban	0.61	0.58	0.63	-0.13	0.58	0.57	0.60	-0.07	0.59	0.58	0.60	-0.05
Test Score Average	665.67	665.14	666.72	-0.08	666.76	665.51	668.11	-0.12	665.77	665.14	666.43	-0.06
	(20.76)	(19.27)	(22.29)		(21.14)	(19.28)	(23.03)		(21.49)	(19.27)	(23.68)	
Student Level												
Race/Ethnic Minority	0.46	0.46	0.46	0.00	0.27	0.29	0.25	0.12	0.35	0.35	0.34	0.03
FRL Status	0.45	0.44	0.46	-0.05	0.25	0.27	0.23	0.13	0.32	0.32	0.33	-0.03
ELL Status	0.05	0.05	0.05	0.00	0.01	0.01	0.01	0.00	0.03	0.03	0.03	0.00
Test Score	661.92	664.14	659.69	0.12	694.65	692.60	696.72	-0.12	683.58	685.01	681.72	0.08
	(36.44)	(36.62)	(36.14)		(35.83)	(33.16)	(38.23)		(38.49)	(36.68)	(40.65)	
Cohort												
2011	0.23	0.24	0.22	0.07	0.48	0.48	0.48	0.00	0.32	0.32	0.33	-0.03
2012	0.24	0.25	0.24	0.03	0.52	0.52	0.52	0.00	0.34	0.34	0.33	0.03
2013	0.26	0.26	0.27	-0.03					0.34	0.35	0.34	0.03
2014	0.26	0.25	0.27	-0.06								
2015												
School N	165	84	81		156	81	75		165	84	81	
Student N	4206	2103	2103		4687	2350	2337		8866	4999	3867	

Notes. "Matched Sample 3" refers to the analytic sample of students who matriculated to a 2-year college within one year of expected high school graduation, met inclusion criteria for the 2-year degree in 2 years research question, and were retained in the sample after propensity score matching at the student level. Urban (1 = rural; 0 = urban/suburban); ELL – English Language Learner (ELL = 1, non-ELL = 0); FRL – Free & Reduced Lunch, a proxy for low-income (FRL = 1, non-FRL =0); Minority (White/Asian = 0; All other = 1).

* = This analysis sample includes the same matched sample used to assess year 1 to year 2 persistence from Table 3 (n=13,830) but drops all students in cohorts 2013-2015 and those who did not enroll in a 4-year college within 2 years of expected high school graduation. Data were not re-matched because baseline equivalence was maintained.

+ = This analysis sample includes the same matched sample used to assess year 1 to year 2 persistence from Table 3 (n=13,830) but drops all students in cohorts 2014-2015 or missing earnings data from the Colorado Department of Labor and Employment. Data were not re-matched because baseline equivalence was maintained.

third (n=8,866) subsample were used to assess differences in on-time 4-year degree attainment and earnings, respectively. From the second matched sample (i.e. matriculaters), we drew a final matched sample (n= 4,206, with 2,103 per condition) to assess impacts on earning a 2-year degree in two years, which is unbalanced at the school level (n= 84 treatment, 81 comparison) because school propensity scores were less important matching criteria for attaining balance in this sample than student-level characteristics. Figure 1 contains school and sample sizes by treatment group for all samples.

A common critique of QEDs using PSM is that the sample(s) remaining after matching is (are) no longer representative of the population from which the data were initially drawn and for whom the treatment is intended (Steiner & Cook, 2013). Indeed, in our largest matched sample, we only assess differences in outcomes for 10% of all students who were eligible. We attempt to dispel this concern as much as possible in three ways. First, we carefully document the flow of students and schools through the various analytic samples via a modified version of the CONSORT diagram (Schulz, Altman, & Moher, 2010) in Figure 2. For each of these samples, we also report descriptive statistics and baseline equivalence, which readers can compare to the corresponding traits from the full, eligible sample in Tables 3 and 4. Finally, we only perform additional matching when necessary to meet What Works Clearinghouse (WWC) standards (USDOE, 2019).

