ABSTRACT

HENDERSON, MIHAELA. Does Taking Dual Enrollment on a College Campus Improve Student Outcomes? A Quasi-Experimental Approach Using Inverse Probability of Treatment Weighting. (Under the direction of Dr. Stephen R. Porter and Dr. A. Brooks Bowden).

As economic forecasts signal the need for more college graduates, policymakers increasingly look to dual enrollment programs to improve college access and success. Although research documents overall positive outcomes associated with dual enrollment participation, very little is known about the effectiveness of variations in dual enrollment delivery. Rigorous quantitative research that examines the role of dual enrollment delivery setting is particularly lacking.

This study uses a quasi-experimental design to investigate the causal effect of dual enrollment location. Implementing a propensity score weighting approach that reduces selection bias, I compare high school- and college-based dual enrollment students on a series of outcomes capturing high school graduation and college-going behaviors. I find that students who take dual enrollment on a college campus graduate from high school at the same rate as students who take dual enrollment at their high school. Moreover, I find no significant differences in FAFSA completion, number of college applications, and postsecondary enrollment between the two groups. These results signal that high school-based dual enrollment could potentially be used to increase dual enrollment participation without sacrificing academic rigor. However, decisions related to dual enrollment implementation features such as delivery setting should consider specific contextual factors, including costs to students, schools, and colleges.

Does Taking Dual Enrollment on a College Campus Improve Student Outcomes? A Quasi-Experimental Approach Using Inverse Probability of Treatment Weighting

by
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DEDICATION

To my grandfather. I could never forget that for me, literacy and postsecondary aspirations began with you. I love you and I miss you.

BIOGRAPHY

Mihaela Henderson earned a bachelor's degree in English and French translation studies from the University of Bucharest in Bucharest, Romania, and a master's degree in clinical mental health counseling from the University of North Carolina at Pembroke in Pembroke, North Carolina. After completing her graduate degree, Mihaela worked as an Assistant Director of Career Services at Appalachian State University and the University of North Carolina at Pembroke. As a PhD student, she spent three years as a Graduate Assistant in the Office of Assessment at North Carolina State University. In 2018, Mihaela accepted a Research Education Analyst position with Research Triangle Institute (RTI). As an analyst, she supports the implementation of nationally representative longitudinal studies of baccalaureate recipients for the National Center for Education Statistics.

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CHAPTER 1: Introduction

Despite media portrayals of unaffordable education (Finney, 2016), debt-overburdened students (Steele & Williams, 2016), and declining value of education (Staton, 2014), education continues to be a wise and worthwhile investment (Abel & Deitz, 2014; Akers & Chingos, 2016). The return to a bachelor's degree rose from 9% in 1970 to a steady 14% to 15% in the last decade (Akers & Chingos, 2016). Likewise, the return to an associate's degree more than doubled from 6% in 1970 (Akers & Chingos, 2016). Although a postsecondary credential is increasingly needed and valuable, many students, particularly from disadvantaged backgrounds, fail to attend college, persist, and earn a postsecondary degree (Baum & Payea, 2013; Lauff & Ingels, 2014; Perna, 2015).

Identifying the barriers to adequate college access, persistence, and degree completion is complex. Some researchers point to the rising cost of college attendance that weighs heavily on students and their families (Goldrick-Rab, 2016). Others contend remediation is a *bridge to nowhere* rather than a path to college success (Complete College American, 2012). Increasingly however, researchers argue that poorly aligned secondary and postsecondary education systems result in uneven college preparation and access and low persistence and completion rates (Bailey & Karp, 2003; Hoffman, 2005; Kirst & Bracco, 2004; Venezia & Kirst, 2005). Secondary and postsecondary education systems have distinct structures that often emphasize separation and hinder the flow of information between levels (Venezia & Kirst, 2005). Absent a shared vision of secondary-to-postsecondary transition, many secondary institutions fail to create an environment that provides students with the college knowledge, skills, and tools needed to apply to, enroll in, navigate, and graduate from college.

Statement of the Problem

As global economy projections signal the need for the U.S. to produce more bachelor's degree holders in order to remain competitive (Carnevale, Smith, & Strohl, 2013), policymakers increasingly look to dual enrollment programs to bridge the gap between K-12 and postsecondary education (An, 2015; Bailey & Karp, 2015; Hoffman, Vargas, & Santos, 2008) and improve college access and success. Dual enrollment arrangements are partnerships between high schools and postsecondary institutions, particularly community colleges, that allow high school students to take college-level coursework while being simultaneously enrolled at a secondary institution (Allen, 2010; Cassidy, Keating, & Young, 2010; Waits et al., 2005; Karp, Hughes, & Cormier, 2012; Kleiner & Lewis, 2005). In 2010-2011, 96% of two-year postsecondary institutions enrolled high school students in dual enrollment courses (Marken, Gray, & Lewis, 2013). Students participating in dual enrollment programs have the opportunity to earn college credits and a high school diploma simultaneously, thus shortening their time to degree and improving their likelihood of earning a postsecondary credential.

Although dual enrollment pathways are open to high school students in all 50 states (Bragg, Kim, & Rubin, 2005), implementation features may vary widely (Community College Research Center, 2012). Contingent on state and local policies, dually enrolled students may take courses for college credit through a community college or four-year institution, with a high school teacher or college professor, before, during, or after school, and on a college campus, at their high school, or online (Tobolowsky & Allen, 2016). High variability in the features of dual enrollment course delivery suggests there may be substantively important heterogeneity in student outcomes.

Empirical research links dual enrollment to the development of skills necessary for college (An & Taylor, 2015; Karp, 2012), higher educational aspirations (Smith, 2007), increased postsecondary enrollment (Cowan & Goldhaber, 2014), higher first-year GPA (An, 2013b; Allen & Dadgar, 2012, Eimers & Mullen, 2003), superior academic motivation and engagement (An, 2015), lower need for remediation (An, 2013b; Grubb, Scott, & Good, 2017), and improved postsecondary persistence (Allen & Dadgar, 2012; Karp, 2007; Swanson, 2008) and attainment (Klopfenstein, 2008; Struhl & Vargas, 2012; Taylor, 2015). However, while research documents overall positive outcomes associated with dual enrollment participation, very little is known about the effectiveness of variations in dual enrollment delivery (Edwards & Hughes, 2011). Rigorous quantitative research that examines the role of dual enrollment location is particularly lacking.

A limited number of studies suggest that taking dual enrollment courses on a college campus is associated with improved student satisfaction (Burns & Lewis, 2000), higher educational aspirations (Smith, 2007), better academic performance in dual enrollment English and mathematics (Arnold, Knight, & Flora, 2017), and increased college enrollment (Speroni, 2011a) and persistence (D'Amico, Morgan, Robertson, & Rivers, 2013). However, to the extent these studies use methods that limit generalizability or fail to account for bias resulting from self-selection into dual enrollment locations, the effects of dual enrollment delivery settings remain unknown. As dual enrollment programs continue to grow in popularity among institutions and policymakers and schools are called upon to provide dual enrollment opportunities to all students (Venezia & Kirst, 2005), more research is needed to better understand how dual enrollment features influence students' high school and college experiences and how impacts may differ for various groups of students. This study used a quasi-experimental design to uncover the causal

effect of dual enrollment location. By implementing a propensity score weighting approach that reduces selection bias, I sought to yield unbiased and consistent causal estimands thus increasing the internal validity of the analyses (Stock & Watson, 2007).

Background of the Study

In 1983, the National Commission on Excellence in Education released one of the most influential educational reports, *A Nation at Risk: The Imperative for Educational Reform*. The report alerted the U.S. Department of Education and the American people to the troubling deficiencies of the educational system which threatened the production of skilled workers and, implicitly, the U.S. dominance in the global arena. More than three decades later, the educational system appears still in need for reform and change (Venezia & Kirst, 2005).

Although the share of adults older than twenty-five holding a bachelor's degree or higher has increased from 12% in 1971 to 31% in 2012, concerns still remain related to higher education access and success (Blumenstyk, 2015). Many students choose to exit secondary education prematurely and forfeit immediate and direct access to higher education. About 25% of all students fail to receive their high school diploma on time (Hooker & Brand, 2009; Tierney & Duncheon, 2015) and graduation rates are particularly low for traditionally underrepresented students. In 2009, roughly 30% of the traditional college-aged Hispanic population had not completed high school (Kim, 2011). By comparison, only 12% of White individuals aged 18 to 24 had failed to obtain a high school credential (i.e., high school diploma or GED) (Kim, 2011). Equipped with only a high school diploma, many high school graduates who forgo college enter a labor market where their status is precarious and their performance and skills are the objects of employer criticism (Hooker & Brand, 2009).

The path is equally challenging for students who choose to enroll in college. Slightly more than half of all high school graduates fail to immediately pursue postsecondary enrollment (Tierney & Duncheon, 2015). Of high school graduates who enroll in college upon high school completion, only a third come back for a second year at a postsecondary institution (Tierney & Duncheon, 2015). When students have difficulties staying in school, they may also be less likely to earn their degrees on time. Only 19% of full-time students at four-year institutions earn a bachelor's degree in four years and 5% of full-time community college students graduate with an associate's degree in two years (Goldrick-Rab, 2016). Graduation rates among students placed in remedial education are especially low. Fewer than 10% of community college students who take remedial courses earn a degree in three years and slightly more than 30% of remediation students pursuing a bachelor's degree successfully do so within six years (Complete College America, 2012).

Bridging the Secondary-Postsecondary Gap

High schools and colleges diverge considerably in how they are organized, funded, and governed, and in their cultural and political contexts (Bailey & Karp, 2014; Kirst & Usdan, 2007). A lack of incentives for collaboration has resulted in mismatched reforms on both sides (Venezia & Kirst, 2005). As the value of postsecondary credentials and the labor market demand for college credentials have increased, several education policy streams have emerged to address the high school-college misalignment (Bailey & Karp, 2014). The first policy stream, the Common Core State Standards (CCSS), aims to create more coherent standards for secondary education to address specific knowledge and skills associated with college success. The second strategy addressing K-12-college disparities is remedial education (Bailey & Karp, 2014).

Finally, the third stream of education policies attempting to integrate secondary and postsecondary education focus on dual enrollment (Bailey & Karp, 2014).

Along with Advanced Placement (AP) and International Baccalaureate (IB), dual enrollment is a common strategy to accumulate college credits during high school (Achieve & Jobs for the Future, 2015). Historically, access to AP and IB has been inequitable as students from schools serving small, rural, and minority communities had very few opportunities to take these courses (Taliaferro & DeCuir-Gunby, 2008; Solorzano & Ornelas, 2002). Inadequate financial resources and uneven access to opportunities facing these schools have maintained the gap in AP and IB course-taking. In addition, the costs incurred by students to accumulate college credits through AP and IB courses renders them unaffordable for many students from low-income families (College Board, 2015).

While the first dual enrollment programs emerged in the 1950s, their popularity and proliferation are rather recent developments that have flourished over the past decade (Lumina Foundation, 2017). Data from a nationally representative survey of public high schools show approximately 1.2 million students enrolled in dual credit courses during the 2002-2003 academic year (Waits, Setzer, & Lewis, 2005). A more recent national survey indicates roughly 2 million students took courses for dual credit during the 2010-2011 academic year, an impressive 76% overall increase (Thomas, Marken, Gray, & Lewis, 2013). Although initially targeting high achieving students, dual enrollment has gradually widened its scope to encompass students of varying academic proficiency and demographics. Over the past decade, dual enrollment opportunities have reached high school students in all 50 states (Bragg et al., 2005). Despite increased access, certain student characteristics continue to be associated with participation in dual enrollment (Miller et al., 2018). Typically, dual enrollment students are more likely to be

White, female, more involved in extracurricular activities, and from economically advantaged families in which English is the first language (Pretlow & Washington, 2014; Taylor, 2015).

Dual enrollment is a structural reform that engages secondary, postsecondary, state, and local systems in negotiating its implementation (Karp, 2015). Within a partnership between a high school and a postsecondary institution, dual enrollment courses may be offered as part of a singleton, comprehensive, or enhanced comprehensive program (Hughes, Karp, Bunting, & Friedel, 2005). Singleton models consist of standalone courses from which students may select (Bailey & Karp, 2003). Alternately, comprehensive models map out a sequence of courses available to students. In addition to a series of courses, enhanced comprehensive models provide students with support services in the form of counseling, mentoring, or assistance with financial aid application (Bailey & Karp, 2003). Enhanced comprehensive programs include middle and early college high schools. These schools typically differ from traditional dual enrollment programs by focusing on traditionally underrepresented students and providing extensive support services (Venezia & Jaeger, 2013). Because middle and early college high schools provide a comprehensive model of learning that differs systematically from the typical dual enrollment models, they are beyond the scope of this study and outside the dual enrollment definition applied herein.