Postsecondary Access, Persistence, and Completion of "Any" Degree

As presented in Table 5, outcomes show substantial positive impacts of Concurrent Enrollment on rates of college enrollment (*OR* = 3.06), attempted credits (*g* = 0.55), persistence (*OR* = 1.30), and degree attainment (*OR* = 2.08). Findings indicate that students who attempt one or more Concurrent Enrollment credits are significantly more likely to enroll in college within a year of their expected high school graduation date, attempt college credits, persist from fall-to-fall of their first year, and earn a postsecondary credential compared to students who do not take college credits in high school.

Marginal effects are also presented to ease with interpretation. Results reveal that 77 percent of students in the treatment group matriculated within one year of their expected high school graduation date compared to 52 percent of students in the control group. For those who matriculated, 82 percent of students in the treatment group persisted from the fall of year 1 to the fall of year 2 compared to 77 percent of the control group. In addition, 37 percent of the treatment group that matriculated within one year of their expected high school graduation earned a credential compared to 22 percent of the control group.

Exploratory analyses reveal no significant moderation effects of the treatment by income or minority status for any outcomes, but did demonstrate a significant, negative interaction effect for achievement on matriculation. There were no subgroup effects for persistence and college completion. That is, Concurrent Enrollment was shown to have somewhat stronger benefits for students with average to slightly below average achievement on matriculation, but the treatment helped all students equally to persist and earn a credential.

We decided to run an additional exploratory analysis after reviewing the confirmatory results. Many of the students in the first matched sample (assessing matriculation, see Figure 1) did not enter college within a year after their expected high school graduation and therefore had "zero" college credits attempted. As such, we realized that the perceived treatment effects on credits attempted were likely driven primarily by improvements in matriculation, rather than any substantial treatment effect on taking more credits if enrolled. Therefore, we re-ran the analysis on a subsample of matched sample #2 (assessing persistence and credential attainment, all of whom matriculated) that included credit data (n = 10,302 students). Findings showed a statistically significant benefit of the treatment ($p < .015$), but only trivial differences in the expected outcome (marginal effects show that treatment students attempted, on average, 24.9 college credits versus 24.5 in the comparison group). That is, the effect size displayed for the confirmatory outcome in Table 5 greatly overstates the actual impact of the treatment on credits attempted, once we adjust for group differences in matriculation.

Table 5: Hierarchical Linear Models Predicting Postsecondary Outcomes (Confirmatory Analyses)

	Matriculation			Credits Attempted (See Footnote a)			Year 1 to Year 2 Persistence			"Any" Credential		
Covariates	OR		(95% CI)	B		(95% CI)	OR		(95% CI)	OR		(95% CI)
School-Level Characteristics												
Treatment	3.06	***	(2.86, 3.29)	7.26	***	(6.85, 7.67)	1.30	***	(1.17, 1.44)	2.08	***	(1.89, 2.29)
Urban	0.97		(0.81, 1.16)	-0.57		(-1.67, 0.54)	1.37	***	(1.19, 1.59)	0.98		(0.85, 1.13)
Student-Level Characteristics												
Test Score	1.92	***	(1.85, 1.99)	3.85	***	(3.66, 4.05)	1.54	***	(1.47, 1.61)	1.28	***	(1.23, 1.34)
ELL	1.04		(0.90, 1.21)	0.45		(-0.38, 1.28)	1.57	**	(1.23, 2.00)	1.25		(0.96, 1.63)
FRL	0.70	***	(0.65, 0.75)	-2.05	***	(-2.45, -1.65)	0.66	***	(0.60, 0.73)	0.81	***	(0.73, 0.89)
Minority	1.01		(0.94, 1.08)	-0.13		(-0.54, 0.28)	0.96		(0.87, 1.06)	0.92		(0.84, 1.02)
Expected Graduation Cohort (vs. 2011)												
2012										0.83	**	(0.75, 0.92)
2013										0.41	***	(0.37, 0.46)
2014										0.15	***	(0.13, 0.17)
Student Intercept	1.28			12.12			3.17			0.68		
School Intercept σ	0.52			3.18			0.31			0.32		
BIC	28502			166140			14019			15485		
ICC	0.08			0.06			0.03			0.03		
Student N	25,262			21,119			13,830			13830		
School N	172			172			168			168		
Treatment Eff. Size	0.68			0.55			0.19			0.44		

Bonferroni-adjusted Significance Levels: * p < .015; ** p < .0025; *** p < .00025

Note. OR = Odds Ratio, 95% Confidence Intervals for Odds Ratios are calculated using the modified Wald method; Urban (1 = rural; 0 = urban/suburban); ELL – English Language Learner (ELL = 1, non-ELL = 0); FRL – Free & Reduced Lunch, a proxy for low-income (FRL = 1, non-FRL =0); Minority (White/Asian = 0; All other = 1). The "Credits Attempted" sample is smaller but the same matched sample as "Matriculation" because the National Student Clearinghouse data set used to track out-of-state college students does not collect data on college credits.

[a] The "credits attempted" result as reported in Table 5 is primarily a manifestation of the matriculation effect.

Time-to-Degree and Earnings

Findings are also positive and in favor of the treatment group, with medium-to-large effect sizes detected for on time-completion, as measured by earning a two-year credential in two years (*OR* = 2.87) and earning a four-year degree in four years (*OR* = 1.61). For students who matriculated to college within one year of their expected high school graduation date, 13 percent of students in the treatment group earned a two-year degree or credential within two years compared to 5 percent of students in the control group. In addition, 26 percent of students in the treatment group earned a four-year degree in four years compared to 18 percent of students in the control group. Benefits of the treatment extended to earnings, as well. Five years after their expected high school graduation date, treatment students had (on average) significantly higher earnings across four quarters compared to control students (g = .08; $15,767.45 in treatment vs. $14,377.98 in control).

In our exploratory models, moderation analyses revealed no statistically significant results of differential impacts of the treatment by student characteristics. Concurrent Enrollment, however, positively impacted early college completion (OR = 1.28; $p < 0.001$). Specifically, marginal effects predict that 1.6 percent of treatment students earned a four-year degree in three years compared to only 0.5 percent of students in the control group.

Table 6: Hierarchical Linear Models Predicting Time-To-Degree and Earnings (Confirmatory Analyses)

	2-Year Degree Attainment in 2 Years			4-Year Degree Attainment in 4 Years			Earnings 5 Years Post-Expected HS Grad ($)		
Covariates	OR		(95% CI)	OR		(95% CI)	B		(95% CI)
School-Level Characteristics									
Treatment	2.87	***	(2.26, 3.64)	1.61	***	(1.37, 1.89)	1389.47	**	(588.11, 2185.91)
Urban	0.48	***	(0.36, 0.63)	1.08		(0.88, 1.31)	940.27		(-41.39, 1924.07)
Student-Level Characteristics									
Test Score	1.25	**	(1.10, 1.41)	1.67	***	(0.29, 0.52)	386.54		(-25.79, 796.61)
ELL	0.76		(0.39, 1.47)	1.15		(0.53, 2.50)	1927.86		(-449.90, 4311.57)
FRL	0.77		(0.61, 0.97)	0.71	**	(0.59, 0.87)	-189.73		(-1084.47, 711.92)
Minority	0.98		(0.77, 1.25)	0.85		(0.71, 1.03)	342.47		(-544.20, 1234.30)
Expected Graduation Cohort (vs. 2011)									
2012	0.77		(0.57, 1.03)	1.12		(0.97, 1.29)	-474.35		(-1375.69, 428.96)
2013	0.84		(0.63, 1.11)				863.73		(-34.37, 1764.58)
2014	0.79		(0.59, 1.06)						
Student Intercept	0.77			0.39			10907.10		
School Intercept σ	0.43			0.29			1417.70		
BIC	2686			4969			198402		
ICC	0.05			0.03			0.01		
Student N	4206			4687			8866		
School N	165			156			165		
Treatment Eff. Size	0.63			0.29			0.08		

Bonferroni-adjusted Significance Levels: * p < .017; ** p < .0033; *** p < .00033

Note. OR = Odds Ratio, 95% Confidence Intervals for Odds Ratios are calculated using the modified Wald method; Urban (1 = rural; 0 = urban/suburban); ELL – English Language Learner (ELL = 1, non-ELL = 0); FRL – Free & Reduced Lunch, a proxy for low-income (FRL = 1, non-FRL =0); Minority (White/Asian = 0; All other = 1).