Defining Dual Enrollment

The literature is widely inconsistent in its definition of dual enrollment. Some researchers use the term interchangeably with *dual credit* and *concurrent enrollment* (Kleiner & Lewis, 2005; Tobolowsky & Allen, 2016). Other researchers associate the terms with similar yet distinct meanings (Andrews, 2004; College in High School Alliance, 2017). To further complicate the matter, some researchers place dual enrollment and Early College High Schools (ECHS) under

the umbrella of *credit-based transition programs* (Karp & Hughes, 2008) and *accelerated learning opportunities* (WICHE, 2006) along with Advanced Placement (AP), International Baccalaureate (IB), Tech Prep, and middle college high schools. Credit-based transition programs and accelerated learning opportunities aim to increase the rigor of the high school curriculum and provide high school students with opportunities to complete college coursework and potentially accumulate college credits (Karp & Hughes, 2008; WICHE, 2006).

Typically, *dual credit* indicates that students receive both high school and college credit, while *dual enrollment* and *concurrent enrollment* suggest high school students are enrolled in college courses for which they are not guaranteed to receive high school credit (Andrews, 2004; Barnett, Gardner, & Bragg, 2004; Kim, Barnett, & Bragg, 2003). For the purpose of this study, dual enrollment refers to pathways, programs, and opportunities that enable high school students to take college-credit courses while still enrolled in high school (College in High School Alliance, 2017). Therefore, within this study, dual enrollment encompasses dual credit and concurrent enrollment offerings.

Dual enrollment provides high school students with the opportunity to earn college credit sometimes at low or no cost to them thus potentially eliminating barriers to higher education, especially for students from socioeconomically disadvantaged backgrounds. By enrolling in dual enrollment courses, high school students may become more acclimated to college academic rigor and culture, build motivation and academic momentum, and receive an early warning about their college preparation (Bailey, Hughes, & Karp, 2002). These benefits have the potential to increase students' postsecondary aspirations and enrollment (Bailey et al., 2002). Successful completion of college-level courses while in high school could decrease students' costs associated with postsecondary education and reduce time to degree. Moreover, college-based dual enrollment

offerings and articulation agreements governing the transfer of dual enrollment credits could stimulate enrollment at partner postsecondary institutions (Cowan & Goldhaber, 2015).

Purpose and Significance of the Study

This study is significant because it adds to the limited body of knowledge concerning the effectiveness of dual enrollment features in improving student outcomes. Roughly two thirds of states have regulations that address the location of dual enrollment courses and several states specify that students take dual enrollment courses on a college campus (Karp, Bailey, Hughes, & Fermin, 2004). Prior studies suggest students and faculty perceive greater benefits associated with college-based dual enrollment (Burns & Lewis, 2000; Cochran & Burns, 2007; Harnish & Lynch, 2005). Additionally, high school students who take dual enrollment courses on a college campus may be more likely to enroll and persist in college (D'Amico et al., 2013; Speroni, 2011a). But research establishing causal relationships between dual enrollment delivery settings and student outcomes is scarce. Policymaking supporting the expansion of dual enrollment and the implementation of specific dual enrollment components could greatly benefit from rigorous evidence about the relative effectiveness of different delivery settings. If college-based dual enrollees graduate from high school and engage in college-going behaviors at higher rates than high school-based dual enrollees, there may be a case for policymaking supporting the expansion of college-based dual enrollment. Alternately, if high school-based and college-based dual enrollees have similar outcomes, policymakers could focus on broadening access to dual enrollment by selecting the most cost-effective dual enrollment delivery setting.

This research examines the effect of dual enrollment course location on students' high school graduation and college-going behaviors. I compare students who took dual enrollment on a college campus with students who took dual enrollment courses at the high school on a series

of proximal (i.e., high school graduation, FAFSA completion, number of college applications, and postsecondary enrollment immediately after high school) and distal (i.e., postsecondary enrollment three years after high school) outcomes. To decrease the risk for selection bias and balance the treatment and control groups, I apply a propensity score weighting approach.

Research Questions

This study focuses on the impact of dual enrollment delivery setting on students' high school graduation and college-going behaviors. Specifically, it seeks to answer the following research questions:

1) Does taking dual enrollment on a college campus improve high school graduation compared to taking dual enrollment at the high school?

2) Does taking dual enrollment on a college campus improve college-going behaviors compared to taking dual enrollment at the high school?

Data

To answer the research questions listed above, I use data from the High School Longitudinal Study of 2009 (HSLS:09), a nationally representative longitudinal survey consisting of 25,206 high school students entering 9th grade in fall 2009 (Ingels et al., 2015). HSLS:09 base year data collection gathered extensive information on student demographic and background characteristics as well as information from parents, teachers, counselors, and school administrators and captured family, classroom, and institutional characteristics likely to influence students' educational outcomes. These variables represent a rich set of covariates captured before treatment, which allows me to model selection into treatment and control for factors that influence both the treatment and the outcomes (Caliendo & Kopeinig, 2008). Additionally, two later HSLS:09 data collection waves capture information about dual enrollment location as well as high school

graduation, FAFSA completion, number of college applications, and postsecondary enrollment. Therefore, HSLS:09 is an adequate data source for examining the effect of dual enrollment location.

Limitations

To establish causality between the location of dual enrollment courses and high school graduation and college-going behaviors, this study applies a quasi-experimental research design. There are several limitations associated with the study design and data used in this research investigation. Because HSLS:09 relies on surveys to collect information from students, parents, and school personnel, most of the data used in this study are self-reported. If self-reported data are affected by variability in the comprehension, memory retrieval, and judgment of factual and attitudinal survey questions (Tourangeau, Rips, & Rasinski, 2000), they may not accurately reflect respondents' experiences. Additionally, the small sample sizes do not allow me to conduct subgroup analyses to determine if college-based dual enrollment may have differential impacts for various student subgroups (i.e., low-income, traditionally underrepresented students). Moreover, potential departures from core assumptions of the counterfactual framework and propensity score analysis may occur if there are unrepresented versions of the treatment (Rubin, 1986) or relevant unobserved characteristics are omitted from the selection model (Caliendo & Kopeinig, 2005).

CHAPTER 2: LITERATURE REVIEW

Dual enrollment programs are partnerships between high schools and postsecondary institutions, particularly community colleges, that allow high school students to take college-level coursework while being *simultaneously* enrolled at the secondary institution (Allen, 2010; Cassidy et al., 2010; Waits et al., 2005; Karp et al., 2012; Kleiner & Lewis, 2005). These partnerships usually rely on memoranda of understanding that set forth each partner's roles and responsibilities and specify model configurations including who may take dual enrollment, which courses may be available and where, who may be authorized to teach, when the course may be offered, what the student composition may be, and how funding is to be obtained and allocated (Cassidy et al., 2010; Edwards & Hughes, 2011). Upon successful completion of a dual enrollment course, students receive college credit that is recorded on a college transcript and which may or may not also count as high school credit (Karp, Calcagno, Hughes, Jeong, & Bailey, 2007; Karp et al., 2012).

Dual enrollment arrangements where students receive credit at the college and high school levels simultaneously are typically defined as *dual credit* (Bragg & Kim, 2006; Hoffman et al., 2009; Karp & Jeong, 2008; Kim et al., 2003). Another subset of dual enrollment courses where high school students receive instruction from a college-approved high school teacher are commonly referred to as *concurrent enrollment* (National Alliance for Concurrent Enrollment Partnerships, 2019). As defined above, both dual credit and concurrent enrollment fall under the broader umbrella of dual enrollment. Notably, despite these widely used definitions, the terminology used to designate dual enrollment remains inconsistent across participating institutions and states (Miller et al., 2017). Dual enrollment continues to be frequently used interchangeably with dual credit and concurrent enrollment (Hoffman et al., 2009). In this

dissertation, I define *dual enrollment* as opportunities to take college courses while enrolled in high school and receive college credit upon successful completion (Barnett & Stamm, 2010; College in High School Alliance, 2017).

The current study investigates the effect of campus-based dual enrollment (i.e. dual enrollment courses taken on a college campus) on students' high school graduation and college-going behaviors. This chapter presents a theory of change that explicates the channels through which dual enrollment location may affect students. To outline the current policy context of dual enrollment, I give an overview of the impetus for dual enrollment, its benefits and drawbacks, and typical model components. A brief comparison of high school-based and campus-based implementation delineates typical similarities and differences between the two delivery configurations. Next I synthesize what we know about the impact of dual enrollment participation in general, and dual enrollment location in particular. Finally, this chapter concludes with a causal model deconstructing the factors likely to influence students' participation in campus-based dual enrollment.

Theory of Change

Best practices in research evaluation suggest estimations of program effects should start by describing the underlying theory of change (Weiss, 1995). A theory of change formulates plausible ties between program activities, outcomes, and contextual factors (Connell & Kubisch, 1998) and articulates "how and why the program will work" (Weiss, 1995, p.66). Explicating a theory of change aims to help the researcher or evaluator focus on a specific component of the program, synthesize relevant theories of change, disclose implicit assumptions, and shape policy (Weiss, 1995). In this section, I rely on information, assumptions, and findings gathered from the literature on dual enrollment to propose a theory of change explaining how and why taking dual enrollment

on a college campus versus the high school may impact student high school graduation and college-going behaviors. I propose that taking dual enrollment on a college campus results in positive student outcomes by providing an authentic college learning experience that includes exposure to college campus, rigorous instruction by college faculty, and interactions with college students, which facilitate college student role rehearsal and integration.

Theories of role integration provide one plausible mechanism through which college-based dual enrollment may influence student high school graduation and college-going behaviors and which lays the foundation of the proposed theory of change. Specifically, dual enrollment provides high school students with opportunities for *role rehearsal* (Karp, 2007; Karp, 2012). High school students taking college-credit courses are expected to learn about college demands and familiarize themselves with what college academics and socializing entail. Authentic college experiences (i.e., experiences that mirror most accurately the college reality) provide high school students with greater opportunities for *role rehearsal* (Karp, 2007; Karp, 2012). To the extent that dual enrollees taking a college-credit course on the campus of a postsecondary institution are more likely to view the course as an authentic college course (Edwards & Hughes, 2013; Karp, 2012), they are more likely to enact and integrate the role of college student thus setting in motion the transition from high school to college. I view the role of college student as integrating five components:

- academic skills (reading and writing skills);
- academic behaviors and habits (study skills, note-taking skills, and the ability to take responsibility for one's learning);
- social and interpersonal characteristics (participating in class discussions and engaging in formal relationships with professors and peers);

- personal habits and traits (intrinsic motivation, time management skills, and the ability to balance multiple roles) (Karp, 2006, p.82); and
- college knowledge (i.e., knowledge about college admission, college costs, financial aid, postsecondary culture, etc.), a construct drawn from Conley's (2010) model of college and career readiness.

Several linkages describe how course authenticity facilitates college student role integration. High school students who participate in dual enrollment on a college campus benefit from direct exposure to the physical college environment. Unlike in the restrictive high school environment, access to and mobility across a college campus are often contingent on a valid student identity card thus signaling to students the prerogatives and responsibilities of adulthood (Cochran & Burns, 2007). Exposure to an actual college campus helps high school students learn how to navigate the college environment, locate available resources (e.g., library, tutorial center, recreation and wellness center, etc.), familiarize themselves with campus norms and culture, attend college events, and start imagining a post high school future as a college student. Considering "adolescents aspire to what they know or can imagine" (Haller & Virkler, 1993), we may safely assume attending college-level courses on a college campus builds college knowledge, facilitates adjustment to college, and expands the boundaries of what high school students know or can imagine. Consequently, college-based dual enrollees are more likely to finish high school, take steps to apply to college, and report higher postsecondary enrollment intentions.

While a limited number of high school-based dual enrollment courses may be taught by college faculty and enroll a mix of high school and college students, students enrolled in dual credit on a college campus most likely receive instruction from college faculty alongside regular college students (Karp & Hughes, 2008). Dual enrollment courses taught by college instructors

tend to be more rigorous than high school-based courses. Exposure to college course rigor and interactions with faculty help students develop a realistic understanding of college academic skills and habits and promote integration of these role aspects into students' self-concepts. Compared to high school teachers, college instructors expect students to show stronger academic skills, require minimal classroom management, and act as adults. As a result, students invest more time and effort in developing academic skills like reading and writing. Additionally, high school students are more likely to take responsibility for their own learning, develop academic behaviors (e.g., engaging in independent note-taking, taking initiative to seek help), and self-manage their class behaviors, attendance, assignments, and study time. High school students who practice college academic skills and behaviors will be more likely to succeed in their dual enrollment courses, thus becoming more confident in their ability to pursue and obtain a postsecondary degree. Increased self-efficacy is likely to result in heightened college-going behaviors (e.g., high school graduation, postsecondary application and enrollment).

Taking college-based dual enrollment means high school students have regular college students as peers. Given that regular college students are likely to exhibit more maturity and college-going attitudes, high school students are inclined to take college-based courses more seriously than high school-based courses, intensify their academic efforts, and adjust their behaviors to more closely match their peers'. Additionally, discussions inside and outside the classrooms with peers may broaden high school students' perspectives by exposing them to diverse viewpoints and help them practice the social and interpersonal skills needed to successfully establish and maintain college interactions and relationships. Thus, interactions with college peers help students practice academic behaviors and habits as well as social and interpersonal skills essential to students' successful transition to college. As students become

savvier in navigating social and academic college norms they will also take steps towards postsecondary entry.

In summary, exposure to a college campus, rigorous instruction, and interactions with regular college students facilitate rehearsing and internalizing key aspects of the college student role. As high school students take on the college student role, they increase their self-efficacy and gain confidence that they belong on a college campus resulting in better proximal outcomes such as increased high school graduation, more adroit navigation of college application process, and higher college aspirations. In turn, these proximal outcomes will have a positive impact on actual postsecondary enrollment. Figure 1 depicts the linkages posited by the theory of change described above.

Why Does Dual Enrollment Matter?

Between 2001 and 2008, roughly 65% of high school students enrolled in a postsecondary institution immediately upon obtaining their diploma (Aud et al., 2010). Despite enrolling in postsecondary education, more than half of college students report their high school failed to teach them the study habits necessary to be successful in college-level work and roughly 40% view themselves unprepared for college expectations (Achieve, 2005). Half of students who start their postsecondary journey at a community college and a fifth of students at four-year institutions are required to pursue remedial or developmental education prior to being allowed to take credit bearing courses (Complete College America, 2012). Despite its good intentions, remediation often marks a grueling path to completion. Fewer than 10% of remedial students at two-year colleges earn their degree in three years and slightly over a third of remedial students at four-year colleges graduate in six years (Complete College America, 2012).

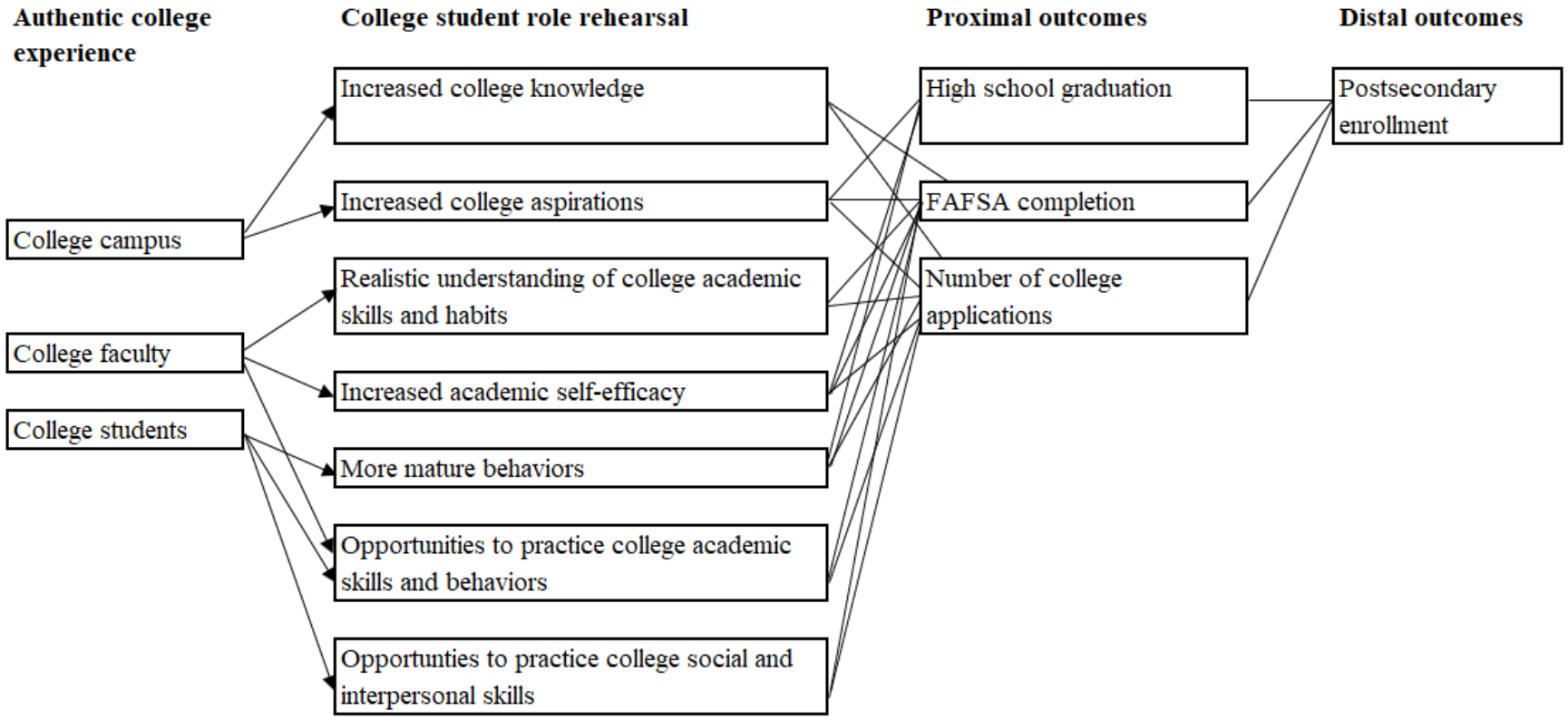


Figure 1. Theory of Change Explicating the Causal Mechanisms Through Which Dual Enrollment Location May Impact Student Outcomes.

Interest in boosting college degree completions is deeply connected to the wide array of benefits college graduates accrue over their lifetime and also translate into broader economic and societal gains. Relative to individuals with lower levels of education, most adults who hold a bachelor's degree tend to receive higher earnings, be employed at higher rates and more satisfied with their job, and benefit from higher social mobility (Baum, Ma, & Payea, 2013). Furthermore, graduates are more likely to take interest in salient political issues, vote, have health insurance through their employer, and less likely to engage in unhealthy behaviors like smoking (Baum et al., 2013). Perhaps most importantly, these seemingly individual gains have rippling implications for society as a whole, leading to overall healthier and happier individuals who lead productive and civically engaged lives that sustain their communities (Baum et al., 2013).

In the context of inadequate preparation for college, transformational strategies that have the potential to expedite students' transition to postsecondary education while also endowing them with the skills needed to be successful garnered increased attention (Hofmann, 2012). With evidence suggesting intense and rigorous high school coursework is the best predictor of college completion (Adelman, 2006), dual enrollment appealed to many policymakers as an opportunity to expose high school students to challenging postsecondary academics and, in the process, enhance the high school curricula and facilitate college preparation and success (Allen, 2010; Karp, 2007). Between 2001 and 2010, the number of dual enrollments nearly doubled to more than 2 million (Thomas et al., 2013).

A growing body of research indicates dual enrollment participation is related to increased college readiness (An & Taylor, 2015), obtaining a high school degree (Karp et al., 2007; Karp et al., 2012), college enrollment (Giani, Alexander, & Reyes, 2014; Hughes, Rodriguez, Edwards, & Belfield, 2012; Swanson, 2008), lower rates of remediation (An, 2013b), higher college GPA

(Adelman, 2006), higher rates of persistence (Rodriguez, Hughes, & Belfield, 2012), greater number of accumulated credits (Karp et al., 2007), shorter time to degree (Allen & Dadgar, 2012) and higher rates of college completion (An, 2013a; Blankenberger, Lichtenberger, & Witt, 2017). When delivering an authentic postsecondary experience, defined as exposure to college-level coursework taught by college instructors in a classroom environment shared with college peers, dual enrollment helps high school students observe and internalize what being a college student means (Karp, 2012). Additionally, dual enrollment is claimed to discount the cost of postsecondary education by providing free or low-tuition college courses and shortening time to degree (Johnson & Brophy, 2006; Vedder et al., 2010), broaden postsecondary access for disadvantaged students (Howley et al., 2013), challenge and build academic motivation, and even expedite college admission upon high school completion (Hoffman et al., 2009).

What Are the Concerns About Dual Enrollment?

Concerns about dual enrollment relate to the financial burden borne by students participating in dual enrollment courses (e.g., tuition, fees, textbooks and transportation costs) (Burns & Lewis, 2000), challenges in securing adequate funding for both secondary and postsecondary partners (Lerner & Brand, 2006), students' maturity (Catron, 2001) and emotional readiness (Zimmerman, 2012), and problematic power dynamics between high school and college staff (Howley et al., 2013). But chief among concerns is that high schools cannot replicate the college experience (Zimmerman, 2012; Thomson, 2017). Critics of dual enrollment claim college-level learning should transcend course content and convey knowledge acquired through interactions with college peers in postsecondary settings and independent thinking gained through unstructured instruction typical of college academics (Johnstone & Del Genio, 2001; Thomson, 2017). Moreover, some states require dual enrollment high school instructors to

obtain at least 18 hours of graduate coursework and pursue credentials equivalent to adjunct faculty status at community colleges (ECS, 2016). As some high schools struggle to attract and retain qualified instructors (Piontek, Kannapel, Flory, & Stewart, 2016), critics have expressed concerns about maintaining quality across the various delivery configurations (Barnett, 2003).

Additional concerns related to dual enrollment stem from issues with credit transferability. As with other dual enrollment components, transfer policies vary across states. For instance, while Ohio clearly designates which credits may transfer towards general education or major requirements, Virginia places decision-making related to course transferability with postsecondary institutions (Pretlow & Patteson, 2015). As a result of this decentralized transfer policy, some students and parents are confused about where they can transfer dual enrollment credits (Pretlow & Patteson, 2015). In states like Connecticut, Michigan, and New York, some four-year institutions choose to disregard college credits earned through high school-based dual credit taught by high school teachers (Barnett, 2018). Other postsecondary institutions choose to restrict credit transferability. In 2009, New York University reversed its decision to grant academic credit for college-level courses taken during high schools in which students had received both college and high school credit (i.e., dual credit) on grounds of being unable to verify academic rigor (Heggen, 2008). In commenting on its decision, the school explicitly distinguished between what it considered *dual enrollment*, namely, taking a college course on a postsecondary campus with other postsecondary students, and high school-based *college-level* courses taught by high school instructors (Allen, 2010). The school concluded that the former should be granted college credits while the latter should only receive high school credit. Thus, where a dual enrollment course is delivered can lead to assumptions about educational quality and rigor and influence the perceived credibility of dual enrollment. In turn, this perceived

credibility may have further implications for the transferability of dual enrollment college credits and overall benefits.

Where and When Does Dual Enrollment Take Place?

Dual enrollment courses may be delivered at the high school, on a college campus, or online (Barnett et al., 2004). Most states have policies permissive of high school students taking dual enrollment on college campuses and only three states restrict dual enrollment access to postsecondary settings (Smith, 2014). A 2010 study conducted by the National Center for Education Statistics indicates over half of public high schools report dual credit courses being taught in locations for secondary school students, predominantly high school campuses (Thomas et al., 2013). Although 43% of public high schools have students enrolled in dual credit courses taught on a college campus, a close look at the number of actual dual credit enrollments by course location shows high schools remain the main stage on which dual enrollment takes place, regardless of course focus. Seventy-three percent of academically-focused dual credit enrollments took place in a location for secondary school students and only 20% occurred at a postsecondary institution (Thomas et al., 2013). The proportion of dual credit enrollments in secondary school locations is even higher among career and technical/vocational dual enrollees. Only 12% of enrollments in career and technical/vocational dual credit courses were associated with a college campus whereas 86% were linked to a secondary school location. These recent statistics corroborate earlier claims that college campuses house a large proportion of dual enrollment courses but a small proportion of dual enrollment students (Barnett, 2003).

National (Thomas et al., 2013) and state-level (Appleby et al., 2011; Miller et al., 2017) studies indicate participation in dual credit is highest among rural high schools where 30% of all public high school dual credit students are enrolled. But although rural high schools are more

likely to offer opportunities for dual enrollment, they are also less likely to provide dual credit courses on a college campus (Thomas et al., 2013; Zinth, 2015). Geographic location and access to resources play significant roles in shaping student access to campus-based dual enrollment. High schools located in close proximity to higher education institutions benefit from wider access to campus-based dual enrollment options (Piontek et al., 2016). In contrast, geographic isolation can raise transportation barriers and restrict students to courses available at the high school.

Decisions about dual enrollment locations are closely related to funding of dual enrollment (Allen, 2010). Some researchers argue that the cost of thirty high school students taking a high school-based college course with a college faculty is lower than the cumulative amount incurred by those same students for the college-based version, even when paying a discounted tuition rate (Hoffman et al., 2008). Conversely, other educators claim campus-based dual enrollment courses are more cost-efficient and raise concerns about the liability associated with high school students driving and scheduling conflicts between secondary and postsecondary institutions (Mace, 2009).

Taking dual enrollment courses at the high school during the regular school day is the most convenient arrangement as it eliminates transportation barriers and facilitates extracurricular activities (Karp et al., 2012). Differences in high school and college schedules may cause students to miss two high school periods (Mace, 2009). To reduce issues related to schedule misalignment, in some states dual enrollment courses are available during the regular school day as well as before or after school and during the summer (Hoffman, Vargas, & Santos, 2009; Karp et al., 2012).