Limitations and Conclusions

Using a two-stage, matched design to follow students who graduated from Colorado high schools between 2010-2011 and 2014-2015, this study evaluated Colorado's Concurrent Enrollment program. The treatment was defined as 11th and 12th grade students who attempted Concurrent Enrollment credits while attending a school with "ample" dual enrollment opportunities. Treatment students were compared to a business-as-usual comparison group of 11th and 12th grade students who did not attempt any dual enrollment credits while attending otherwise similar high schools offering "few" dual enrollment opportunities. Findings revealed substantial positive impacts of Colorado's dual enrollment program (Concurrent Enrollment) on rates of college enrollment (OR = 3.12), persistence (OR = 1.30), and degree attainment (OR = 2.11). Concurrent Enrollment also showed significant positive impacts on on-time or early college completion, as measured by earning a two-year credential in two years (OR = 2.87) and earning a four-year degree in four years (OR = 1.61). Meanwhile, five years after expected high school graduation, students who participated in Colorado's Concurrent Enrollment program earned significantly higher wages than students who did not participate (g = .079).

The most significant limitation of this study was the limitation of our study design due to unobserved variable bias. Data on students' academic and career expectations and aspirations and parents' education, for example, are variables important to the college choice process (Hossler, Schmit, & Vesper, 1999) that likely influence students' selection into the treatment and the dependent variables. To address selection bias, however, treatment and comparison students were never drawn from the same school. By selecting comparison students from schools offering "few" dual enrollment opportunities, the potential confound from the self-selection of comparison students out of dual enrollment courses was minimized. Another limitation was the decision to base the sample on cohorts of 11th graders, since some students take dual credit as early as 9th grade. As mentioned in the introduction, the vast majority of dual credit participants do not take dual credit courses until the 11th grade, particularly when considering general dual credit (as opposed to early college high schools: Edmunds et al., 2012, 2017; Haxton et al., 2016, Song & Zeiser, 2019). However, most students who take dual credit courses prior to 11th grade would also take dual credit courses during the 11th or 12th grade, and hence would be classified as dual credit participants in the present study. This decision is consistent with other studies on dual enrollment (Miller et al., 2017).

Despite the study's limitations, the outcomes data reveal that students have benefitted from Colorado's Concurrent Enrollment program. Findings indicate that Colorado's investment in dual enrollment has contributed to more high school students that have graduated with the experiences needed to be successful in college. Additional studies are needed to examine the long-term impacts of Concurrent Enrollment in Colorado, especially as the economy begins to recover from the effects of the COVID-19 pandemic in the years to come. Furthermore, additional research is needed to examine if impacts vary by instruction mode (e.g., face-to-face classroom instruction, instruction with teacher and students connected by video, computer-based instruction, or a combination of computer and face-to-face instruction); and if Concurrent Enrollment courses located on a high school campus produce a different impact than those located on university or community college campuses. Finally, additional research is needed to examine long-term outcomes for students who participate in Concurrent Enrollment but do not matriculate to college, and/or students who delay matriculation for more than one year after their expected high school graduation date. Answers to these questions will provide additional guidance to educators, policy makers, students, and families as they make investments in Colorado's future.

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Appendix A: History of Dual Enrollment Programs in Colorado

Below is a list of the different concurrent enrollment policies adopted by Colorado during the period of this study. This information is also summarized in Table 7.

PSEO, Fast College/Fast Jobs, and Fast Tracks (FT) – Post-Secondary Enrollment Options (PSEO), Fast Tracks (FT) or Fast College/Fast Jobs (FC/FJ) – All these programs were phased out a few years after the passage of the Concurrent Enrollment Programs Act in 2009. These state-funded programs allowed students to earn college credit by completing community college courses while still in high school. PSEO and FT were open to juniors and seniors in participating high schools; FC/FJ was limited to certain qualifying schools and required students to commit to rigorous coursework throughout their high school career. Participating students were required to demonstrate ability to take college level courses. Many, though not all, of these courses qualified for both associates and bachelor's degrees.

Concurrent Enrollment – state statutorily defined according to The Concurrent Enrollment Programs Act of 2009. Concurrent enrollment (CE) in Colorado is defined as "the simultaneous enrollment of a qualified student in a local education provider an in one or more postsecondary courses, including academic or career and technical education courses, which may include course work related to apprenticeship programs or internship programs, at an institution of higher education"(CRS 22-35-103 (6)(a)). Additionally, students, districts, and institutions of higher education must abide by the financial provisions outlined in CRS 22-35-105 for a student to be considered as part of the state's Concurrent Enrollment program. The CDHE website reads: "The Concurrent Enrollment program provides high school students with the opportunity to enroll in postsecondary courses and earn credit at no cost to them for tuition." Local Education Providors (LEPs) use their per pupil funding to pay for tuition up to the community college tuition rate (in most cases). LEPs and Institutions of Higher Education (IHEs) negotiate in their Cooperative Agreement who pays for books, supplies and fees (could be either IHE, LEP, or students). Additionally, students apply their College Opportunity Fund (COF) stipend toward CE courses. If tuition is more than the community college rate (as is the case of most four-year institutions), often the student pays the cost difference. However, beginning 2020/21, SB 19-176 mandates that students will not be responsible for tuition costs. Credits earned from Concurrent Enrollment courses are guaranteed to be transferable to any public institution of higher education in Colorado. Further, SB 19-176 requires that courses taken through Concurrent Enrollment be applicable to a program of study.

Other high school dual enrollment programs – students taking a course outside the Concurrent Enrollment program. Programs identified by the state of Colorado as "other" high school dual enrollment programs are administered directly by postsecondary institutions and do not fall under the state's statutory definition of Concurrent Enrollment. Students can receive college-level credit through these other programs, but they and their families may be required to pay for courses. Additionally, these completed courses are not required to transfer and/or apply to programs of study at other Colorado public institutions of higher education (Colorado Department of Higher Education & Colorado Department of Education, 2018).

Early College High School Model (ECHSM) – Students attend a Colorado state board-approved high school which, through partnerships with institutions of higher education, enable students to earn 60 credits and an associate degree (or a specified number of college credits). The legal authorization for

ECHSM is Colorado Revised Statutes 22-35-104(10). The program is funded through the annual K-12 school finance act/PPR and is therefore exempt from Colorado's Concurrent Enrollment Programs Act.

Table 7: Concurrent Enrollment Programs in Colorado

Description	Concurrent Enrollment	ASCENT	PSEO	Fasttrack	Other dual
Legal Authorization	House Bill 09-1319, Senate Bill 09- 285, Colorado Revised Statutes 22- 35-101, State Board Rules 1 CCR 301-86.	House Bill 09-1319, Senate Bill 09- 285, Colorado Revised Statutes 22- 35-101, State Board Rules 1 CCR 301-86.	Colorado Revised Statute 22-35- 101, DHE Policy V part B.	Colorado Revised Statute 22-34-101.	n/a - dual enrollment program which is not a part of the Concurrent Enrollment Programs Act.
Grade/Age Requirement	Open to 9th-12th graders who receive academic plan approval, meet application deadlines, and meet college course requirements. 12th graders not meeting graduation requirements and who are held back for instructional purposes may not enroll into more than 9 credit hours for the academic year.	5th year program for students prior to high school graduation and who are on schedule to complete 12 credit hours of postsecondary work prior to completion of 12th year. Participants are selected by high school admin and must meet course requirements and prerequisites.	Open to 11th and 12th graders, who are under 21 years old.	High School Seniors (12th grade) who have completed their graduation requirements.	Depends on the requirements of the institutional specific dual enrollment programs (CU Succeed, MEUP and others).
Funding	School district required to pay up to the community college tuition rate. COF stipend eligible. Parents can be charged more than community college rate for four-year institutions. However, beginning 2020/21, students enroll in CE courses tuition free.	School District required to pay the tuition up to the community college residential tuition rate. COF stipend eligible. Parents can be charged more than community college rate. However, beginning 2020/21, students enroll in CE courses tuition free.	Tuition is paid by the student's school district when the courses count toward high school graduation.	School district pays the tuition at the time the student registers.	Varies depending on agreement. Districts may pay, students may pay, or a combination of the two. May or may not be COF eligible depending on course, location, and other factors.