Who Can Take Dual Enrollment?

According to data reported by the Education Commission of the States (ECS) (2016), forty-seven states have policies that address dual enrollment at least to some extent. Some state policies establish specific eligibility requirements while others delegate this task to partnering institutions (Karp et al., 2012) Twenty-five states require dual enrollment candidates to meet the admission requirements set forth by postsecondary institutions or demonstrate college readiness by scoring over a particular score threshold on a college readiness assessment or placement tests (ECS, 2016; Friedman et al., 2011; Karp et al., 2012). Sometimes, eligibility criteria for academically oriented dual enrollment courses are higher than those for vocational dual enrollment courses (ECS, 2016). Other states impose a minimum high school GPA or age and grade restrictions that limit access to mostly junior and senior high school students (ECS, 2016; Friedman et al., 2011). And a third of states leave eligibility decisions at the discretion of secondary and/or postsecondary institutions (ECS, 2016). Although postsecondary institutions typically make the final eligibility call, they often expect high schools to serve as gatekeepers by laying out additional enrollment criteria and making recommendations for potential dual enrollment candidates (Miller et al., 2017). Hence, admission into a dual enrollment course is often contingent on school approval or recommendation (ECS, 2016; Friedman et al., 2011).

How Are Dual Enrollment Courses Selected and Designed?

A variety of factors may influence the range of dual enrollment course offerings. Twenty-two states explicitly exclude remedial courses from at least one or all dual enrollment programs (Miller et al., 2017). Some high schools seek to enrich their curricula and provide students with courses previously unavailable (Barnett et al., 2004). Partnering with postsecondary institutions may enable high schools to offer courses that the absence of credentialed instructors or adequate

equipment would have rendered untenable (Barnett et al., 2004). In other cases, the selection of dual enrollment courses is highly contingent on postsecondary institution interests and preferences (Piontek et al., 2016). Additionally, high school proximity to the postsecondary institution may impact students' ability to access the college campus in a feasible and timely manner and shape decisions about which courses are offered.

Dual enrollment courses serve various needs, with some intended to meet general education requirements and other focusing on specific career pathways (Purnell, 2014). In support of the dual enrollment college readiness agenda, most dual credit offerings favor general education courses (i.e., English, history, math, science, etc.) over career or technical/vocational courses (i.e., computer technology, automotive technology, nursing, etc.) (Friedman et al., 2011; Miller et al., 2017; Thomas et al., 2013). Hence, 93% of public high schools offering dual credit have students in dual-credit courses with an academic focus. The rationale for promoting academic dual enrollment is anchored in the desire to secure course transferability (Miller et al., 2017). To this end, partnership agreements typically instruct dual enrollment courses and corresponding regular college courses to rely on common materials and examination practices (Swanson, 2008).

Who Teaches Dual Enrollment?

Dual enrollment students may receive instruction from postsecondary instructors or properly credentialed high school teachers (Allen, 2010). With high schools having emerged as the primary setting for dual enrollment, it follows that most dual enrollment courses are taught by high school instructors (Barnett, 2003; Kim et al., 2003; Zinth, 2015). Almost two thirds of public high schools where students are taking academic dual credit courses at secondary school locations indicate courses are taught exclusively by a high school instructor (Thomas et al.,

2013). The proportion is even higher for high schools with students in career and technical/vocation dual credit courses. Moreover, only 11% of high schools with academically-focused dual enrollments and 14% of high schools with career and technical/vocational dual enrollments report these courses were taught by a college instructor solely.

To uphold similar standards of academic quality across dual enrollment courses irrespective of instructor level, many high school teachers have to meet requirements for and receive adjunct status with the postsecondary institution (Allen, 2010; Hoffman, 2005; Johnstone & Del Genio, 2001; Kim et al., 2003). For instance, in California, high school teachers who wish to gain adjunct status with a two-year postsecondary institution must earn a master's degree in their subject of interest, the same qualification required of community college instructors (Allen, 2010). As a result, some schools face the conundrum of broadening access to dual enrollment courses within the constraints of a limited number of qualified high school instructors.

Who Pays for Dual Enrollment?

Taking a college-level course while enrolled in high school involves simultaneous enrollment in both the secondary and postsecondary institutions and raises questions related to state allocation of per-pupil funding (Karp et al., 2012). To alleviate school concerns over loss of funding and encourage dual enrollment participation, roughly two thirds of states and the District of Columbia provide equal funding to high schools and postsecondary institutions for both regular students and dual enrollees (ECS, 2016). For example, in North Carolina, dual enrollees may count towards both the high school average daily attendance (ADA) and college full-time equivalency (FTE) resulting in concurrent funding (Karp et al., 2012). In a few states, funding is contingent on the type of dual enrollment program in which the student enrolls (ECS, 2016). Thus, Kentucky determines funding based on the course location and instructor: dual enrollees

pay no tuition for campus-based dual enrollment or high school-based dual enrollment taught by a high school teacher but must cover 50% of tuition costs when taking a high school-based dual enrollment course taught by a postsecondary instructor (Karp et al., 2012).

Tuition for dual enrollment courses is a major expense associated with dual enrollment programs and most state policies address it albeit not necessarily prescribe it. Only nine states have dual enrollment policies that clearly place responsibility for paying dual enrollment tuition with the state or district (ECS, 2016). Twenty-five states and the District of Columbia either relay decisions about tuition responsibility to local agreements between the secondary institution or district and the postsecondary institution or establish different levels of financial responsibility for different dual enrollment programs.

It is important to note that although many students participating in dual enrollment programs benefit from free tuition (Andrews & Barnett, 2002), in twenty-four states students and parents are either fully or partially responsible for paying dual enrollment tuition (ECS, 2016). Moreover, limiting the costs of dual enrollment to tuition is highly simplistic. In reality, student expenses associated with dual enrollment courses may include textbooks, transportation, support services, and instructor professional development (Cassidy et al., 2010; Hoffman, et al., 2008; Smith, 2014; Thomas et al., 2013).

Differences in Dual Enrollment Implementation

Despite the staggering increase in the number of dual enrollments and soaring interest in examining the overall effects of dual enrollment participation, little is known about the mechanisms through which different dual enrollment configurations influence students' postsecondary attendance and completions (Sunderman, 2016). Program process or implementation evaluation is an assessment strategy that seeks to capture the extent to which

program components are integrated and function as intended (Rossi, Lipsey, & Freeman, 2004). To this end, implementation evaluations may rely on data describing program operations, site comparisons, and adherence of implementation to initial design (Rossi et al., 2004). While there are many state-level analyses of dual enrollment, the bulk of them focus on describing local trends in dual enrollment access, participation, and practices (Miller et al., 2017). A limited number of state-level studies (Miller et al., 2017; Miller et al., 2018; Piontek et al., 2016) approach dual enrollment from an implementation perspective and seek to shed light on issues related to the quality of and adequate delivery of dual enrollment services. Those studies provide the foundation for my general comparison of college-based and high school-based dual enrollment implementation.

The typical dual enrollment arrangement consists of students taking academically-focused college courses where they receive instruction from a high school teacher in their home high school (Barnett, 2003; Hoffman, 2012; Miller et al., 2018; Piontek et al., 2016; Thomas et al., 2013; Zinth, 2015). To minimize variation in dual enrollment course quality regardless of delivery setting, state-level policies often establish course guidelines and minimum requirements for dual enrollment instructors (Borden, Taylor, Park, & Seiler, 2013). To teach dual enrollment courses, high school teachers are often required to have a graduate degree with at least 15 to 18 credit hours in the subject being taught or qualifications equivalent to adjunct faculty (ECS, 2016), Despite these efforts to secure qualified instructors, a specialized graduate degree and other competences deemed necessary for quality dual enrollment instruction remain absent from many high school teachers' repertory of professional qualifications (Zinth, 2015). In some states, postsecondary institutions apply accreditation standards in selecting dual enrollment instructors

but researchers find no evidence of systematic efforts to assess the equivalency in qualifications and experience between high school instructors and college faculty (Miller et al., 2017).

Many districts require dual enrollment courses to follow the same course syllabi, textbooks, learning outcomes, and assessment strategies across different instructors and delivery modes and locations (Piontek et al., 2016). In light of these efforts to ensure consistency, high school-based dual enrollees often benefit from the same materials used in the college-based version of the course.

Given that postsecondary institutions have unrestricted access to faculty members who have both the qualifications and content expertise to teach college-level courses, students who take dual enrollment courses on a college campus are less likely to experience problems related to the quality of their dual enrollment courses (Tobolowski, 2016). Findings from a recent study in Texas suggest there are many similarities between dual credit taught by high school teachers, dual credit taught by college faculty, and college-credit only courses where the instructor is a college faculty (Miller et al., 2018). In examining course assessments, researchers observed that high school dual credit instructors were more likely than postsecondary faculty members to employ test items in the format of multiple choice and true/false questions (Miller et al., 2018). High school dual credit instructors relied more on technology to deliver instruction while college faculty required students to engage in more independent work, make analytical sense of information obtained from multiple sources, and participate in group discussions. Finally, high school dual credit instructors also allocated the least amount of class time to metacognitive exercises (Miller et al., 2018).

These findings suggest students in high school-based dual enrollment may receive more prescriptive instruction while college-based dual enrollees are initiated into the college rites of independent study and analytical thinking. It is important to note that these assumptions rest on some caveats. First, because many college instructors fail to distinguish dual enrollment participants from

regular college students when colleges courses take place on a postsecondary campus (Lile, Ottusch, Jones, & Richards, 2017), I assume the comparison between the high school dual credit and the college-credit-only course is a more accurate reflection of implementation differences between high school-based and college-based dual enrollment. Second, Miller et al.'s (2018) study has several limitations including a small sample (i.e., four instructors for each type of course) and a focus on course content and lacks classroom observations or other direct assessments of the quality of instruction.

The influence of dual enrollment locations on students' experience of dual enrollment courses extends beyond course content and pedagogical approaches. In addition to encouraging independent study skills and responsibility for one's education, college faculty tend to provide college-based dual enrollees with better insight into college life as they are more likely to know the intricacies of college learning and norms (Karp et al., 2012). Consequently, it is unlikely that all high school-based dual enrollees receive the same college-level instruction and information they would have gained in a college-based dual enrollment course.

Taking dual enrollment on a college campus rather than at the high school has implications for the peer group composition and, implicitly, for students' experiences. Students who take dual enrollment courses on college campuses attend class alongside diverse college students (Thomas et al, 2013). In contrast, high school students taking dual enrollment in a high school setting typically attend class with other high school students (Lile et al., 2017). In some states, those high school peers may also be regular students who are enrolled in dual enrollment courses albeit without earning college credits (Miller et al., 2017). Thus, high school-based dual enrollment courses tend to provide students with a more homogenous and familiar environment, while college-based dual enrollment courses may provide students with a more diverse student body. Through interactions with college-level peers inside and outside the classroom, college-

based dual enrollees are more likely to learn about and try on the role of student, which may evade high school-based dual enrollees whose peers are also high school students.

When students take dual enrollment courses at the high school they tend to choose their courses from a more narrow list of available dual enrollment coursework that typically focuses on general education or career pathways (University of California at Berkeley, College and Career Academy Support Network, 2019). In contrast, because postsecondary institutions have greater access to qualified instructors than secondary institutions, college-based dual enrollment courses often include a wide range of courses, including electives (Friedman et al., 2011). Thus, high-school based dual enrollment are more likely to take general education or career and technical education dual enrollment courses while college-based dual enrollees can choose more advanced courses or electives that are unavailable at their high schools.

Teaching a dual enrollment course in a high school setting allows high schools more control over the course, even when the instructor is a college faculty member (Martell, Navin, & Sullivan, 2006). High school-based dual enrollment instructors, including college faculty, typically conform to high school policies governing student learning evaluation and grading. While college-based courses preclude students with unexcused absences from requesting make-up examinations or submitting late assignments, students who take dual enrollment at the high school can generally capitalize on these options (Martell et al., 2006). Additionally, they also tend to benefit from a disciplinary leniency rarely extended to college-based dual enrollees (Mace, 2009). In college-based courses, students caught napping, carrying on side conversations, or engaging in other high school-like behaviors disruptive of learning may be simply dismissed from class (Mace, 2009). This course of action is unavailable in a high school setting. Consequently, students in high school-based dual enrollment may be more likely to display less

mature behaviors and spend less time engaged in course content as instructors have to invest more time in classroom management activities rather than teaching.

Participating in dual enrollment on a college campus provides a more authentic college experience but may collide with cost and logistical constraints (Miller et al., 2018; Smith, 2014; Sunderman, 2016). College-based dual enrollees often have to navigate the misalignment between high school and college schedules (Mace, 2009). Moreover, they have to secure transportation to the postsecondary campus resulting in increased financial burden for their families (Sunderman, 2016). Over half of public high schools with dual enrollees report transportation needs related to dual enrollment courses and almost all indicate that financial burden falls to students and their families (Thomas et al., 2013). Additionally, students who take dual enrollment on a college campus may have to pay fees for campus student services that high-school based students are typically exempt from (University of California at Berkeley, College and Career Academy Support Network, 2019). On the one hand, these expenses may limit low-income students to high school-based dual enrollment; on the other hand, they may open access to resources on the college campus. Regardless of whether they have to pay fees or not, students enrolled in college-based dual enrollment courses typically have a college identification card and access to the numerous resources college campuses provide: college-level research facilities, library, laboratories, technology, advising and career development professionals, tutoring center, tutoring, and other student services that high school-based dual enrollees may not access (Mace, 2009; Piontek et al., 2016). Most importantly, access to the resources available on the college campus may enhance learning and acclimatize students to college structures. In contrast, access to technology is more restricted in high schools and high-school based dual enrollment are likely to lack college-level student resources and services (Mace, 2009).

Across the nation, dual enrollment partnerships strive to ensure consistency in the quality of dual enrollment courses irrespective of where course may be taught, who may be teaching them, and how they may be delivered. Nevertheless, some differences between high school-based and college-based dual enrollment are likely to persist. In general, college-based dual enrollees receive instruction from college faculty, face stricter expectations regarding personal and academic conduct, and interact with diverse college peers. All these factors are likely to influence students' understanding of college norms, academics, and structures.

Research on Dual Enrollment

In 2010-2011, four out of five public high schools had students enrolled in dual credit courses (Thomas et al., 2013). While broadening dual enrollment access has seen a tremendous surge in policymaker interest and buy-in, there has been little effort to standardize dual enrollment and provide a uniform approach (Karp et al., 2005; Miller et al., 2017). Consequently, the dual enrollment landscape is rife with variations in program design and implementation but lacking in knowledge about *how* model configurations work and *which* dual enrollment components are more effective (Sunderman, 2016). Insofar as dual enrollment delivery setting remains a model component largely unexplored, its prevalence and causal implications remain vastly unknown (Miller et al., 2017).

In reviewing the literature on dual enrollment, I focus on studies that seek to understand the role of dual enrollment, dual credit, and concurrent enrollment in shaping students' experiences and higher education access and success. Although some studies presented here may also examine the role of AP or IB participation, research exclusively focused on comprehensive dual enrollment programs (i.e., early college high schools) and accelerated learning programs other than dual enrollment, dual credit, or concurrent enrollment were excluded from this

overview. To situate my study in the context of dual enrollment research, I summarize the literature based on the most common operationalization of dual enrollment (i.e., dual enrollment participation) and the variable of interest (i.e., location of dual enrollment).

Participation. The bulk of what we currently know about dual enrollment and its role in students' high school and college experiences is the product of research studies that operationalize dual enrollment as a participation indicator (An, 2013a; An, 2013b; An, 2015; An & Taylor, 2015; Allen & Dadgar, 2012; Cowan & Goldhaber, 2014; Eimers & Mullen, 2003; Giani et al., 2014; Struhl & Vargas, 2012; Taylor, 2015). Typically, these studies conflate students who took one or more dual enrollment course(s) or earned one or more college credit(s) during high school into one single category. Researchers may then compare dual enrollment participants' outcomes against those of dual enrollment non-participants or, sometimes, of high school students who earned college credits through AP, IB, or a combination of dual enrollment and AP or IB.

Taking college courses during high school has been linked to higher educational aspirations (Smith, 2007). However, the association between dual enrollment participation and high school completion appears inconclusive. Early research on students in Florida shows that dual enrollment participants are more likely to obtain a high school diploma than nonparticipants (Karp et al., 2007). However, a more recent investigation of students in the same state finds that dual enrollment has no effect on high school completion (Speroni, 2011b). Evidence from Washington State shows that dual enrollment participation is associated with decreased likelihood of obtaining a credit-based diploma and increased likelihood of leaving high school without a credential or earning the GED (Cowan & Goldhaber, 2014). Findings related to high

school graduation suggest taking college courses during high school may not necessarily benefit all students.

Discussions around college readiness point out that students often enter college without having a sound understanding of college expectations (Bailey et al., 2002). Consequently, research on dual enrollment has been concerned with identifying its role in improving cognitive and non-cognitive aspects of college readiness. In a study that used longitudinal data from the Wabash National Study of Liberal Arts Education (WNSLAE), undergraduates who had participated in dual enrollment outperformed non-participants in three of four college readiness categories (An & Taylor, 2015). While dual enrollees were similar to non-participants in terms of demographic characteristics, they displayed higher levels of key cognitive strategies, key content knowledge, and key learning skills and techniques. Explorations of the mechanisms through which dual enrollment prepares students for college reveal that taking dual enrollment courses helps students learn what it means to be a college student, try that role, and learn how to take responsibility for their learning (Karp, 2012). Notably, although dual enrollment participation was not associated with key transition knowledge and skills in the WNSLAE study, non-participants included students who had enrolled in one or more AP course(s) but had not earned college credit which may have biased the coefficient downward (An & Taylor, 2015).

In addition to better preparing students for college, dual enrollment participation also influences college-going behaviors. Results from quasi-experimental studies in Texas suggest that dual enrollment participation increases the likelihood of college enrollment (Cowan & Goldhaber, 2014; Giani et al., 2014; Karp et al., 2007; Struhl & Vargas, 2012). And in addition to enrolling in college at higher rates than traditional students, dual enrollment participants are more likely to attend college full-time (Karp et al., 2007). Dual enrollment also impacts time to

college enrollment. Findings based on a study of a nationally representative sample suggests dual enrollment participation results in a 12 percentage point increase in the probability of enrolling in a postsecondary institution within seven months of high school completion (Swanson, 2008). Low-achieving dual enrollees who delayed enrollment also benefit from dual enrollment as they eventually enter college at higher rates than anticipated (Cowan & Goldhaber, 2014). However, dual enrollment participation may increase attendance at two-year colleges at the detriment of four-year college attendance.

Interest in the link between dual enrollment and remediation has also heightened, especially as evidence supporting the negative impact of remediation on college completion has grown (Tierney & Duncheon, 2015). In a nationally representative study, students who did not take dual enrollment courses had a 6 percentage-points higher probability of enrolling in remedial education than dual enrollment participants (An, 2013b). The effect is even larger for community college students as dual enrollment decreases their probability of remediation by 9 percentage points (Grubb et al., 2017).

Most studies investigating the link between dual enrollment participation and postsecondary academic performance attest to the positive effects of dual enrollment. Using data from a nationally representative longitudinal study, the Beginning Postsecondary Students Longitudinal Study 2004-2009, An (2013b) finds that dual enrollment participation increases first-year GPA by 0.11 percentage points. This estimate is similar to other state-level findings associating dual enrollment participation with increases in first-semester and first-year GPA (Allen & Dadgar, 2012; Karp et al., 2007).

Accounting for student characteristics (i.e., race, gender, family background, ACT, motivation during high school), dual enrollment participants at mid- and very selective colleges

have a 0.14 higher first-year GPA than undergraduates who did not participate in accelerated learning programs (An, 2015). Academic motivation and engagement appear to explain only a small proportion of the relationship between dual enrollment and GPA (An, 2015). The exception is dual enrollment participants attending highly selective institutions for whom the effect of dual enrollment participation on first-year GPA is entirely mediated by academic motivation and engagement. Compared to students who did not participate in accelerated learning programs, dual enrollees exhibit higher levels of academic motivation and engagement as evidenced by increased involvement in college conversations (An, 2015). The influence of dual enrollment participation on academic engagement varies by level of college selectivity.

As touted by its supporters, one way in which earning college credits during high school may be promoting degree completion and shortening the time to degree is by instilling academic momentum (Adelman, 1999; Adelman, 2006). This claim is supported by an examination of first-time freshmen at 17 colleges within the City University of New York. Students who had participated in New York's dual enrollment program, College Now, earned more credits during their first year of college (Allen & Dadgar, 2012) suggesting dual enrollment does foster academic momentum into postsecondary environments.

Undergraduates who earn college credit in high school are also more likely to persist into their second year of college than students entering higher education without any college credits (Allen & Dadgar, 2012; Eimers & Mullen, 2003; Struhl & Vargas, 2012; Swanson, 2008). Dual enrollment participation increases second-year persistence in both state-level (Allen & Dadgar, 2012; Eimers & Mullen, 2003; Karp, 2007; Karp et al., 2007; Struhl & Vargas, 2012) and national-level analyses (Swanson, 2008). Furthermore, the credit threshold previously identified by Adelman (2006) is solidified by findings associating increased persistence with dual

enrollment students' completion of at least 20 college credits during their first year in college (Swanson, 2008).

In addition to improved persistence, dual enrollment participants seem to complete their degrees at higher rates than students who completed no dual enrollment courses. Thus, dual enrollees are eight percentage points more likely to obtain any college degree and seven percentage points more likely to obtain a bachelor's degree (An, 2013a; Blankenberger et al., 2017). Results from the NELS:88 study confirm prior findings from Texas indicating higher rates of six-year graduation for dual enrollment students enrolled in two- or four-year colleges (Struhl & Vargas, 2012). The type of postsecondary institution dual enrollment students attend also plays a role in how dual enrollment impacts students. At the community college level, dual enrollment participants are 26% more likely to complete their degree in two years and 28% more likely to complete their degree in three years than non-participants (Grubb et al., 2017). Additionally, the probability of persistence and completion is higher for dual enrollment participants enrolled at community colleges than for those at four-year institutions (Struhl & Vargas, 2012).

Notably, benefits of dual enrollment participation extend to traditionally underserved students as well (Borden et al., 2013). While college access benefits appear to accrue to all dual enrollment students, traditionally underserved students (i.e., African-American students and students from economically disadvantaged families) attending four-year institutions benefit the most (Struhl & Vargas, 2012). First-generation dual enrollees also reap more gains than their non-first-generation counterparts (An, 2013a). Dual enrollees who are the first in their family to attend college are 4 percentage-points lower in their probability of taking remediation relative to non-participants with at least one college-educated parent (An, 2013b). They also earn a higher first-year GPA than similar non-participants albeit the increase is small, 0.09 points (An, 2013b).

Furthermore, economically disadvantaged students are almost twice more likely to attain their degree in six years (Struhl & Vargas, 2012) and dual enrollment students of color have significantly higher probability of completing college (Taylor, 2015). These findings corroborate the relationship between dual enrollment and four- and five-year degree attainment established in previous research (Klopfenstein, 2008) and lend support to those advocating for dual enrollment opportunities provided to all students.

Location. A limited number of studies and dissertation inquiries have attempted to understand how the location of dual enrollment courses may influence students' academic and social experiences. Qualitative evidence from rural Southeast Texas indicates that although students report positive impressions of all their dual enrollment courses, overall they place greater value on college-level courses taken on a college campus. Students who take dual enrollment on a college campus express higher satisfaction with their experiences. Additionally, some students report that being on a college campus compelled them to take classes more seriously, infused a heightened sense of responsibility for their learning, and induced a growth-stimulating discomfort that, unlike the familiarities of high school, helped them confront and overcome their fears surrounding the college transition (Burns & Lewis, 2000).

Other qualitative studies focus on capturing the idiosyncrasies of high school-based dual enrollment taught by high school teachers. A mixed-methods evaluation of College Now, New York City's dual enrollment program, reveals that challenges in high school-based dual enrollment scheduling and cumbersome school safety measures are highly restrictive of students' independence and free movement resulting in frequent tardiness to dual credit courses (Cochran & Burns, 2007). Student perceptions of the distinction between high school and college courses are fairly mixed. Despite intuiting a difference between students' and teachers' roles in high

school and college settings, as in students should take their own notes in college classes instead of copying the teacher's notes off the board, many students struggle to articulate the difference. There is some perception that college means stereotypical "business like" interactions with stringent and uncompromising professors (Cochran & Burns, 2007). Consequently, some students viewed high school instructors who taught dual enrollment as too supportive and high school-based dual enrollment courses as too high school-like. This may explain why some students approached dual credit courses the same as regular high school courses. Similar to students in Burns and Lewis' (2000) study, most students seemed to see value in high school-based dual enrollment courses although. However, absent transportation restraints, many students would have preferred to take them on a college campus with college students (Cochran & Burns, 2007).

When high school students take dual enrollment courses on a college campus, they report multiple benefits including exposure to college campus, initiation to campus culture, and newly found autonomy (Kanny, 2015). However, in addition to benefits, students also identify several shortcomings associated with college-based dual enrollment: credit transferability, invalidating exchanges with college peers and faculty, and reduced access to support services. Students' dual enrollment grades lagged behind their typical high school grades ramping up their concerns over college admission. Perceptions of a chilly receipt by some college students and faculty corroborated with the unfamiliarity of the college environment exacerbated student discomfort and diminished sense of belonging (Kanny, 2015). Nevertheless, some dual enrollees acknowledge that their or other dual enrollees' immature behavior may have contributed to college peers' unwelcoming attitude. Finally, perceptions of insufficient support from their high

school and limited access to campus resources hampered students' college-based dual enrollment experiences (Kanny, 2015).