Description	Concurrent Enrollment	ASCENT	PSEO	Fasttrack	Other dual
Specifics	Can be degree seeking but not required.	Accepted into degree program. Selected by HS admin to participate.	Need not be degree seeking. Program ended Fall 2012.	Need not be degree seeking. Program ended Fall 2012.	
Credit transferability	Coursework completed qualifies as credit applicable toward earning a degree at the institution and is transferable to other Colorado public institutions.	Coursework completed qualifies as credit applicable toward earning a degree at the institution and is transferable to other Colorado public institutions.			If the program is extended studies and courses are not transcripted it could prevent transferability.

History of legislation in Colorado around concurrent enrollment:

- Prior to the 2009 legislation, PSEO, Fast College/Fast Jobs, and Fast Tracks (FT) were the state-legislated concurrent enrollment programs.
- PSEO was very similar to Concurrent Enrollment with a few exceptions, such as students/families paid the whole cost for PSEO college courses and were reimbursed by the school district if the student passed the course with a C- or higher.
- The Concurrent Enrollment Program Act and the ASCENT Act were both passed in 2009.
- ASCENT program – 13th year of school. ASCENT stands for Accelerating Students through Concurrent ENrollmenT. Students who have completed at least 12 credit hours of postsecondary course prior to completion of his/her 12th grade year may be eligible for the ASCENT Program. They remain students in their Local Education Provider (LEP) for one year following their 12th grade year, and the LEP receives ASCENT specific per-pupil state funding that it uses to pay their college tuition at the resident community college rate. Students receive their high-school diplomas at the end of their ASCENT year. [C.R.S. § 22-35-108]. The Colorado Department of Education (CDE) administers the program, and a district must have an ASCENT program in place for students to participate. The statewide cap set in statute to be around 600 students per year. Historically, the state has never met this cap.
- Concurrent Enrollment & ASCENT began to be offered in the Colorado Community College System (CCCS) colleges in the fall 2010 – as such, there was overlap between PSEO and Concurrent Enrollment until the summer 2012, when HB-1319 ended PSEO, FT and FC/FJ.
- For this study, PSEO and Concurrent Enrollment were treated as the state's dual enrollment option during their respective years.

Table 8 presents the count of students enrolled in each program over time. Notes:

- The counts in Table 2 are unduplicated by program type so a student taking concurrent enrollment is only counted once per academic year.

- If the student takes Concurrent Enrollment (CE) and "other dual," then that student would show up once in the CE row and once in the "other dual" row. Thus, the "total" reported in Table 8 may include duplicate counts because of enrollments in multiple programs during an academic year.

Table 8: Unduplicated student counts of concurrent enrollment in Colorado, 2009-10 to 2015-16

Program	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16
State CE	5,791	9,349	13,928	17,873	20,488	23,127	25,534
ATC	--	--	--	--	--	883	946
PSEO	3,448	5,185	1,935	--	--	--	--
Fasttract	62	192	10	--	--	--	--
ASCENT	84	99	208	291	415	462	485
Other CE	5,816	5,691	7,998	8,771	10,189	11,241	11,554
Total	*15,201*	*20,786*	*24,079*	*26,935*	*31,092*	*35,713*	*35,519*

Source. Annual report on Concurrent Enrollment prepared by the Colorado Department of Higher Education (CDHE) and the Colorado Department of Education (CDE) pursuant to C.R.S. §22-35-112.

Notes. CE – Concurrent Enrollment. ATC – Area Technical Colleges. Students attending these programs participating in the state's Concurrent Enrollment program (i.e., big C). However, the Colorado Department of Higher Education separated these counts from the rest of the state count (see State CE) due to data inaccuracies and concerns over quality of the data provided by the ATCs.