Students are not the only ones to perceive that college and high school settings may promote different student roles. Technical college dual enrollment instructors also favor college-based dual enrollment and deem it essential in conveying what college and being a college student mean (Harnish & Lynch, 2005). Moreover, instructors cite resource (e.g., equipment, lab facilities, class materials, etc.) availability on college campuses as another notable benefit for college campus dually enrolled students. However, greater perceived benefits associated with the college campus location are also accompanied by greater perceived obstacles like transportation and scheduling complexities (Harnish & Lynch, 2005).

While qualitative research helps researchers understand how dual enrollment location may influence student perceptions and experiences, quantitative studies seek to measure the relationship between location and student beliefs and outcomes. An early study uses data from a survey administered to 304 high school students from five rural high schools in Kansas to examine the association between dual enrollment location and students' educational aspirations (Smith, 2007). Controlling for parental education and student ability, academic performance, and attitudes towards courses and education, analyses reveal that dual enrollment is positively associated with educational aspirations with students taking dual enrollment on a college campus displaying increased educational aspirations over those taking college credit courses at the high school (Smith, 2007). Alternately, evidence from Washington suggests students' college self-efficacy may not differ by dual enrollment setting (Wallace, 2017). To measure self-efficacy, the author administered the College Academic Self-Efficacy Scale (CASE) to 181 dual credit students enrolled in similar English, history, or mathematics dual enrollment courses at one of

three community colleges. Using analyses of variance (ANOVA) and Tukey HSD, the author finds a statistically significant difference in mean scores of high school- and college-based dual enrollees, with higher self-efficacy scores among students who took the dual enrollment courses at the high school (Wallace, 2017).

Several studies investigate the relationship between dual enrollment delivery settings and academic performance with mixed results. Some researchers compare dual enrollment course grades of dual enrollees attending a community college in Southeast Virginia across three delivery environments: face-to-face on a college campus, face-to-face at the high school, and online (Arnold et al., 2017). Analyses of variance indicate students who took dual enrollment English 111 and Math 163 at the high school had higher grades than those who took dual enrollment on a college campus. However, another comparison of academic achievement between dual enrollees who took English or mathematics dual credit at one community college campus and those who completed the courses at one of five high schools found no statistically significant difference in end-of-course grades for neither the English nor mathematics dual credit group (Flores, 2012). These results led the author to conclude that where students took dual enrollment may be inconsequential for their college readiness (Flores, 2012). Using a random sample of 2,016 dual credit students enrolled at one of three community colleges, Martin (2014) finds a statistically significant difference in grades between college-based dual credit and high school- or online-based dual credit. Students who took dual enrollment on the college campus received more As and fewer Cs than students in the other groups (Martin, 2014).

One quasi-experimental study examines heterogeneity in dual credit effects across different dual credit settings. A recent study from Texas implements a fixed-effects approach exploiting variation in dual-credit participation within school districts to examine how changes in

average academic dual credit earned by instruction location influence several student outcomes (Villareal, 2018). Findings show no statistically significant difference in the percentage of high school completers across university, community college, and high school settings.

Comparisons of students' academic achievement by dual enrollment location also extend to postsecondary education. Following a sample of recent high school graduates who enrolled at Santa Barbara City College, Wintermeyer (2012) investigates whether dual enrollees' postsecondary outcomes (i.e., full-time college enrollment, first semester GPA and cumulative GPA at the end of their sixth semester, placement levels, and transferable credit earned) differ by dual enrollment setting (i.e., high school, college campus, or both). Tests of association suggest students who take dual enrollment on the college campus have higher full-time postsecondary enrollment. However, analyses of variance reveal students who took both high school- and college-based dual enrollment have higher first-semester and cumulative GPA, score better on placement tests, and complete more transferable credits (Wintermeyer, 2012).

Research suggests where students take dual enrollment courses may also affect postsecondary access. Controlling for student demographics, SES, and academic performance, school and district characteristics, and school fixed-effects, a study of dual enrollment and AP students in Florida shows that dual enrollment students are more likely to enroll in a postsecondary institution than AP students but less likely to attend a four-year college (Speroni, 2011a). Interestingly, for students taking both high school- and college-based dual enrollment courses the effect of dual enrollment on college enrollment occurs mainly through the community college location with apparently no benefit from the high school-based courses (Speroni, 2011a). In fact, taking dual enrollment exclusively at the high school has the same effect as AP or dual enrollment nonparticipation. These findings appear to question the quality of

dual enrollment courses held at the high school and reiterate the importance of exposing high school students to authentic college experiences.

Not only do college-based dual enrollees enroll in college at higher rates than high school-based dual enrollees, they also seem more likely to persist. Using data on high school students who took dual enrollment in South Carolina during 2005-2008 and enrolled in a technical college upon high school completion, researchers investigated the extent to which dual enrollment type (i.e., transfer or career) and setting (i.e, college campus or high school) predicted students' persistence into second year of college (D'Amico et al., 2013). The study found that the odds of persistence into the second year of college for college-based dual enrollment students were 1.325 the odds of high school-based dual enrollment students. A bivariate analysis yielded similar results, with students who took dual enrollment courses on a college campus having higher odds of persistence than those who took them at the high school. These findings hint at the potentially influential role college-based dual enrollment may play in helping students navigate and integrate in the college environment (D'Amico et al., 2013).

Limitations of Previous Studies

Although many recent studies (Arnold et al., 2017; Burns & Lewis, 2000; Cochran & Burns, 2007; D'Amico et al., 2013; Flores, 2012; Harnish & Lynch, 2005; Kanny, 2015; Martin, 2014; Smith, 2007; Speroni, 2011a; Wallace, 2017; Wintermeyer, 2017) explore how variations in dual enrollment setting may affect students, absent rigorous experimental and quasi-experimental research, little is known about the effectiveness of dual enrollment location in promoting student access and success. Qualitative studies provide us with rich information about dual enrollment students' and instructors' perceptions of benefits (Burns & Lewis, 2000; Cochran & Burns, 2007; Harnish & Lynch, 2005) and drawbacks (Kanny, 2015) associated with specific

dual enrollment delivery settings. However, although qualitative research offers valuable insights that further our understanding of dual enrollment workings and inform policy, answering questions about the effect of dual enrollment location is outside its scope.

A paucity of quantitative studies investigates the role of dual enrollment course location in shaping college access and success. However, most of these studies rely on less than rigorous methodological approaches that cannot establish causation. Several researchers use chi-square and ANOVA with Tukey HSD post hoc tests to compare dual enrollees' secondary (Arnold et al., 2017; Flores, 2012; Martin, 2017; Wallace, 2017) and postsecondary (Wintermeyer, 2012) outcomes by dual enrollment setting. While chi-square and ANOVA statistics may identify and, in some cases, locate significant differences in outcomes among groups, they fail to address the influence of confounding factors (e.g., prior academic achievement, motivation, school engagement, socioeconomic status, family, etc.) on students' selection into dual enrollment settings and subsequent outcomes. Consequently, these findings are inconclusive at best as we may not attribute differences in outcomes to the effect of dual enrollment location.

A handful of studies attempt to account for differences between comparison groups by using regression with controls for preexisting characteristics (D'Amico et al., 2013; Smith, 2007; Speroni, 2011a). And only one study uses quasi-experimental methods to examine heterogenous effects of dual credit by instruction location (Villarreal, 2018). Although researchers with access to state administrative data (Speroni, 2011a) are more likely to include variables that capture group differences than those using minimal controls (D'Amico et al., 2013), studies relying exclusively on multiple regression are ill-suited to handle selection bias and yield a causal treatment effect. Moreover, although recent research uses more rigorous methods (Villarreal,

2018), more studies are needed to build a robust body of knowledge related to the effects of dual enrollment location.

Modeling Selection into Dual Enrollment on a College Campus

Despite tremendous growth in dual enrollment participation over the past two decades, where students take dual enrollment courses is far from being a standardized dual enrollment implementation feature devoid of personal and contextual influences. Limited exploration of dual enrollment delivery means researchers have yet to explicate a formal theory for selection into dual enrollment on a college campus. Consequently, in describing the proposed mechanisms of selection into treatment, I draw from the extant albeit limited literature on dual enrollment location as well as program configuration discussions embedded in the broader dual enrollment research.

Student-level characteristics. There is evidence that participation in dual enrollment in general is associated with specific individual (Jones, 2013; Kanny, 2014; Struhl & Vargas, 2012; Swanson, 2008; Welsh, Brake, & Choi, 2006) and school-level characteristics (Taylor, 2015; Waits et al., 2005). Student-level factors likely to also influence selection into college-based dual enrollment include individual and family demographics, academic achievement and aspirations, social influence, and participation in extracurricular activities.

***Demographic characteristics*.** Empirical studies documenting the role of gender and race in shaping the decision and opportunity to take dual enrollment on a college campus are strikingly scarce. However, uneven gender and racial participation in college-based dual enrollment are likely to mirror patterns observed in dual enrollment participation (Miller et al., 2017), high school completion (Barry & Reschly, 2012) and college access and success (Perna, 2006; Tierney & Duncheon, 2015), with women and non-minority students generally

overrepresented. Insofar as student demographics consistently explain, at least partially, students' heterogeneous responses to educational programs and policies (Perna & Thomas, 2006), the assumption that students' gender and race affect dual enrollment location remains valid.

Family characteristics. Research consistently suggests that when parents are involved in their children's education, the latter have better academic results, attend school on a regular basis, and are more likely to complete high school and enroll in college (Henderson & Mapp, 2002). Involved parents may perceive college-based dual enrollment as more legitimate and challenging coursework and encourage students to pursue it over high school-based dual enrollment. Students from affluent families tend to have parents who attended college, are more involved in their children's school-related decision-making, espouse higher educational expectations, and can provide them with the financial and informational resources necessary to successfully navigate college courses and processes (Perna, 2006). As parental preferences impress themselves upon students' education choices and behaviors (Walpole, 2003), participants in college-based dual enrollment are more likely to display higher levels of school engagement, educational aspirations, and college expectations than high school-based dual enrollment. Additionally, to the extent middle- and upper-class families harness their knowledge of postsecondary education to engage their students in accelerated learning options (i.e., dual enrollment, AP, IB) and increase their college preparation and competitiveness, students with native English proficiency have higher odds of taking dual enrollment on a college campus.

Although students from disadvantaged backgrounds may benefit from dual enrollment in equal degree high-SES students (An, 2013b), they may be more likely to pursue high-school based opportunities. Students who take dual enrollment on a college campus may be required to absorb some of the expenses associated with access to a college campus course such as

transportation and tuition costs (e.g., transportation, books, course fees, or tuition and fees) (Flores, 2012; Johnson & Brophy, 2006). In this context, lack of family wealth and affluence may render access prohibitive and steer low-SES students away from dual enrollment on a college campus while encouraging high-SES student participation. With many districts and states holding parents and students at least partially responsible for dual enrollment textbooks, fees, and transportation, students and their siblings may have competing needs for resources. Notably, in some cases the relationship between SES and dual enrollment location may be mitigated by personal attributes. Low-SES students who are highly motivated and seek college-level academic rigor may find alternative options to overcome barriers to college-based dual enrollment.

Academic engagement, preparation, and achievement. Students who are engaged in the classroom and feel a sense of belonging with their school are more likely to pursue educational interests and have better outcomes, including improved high school completion rates (Barry & Reschly, 2012). Moreover, academic performance and preparation are staple influencers of dual enrollment participation (An, 2013; Jones, 2014; Kanny, 2014; Taylor, 2015), successful completion of dual enrollment courses (Karp et al., 2007; Welsh et al., 2006), and college choice (Perna, 2006). Considering the quality or rigor of the school curriculum has been shown to challenge students (Johnson & Brophy, 2006) and improve college preparation and outcomes (Adelman, 2006), it is safe to assume it would also steer students towards dual enrollment on a college campus.

Educational aspirations. Academic and career expectations and aspirations are core components of secondary and postsecondary student success (Perna & Thomas, 2008; Taylor, 2015) and likely predictors of dual enrollment participation on a college campus. Students who are academically successful and have plans to go to college are more motivated to seek rigorous

coursework in a more mature environment (Johnson & Brophy, 2006). To the extent college-based dual enrollment embodies college rigor and quality, students who are high achieving and plan to go to college may seek more challenging coursework and be more likely to participate in dual enrollment on a college campus.

Social influence. While families have strong holds over students' educational choices, other social interactions may also matter to students. Relationships with friends and high school peers are likely to also shape students' education decisions (Brooks, 2003). Students with high achieving college-aspiring peers may be more likely to learn from their friends about the benefits of taking dual enrollment on a college campus and perhaps even persuaded to join in. Similarly, relationships with teachers and counselors may also be influential. In determining dual enrollment eligibility, postsecondary institutions often rely on counselors' approval to signal a student's college readiness. Students who engage in conversations with counselors and teachers about college may learn more about the distinctions between high school-based and college-based dual enrollment which could further affect their decision.

Extracurricular activities. There is concern that the amount of time invested to attend dual enrollment courses on a college campus crowds out high school extracurricular activities like sports, drama, and music (Smith, 2014; Stone & Adams, 1999). College-based dual enrollment courses that take place after school may cause conflicting schedules for high school students engaged in extracurricular activities. Considering the utility students may derive from being around their high school peers and engaging in an enjoyable activity, they may also be more likely to forgo college-based dual enrollment and perhaps opt for high school-based courses.

School-level characteristics. Student-level characteristics play a crucial role in students' participation in dual enrollment on a college campus. Yet environmental factors inherent in the high school and postsecondary contexts can be equally influential. In the aftermath of the Coleman report, educational research has yearned to illuminate the link between resource allocation, racial makeup, school quality, and student outcomes (Card & Krueger, 1996). While the results have been less elucidating, there is evidence that resources not only may differ by student racial composition (Card & Krueger, 1996) but may also shape students' access to information and implicitly, their academic and career decisions and outcomes (Rumberger & Palardy, 2005).

School-level resources may determine the extent to which high schools have the structural components necessary to sustain dual enrollment on a college campus although the direction of the relationship may be less clear. On the one hand, students attending high schools with insufficient human and material resources are less likely to have access to dual enrollment on a college campus. If high schools lack the means to ensure adequate transportation to and from the college campus or guidance counselors to nurture and support students' college preparation and planning, students' exposure to dual enrollment on a college campus is likely to be considerably diminished. To the extent that schools enrolling large proportions of students from economically disadvantaged families struggle to obtain and maintain resources, such as an adequate number of teachers (Hanushek, Kain, & Rivkin, 2004), they may also be less likely to provide college-based dual enrollment opportunities. On the other hand, high schools that lack resources and serve disadvantaged students may also face difficulties hiring and retaining qualified teachers to provide AP/IB or dual enrollment at the high school. As a result, these schools may be more likely to enter partnerships with local community colleges in order to

provide college-based dual enrollment and take advantage of resources available on the college campus at no or low cost.

Similar considerations apply to the relationship between high school size and college-based dual enrollment participation. High schools with large enrollment size are more likely to provide students with dual enrollment opportunities on a college campus (Waits et al., 2005). Larger high schools may have the resources and influence needed to establish partnerships with nearby postsecondary institutions and perhaps even absorb costs such as transportation expenses. Perhaps a more plausible explanation relates once again to geographic location. High schools in urbanized areas where the population is higher tend to boast larger average enrollments than high schools in areas classified as rural distant (i.e., within 5 to 25 miles from an urbanized area or within 2.5 to 10 miles from an urban cluster) or rural remote (i.e., more than 25 miles from an urbanized area or more than 10 miles from an urban cluster) (Snyder, De Brey, & Dillow, 2016). The intersection between geography, rural-urban continuum, and demographics may also explain why public high schools that enroll larger proportions of minority students are more likely to provide students with access to college-based dual enrollment and less likely to provide then with opportunities for high school-based dual enrollment (Waits et al., 2005).

Access to resources is closely related to geographic location. Rural high schools face challenges that stem from longer than average distance from postsecondary institutions and fewer resources (Appleby et al., 2011). For students and high schools in remote locations, dual enrollment on a college campus can simply be impractical and unfeasible because of commuting distance and transportation barriers (Cochran & Burns, 2007; Edwards, Hughes, Weisberg, 2011). Uneven geographical distribution of dual enrollment offerings attests to the popularity of high school-based dual enrollment as a strategy for increasing access in traditionally underserved

and difficult-to-reach areas where AP and IB programs are less likely to be available (Hoffman et al., 2009). Given that dual enrollment participation overall varies by urbanicity (Thomas et al., 2013), it follows that taking dual enrollment on a college campus may also vary by locale. Seventy-eight percent of public high schools located in cities provide dual enrollment opportunities on a college campus compared to 58% of rural public high schools (Waits et al., 2005). Thus, while rural high schools may enroll more dual enrollment students, most of those dual enrollees take their college-level courses at their high school campus. Consequently, urbanicity of area in which a high school is located and its proximity to a postsecondary institution's main or satellite campus are likely to be strong forces driving that high school's ability to provide students with authentic dual enrollment and, implicitly, students' access to and participation in college campus dual enrollment.

The associations between location of dual enrollment courses and high school size, urbanicity and student composition are closely interconnected although not unidirectional. In some contexts, providing dual enrollment to large numbers of high school students may raise implementation challenges characteristic of high-demand low-supply higher education scenarios and increase the likelihood of high-school based dual enrollment. In fact, concerns over capacity and, implicitly, quality of college dual enrollment courses have led 66% of postsecondary institutions offering dual enrollment to impose minimum high school GPA requirements (Kleiner et al., 2005). It follows that high schools that foster a strong academic climate may better position their students for college-based dual enrollment. One way in which high schools shape student behaviors and outcomes is through the programs they offer and the experiences they facilitate (Perna & Thomas, 2006).

Last but not least, it is imperative to consider how high school schedules may shape decisions related to dual enrollment location. In Illinois, researchers have remarked that high schools that use block scheduling tend to facilitate their students' participation in college-based dual enrollment courses (Barnett et al., 2004). Block scheduling extends class time from the typical 50 minutes to 90 minutes (Dills & Hernandez-Julian, 2008). As a result, students may have more time and flexibility to travel to and from the college campus and may be more likely to choose college-based dual enrollment over high school-based. Additionally, when school districts use a semester- as opposed to a trimester-based schedule, dual enrollment activities run more smoothly and students' credits transfer more easily (Kilgore & Taylor, 2016). If high school and college schedules align, managing classes across different settings may be less challenging and students may be more likely to participate in college-based dual enrollment.

State-level policies. Finally, it is important to account for state-level policies that govern dual enrollment and impact availability of college-based options. While a majority of states have dual enrollment policies, implementation features run the gamut. A very small number of states mandate that dual enrollment take place on a college campus (ECS, 2016; Karp et al., 2005). Almost half of all states allow both high schools and postsecondary institutions to house dual enrollment classes, whereas the remaining states lack provisions addressing dual enrollment setting.

Summary

A significant body of literature documents the overall positive relationship between dual enrollment participation and high school graduation (Karp et al., 2007), college preparedness (An & Taylor, 2015; An, 2013b; Grubb et al., 2017), postsecondary participation and persistence (Cowan & Goldhaber, 2014; Struhl & Vargas, 2012; Swanson, 2008), college academic

achievement (Allen & Dadgar, 2012; Eimers & Mullen, 2003), and postsecondary attainment (Klopfenstein, 2008). Yet rigorous quasi-experimental research on dual enrollment remains fairly limited (Bailey & Karp, 2014). Much of what we know about dual enrollment comes from studies that operationalize dual enrollment as an overall participation indicator and fail to model the effect of dual enrollment features such as course location.

A limited number of studies specifically examine how dual enrollment delivery setting influences student lived experiences and outcomes. Qualitative findings show high school-based dual enrollees (Burns & Lewis, 2000) and college instructors (Harnish & Lynch, 2005) see higher value in college-based dual enrollment and students would prefer to take dual enrollment on a college campus (Cochran & Burns, 2007). College-based dual enrollees experience higher satisfaction (Burns & Lewis, 2000) and benefit from independence and campus culture but may feel a diminished sense of belonging when interactions with college faculty and peers are negative (Kanny, 2015). Evidence from quantitative studies suggests taking dual enrollment on a college campus is associated with higher educational aspirations (Smith, 2007), better grades in dual enrollment English and mathematics (Arnold et al., 2017), and increased postsecondary enrollment (Speroni, 2011a) and persistence (D'Amico et al., 2013). However, research examining the causal relationship between dual enrollment setting and high school graduation and college-going behaviors is extremely scarce. This study uses a quasi-experimental approach and longitudinal data from a nationally representative sample of high school students to fill both a knowledge and methodological gap.

CHAPTER 3: METHODS

This study seeks to estimate the causal effect of dual enrollment course location on college-going behaviors and access. Despite being the gold standard for causation-focused research (Schneider, Carnoy, Kilpatrick, Schmidt, & Shavelson, 2007; Shadish, Cook, & Campbell, 2002), randomized experiments with human participants can often be expensive, unethical, or simply impractical (Guo & Fraser, 2015; Schneider et al., 2007; Winship & Morgan, 1999). Absent random assignment to treatment and control groups, individuals are assigned to or self-select into a treatment or intervention based on their preexisting characteristics introducing *selection bias* (i.e., self-selection and sample-selection biases) (Rosenbaum, 2005).

In the presence of selection bias, comparisons of outcomes between the treated and untreated are likely to reflect pretreatment differences rather than the causal effect of the intervention. To reduce selection bias, establish equivalence of treatment and control groups, and obtain a meaningful causal estimate (Rosenbaum, 2005), I implemented a quasi-experimental design, propensity score weighting, with data from a nationally representative longitudinal survey. This section describes the quasi-experimental design, the data, sample, and variable selection and provides an overview of the analytic strategy and design limitations.

Research Questions

The research questions guiding this study design are:

1) Does taking dual enrollment on a college campus improve high school graduation compared to taking dual enrollment at the high school?

2) Does taking dual enrollment on a college campus improve college-going behaviors compared to taking dual enrollment at the high school?

Data

To answer the research questions listed above, this study uses data from a nationally representative longitudinal survey, namely the High School Longitudinal Study of 2009 (HSLS:09). HSLS:09 follows a single cohort of 9th graders from a nationally representative sample of high schools that have both 9th and 11th grade enrollments (Ingels et al., 2011). There are two primary reasons supporting the choice of HSLS:09 as an appropriate data source for this study. First, HSLS:09 base-year data collection gathered extensive information on student demographic and background characteristics for over 25,000 9th graders in more than 900 public and private schools across the nation. The base-year survey also collected information from parents, teachers, counselors, and school administrators and captured family, classroom, and institutional characteristics likely to influence students' educational outcomes. These variables provide a rich set of covariates that precede treatment, which is instrumental to successfully meet the assumptions required to establish causality through inverse propensity score weighting (Caliendo & Kopeinig, 2008).

Second, HSLS:09 completed a First Follow-up in 2012 when most students were in eleventh grade. This wave of data collection captures information about dual enrollment location, allowing student to be longitudinally followed through their exposure to the treatment of interest. In addition, subsequent data collection waves provide ample opportunities to examine students' high school graduation and college-going behaviors. The 2013 Update, conducted when most students had just completed twelfth grade, allows researchers to examine college-going behaviors and postsecondary enrollment immediately after high school. The Second Follow-up, administered in 2016 when many students were expected to be finishing their third year of college, collects information about any postsecondary enrollment since high school.

Throughout this dissertation, I refer to the 2009 Base Year survey as the *9th grade survey*, the 2012 First Follow-up as the *11th grade survey*, the 2013 Update as the *12th grade survey,* and the Second Follow-up as the *college survey*. It is important to note that this terminology aims primarily to help the reader make better meaning of the timeline and does not necessarily describe students' class status at the time of a particular data collection wave. For example, while I refer to the 2013 Update as the 12th grade survey, this abbreviated survey was administered during the summer and fall of 2013, immediately after many students would have just graduated from high school. To investigate the effect of dual enrollment location on student outcomes, I use information from all four HSLS:09 data collection waves (i.e., 9th grade survey, 11th grade survey, 12th grade survey, and college survey). Table 1 outlines the HSLS:09 timeline and the sources for the variables of interest in this study.

Table 1.

HSLS:09 Data Collection Timeline for Matching Covariates, Treatment, and Outcome Variables

HSLS:09 Timeline			
Survey Year	Pre-Treatment Covariates	Treatment	Outcomes
9th grade (Fall 2009)	Student-level covariates School-level covariates		
11th grade (Spring 2012)		Dual enrollment on a college campus	
12th grade (Summer/Fall 2013)			High school graduation FAFSA completion College applications Postsecondary enrollment immediately after high school
3rd year of college (2016)			Postsecondary enrollment three years after high school

Analytic Samples

High school graduation, FAFSA completion, the number of college applications and postsecondary enrollment immediately after high school use information from the 12th grade survey. Postsecondary enrollment as of three years after high school comes from the college survey. Because outcomes have two distinct timelines (i.e., 12th grade survey and college survey), I created two base analytic samples: the high school analytic sample for outcomes captured in the 12th grade survey and the college analytic sample for enrollment captured in the college survey. In the base analytic samples, the treatment group consists of students who took dual enrollment on a college campus, potentially in combination with other locations. Students who took dual enrollment courses only at their high school make up the control group.

The HSLS:09 base year sample consists of 25,206 high school students entering 9th grade in fall 2009 at a public or private school with 9th and 11th grade enrollments (Ingels et al., 2015). To create the high school base analytic sample, I implemented several steps. In order to be able to use the longitudinal student-level analytic weight and generalize results, I restricted the sample to students who had participated in the 9th, 11th, and 12th grade surveys. Because dual enrollment arrangements are more prevalent in public high schools and, as such, traditional dual enrollment experiences are based in public schools, I removed all 9th graders enrolled in private schools from the high school base analytic sample. Since I was interested in the location of dual enrollment courses, I then restricted the analytic sample to students who, during the 11th grade survey, indicated that they took dual enrollment on a college campus or at their high school only. In order to be able to impute missing data and use state fixed effects, I further dropped states with too few students. Last but not least, I removed students from states that perfectly predicted

taking dual enrollment at the high school in the treatment model. Applying the exclusion criteria described above resulted in a high school analytic sample of 2,260 students.

To create the college base analytic sample, I restricted the sample to students who had participated in the 9th, 11th, 12th grade, and college surveys. I then followed decision steps similar to those implemented for the high school base analytic sample. These steps resulted in a college base analytic sample of 1,840 students. Figures 2 and 3 provide an overview of the decisions and restriction criteria applied to identify the base analytic samples used in this study.

The base analytic samples include students who took dual enrollment on a college campus possibly in combination with other locations. Because this less restrictive treatment identification could potentially bias the estimates, I created a second version of the treatment group containing only students who reported taking dual enrollment exclusively on a college campus. Thus, each base analytic sample has a parallel analytic sample based on a more restrictive treatment identification.

Multiple Imputation

The longitudinal nature of the HSLS:09 study and the multitude of stakeholders involved (i.e., students, parents, administrators, counselors, and teachers) provide researchers with access to valuable information about students' individual characteristics, family background, and school environment. Unfortunately, while the HSLS:09 information is rich, it is often incomplete. Roughly 90% of covariates had at least some missing values with the level of missingness ranging from 0.4% to 20% for a single variable. Missing values are the consequence of respondents answering some but not all survey questions (i.e., item non-response). Tables B1 and B2 in Appendix B provide the number and percentage of complete and missing cases for the covariates in the high school and college base analytic samples.

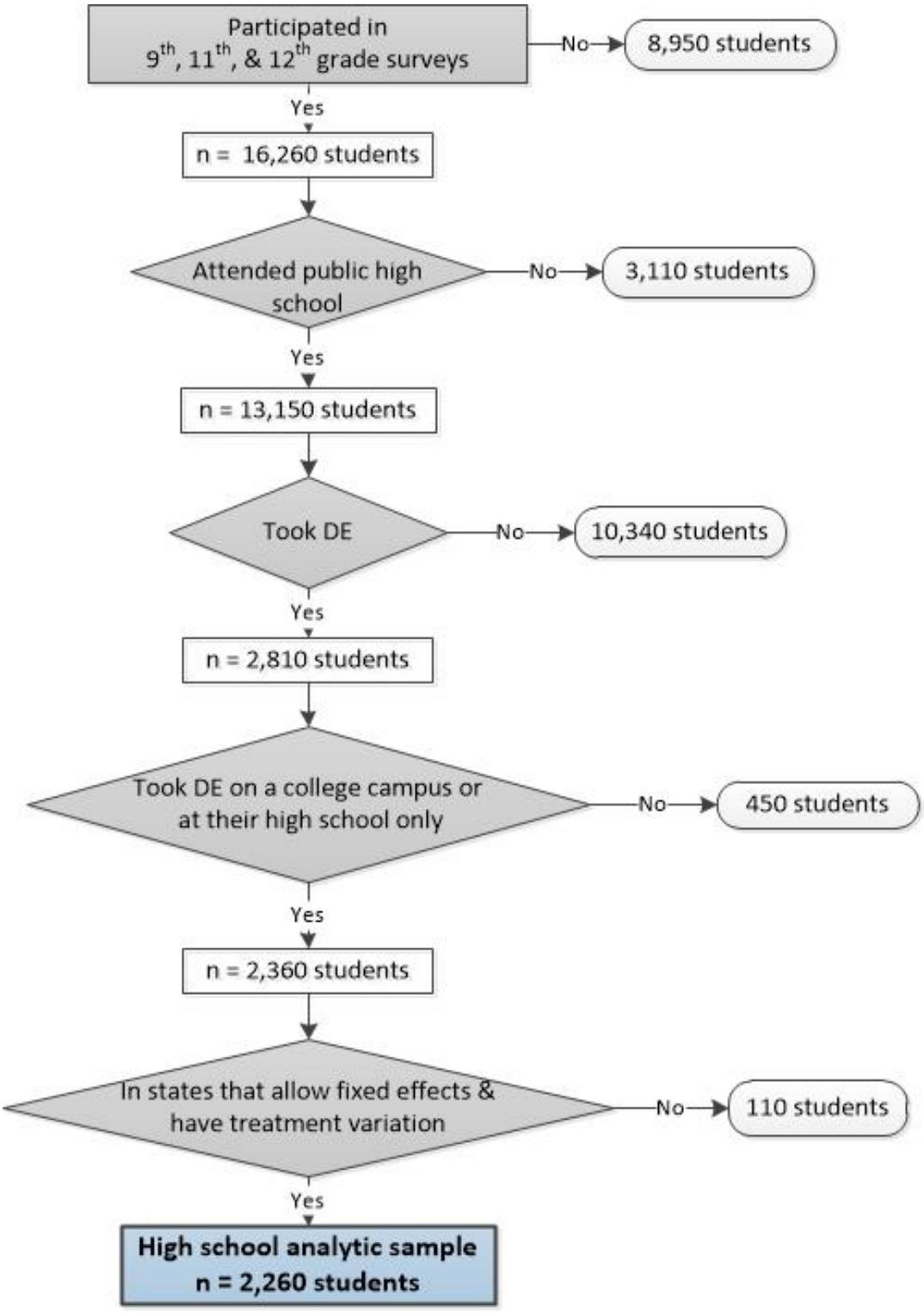


Figure 2. Criteria Used in Identifying the High School Base Analytic Sample. DE = dual enrollment. N = sample size. Sample sizes are rounded to the nearest tenth according to restricted-use data guidelines and may not always sum up perfectly.

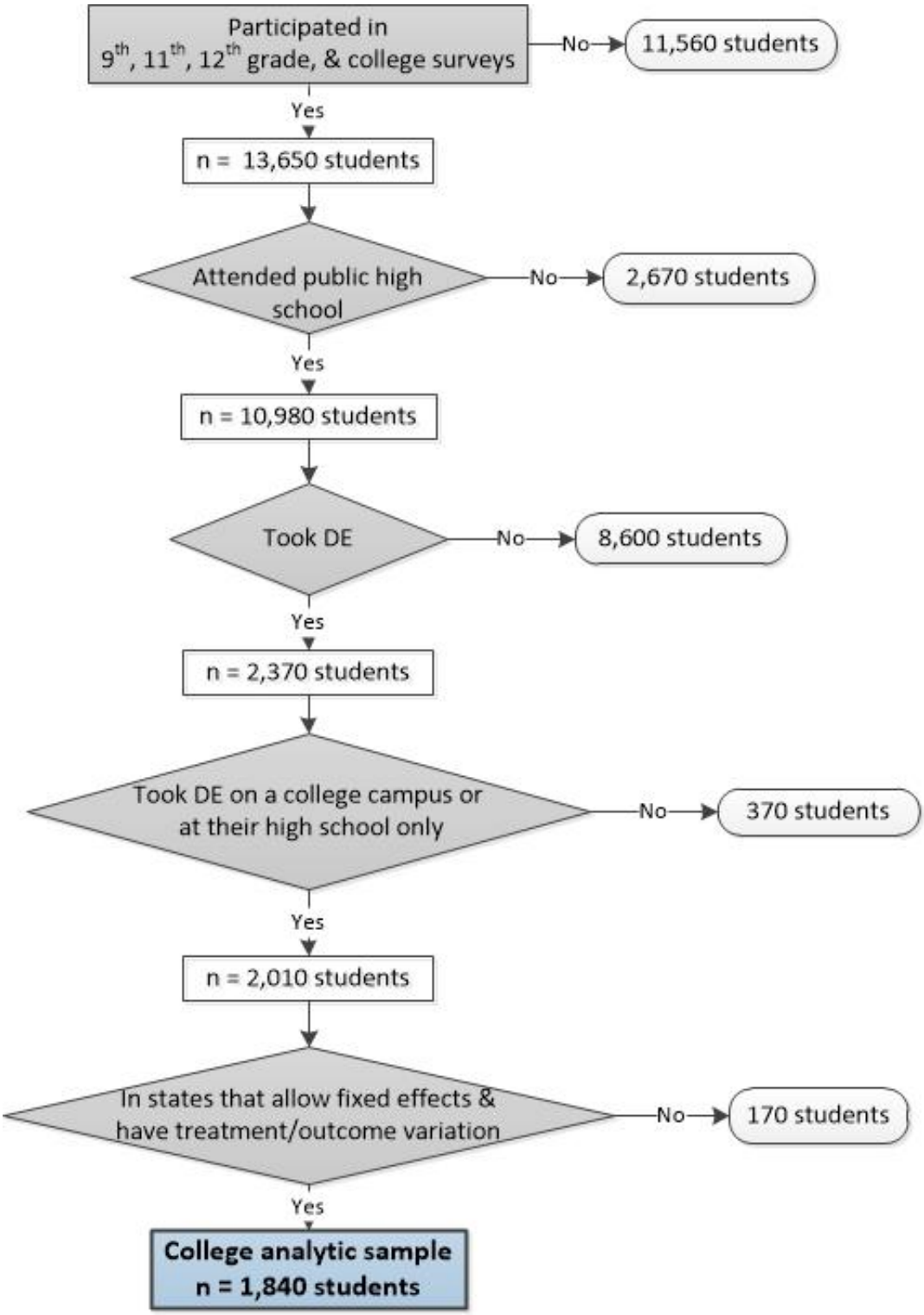


Figure 3. Criteria Used in Identifying the College Base Analytic Sample. DE = dual enrollment. N = sample size. Sample sizes are rounded to the nearest tenth according to restricted-use data guidelines and may not always sum up perfectly.

Conventional approaches to missing data include, among others, complete case analysis, pairwise deletion, and dummy variable adjustment. As indicated by its name, complete case analysis or listwise deletion removes all observations with any missing data and includes only complete cases in the analysis (Allison, 2010). However, this approach would have discarded 55% of cases in the high school base analytic sample and 53% of cases in the college base analytic sample regardless of the scale of missingness. This approach would have significantly diminished the study's statistical power. Additionally, unless data are missing completely at random (MCAR) (i.e., the probability that a variable is missing is not contingent on any other variables in the model), listwise deletion may result in biased parameter estimates (Allison, 2010). Unlike listwise deletion, pairwise deletion and dummy variable adjustment make use of all the available information but either rely on unrealistic assumptions or are likely to introduce bias (Allison, 2010).

Recent studies suggest multiple imputation is a best practice approach to handling missing data (Allison, 2009; Cox, McIntosh, Reason, & Terenzini, 2014; Enders, Keller, & Levy, 2018; van Buuren, 2018). Multiple imputation fills in the missing data to create complete analysis datasets while also accounting for the uncertainty of the imputed values (Allison, 2010). Rather than create single replacement values, multiple imputation iteratively generates multiple values by first using regression to predict the values and then supplementing them with random draws from the error distribution of the regression equation (Allison, 2009). Benefits of multiple imputation include the ability to accommodate any type of data (Allison, 2009), perform well even when as much as 50% of values on a single variable are missing (Graham, 2009), and lower nonresponse bias (Enders et al., 2018). Moreover, while multiple imputation assumes data are missing at random (MAR) (i.e., the probability that a variable is missing is contingent on the observed data),

MAR violations do not automatically negate its effectiveness. The literature suggests multiple imputation always performs at least as well as conventional methods such as listwise deletion and, in fact, most often surpasses traditional approaches by a wide margin (Cox et al., 2014; Graham, 2009).

The two most common applications of multiple imputation are the Markov Chain Monte Carlo (MCMC) and the fully conditional specification (FCS) or multiple imputation by chained equations (Allison, 2006). MCMC assumes a joint multivariate distribution and is commonly used for continuous data. In contrast, FCS allows the researcher to specify a model for each variable with missing data according to the type of variable (e.g., regression for continuous variables, logistic for binary data, ordered logistic for ordinal variables, multinomial logistic for categorical variables with multiple categories, etc.).

Since complete case analyses would have resulted in the loss of more than half of the observations in my samples, I opted to address missing data within each base analytic sample using multiple imputation. Because my covariates included both continuous and categorical variables, I initially attempted to implement the fully conditional specification using Stata's *mi impute chained* command. Unfortunately, the combination of fixed effects and already existing numerous binary indicators and ordered categorical variables required excessive computation time rendering the models impractical.

When the fully conditional specification with ordered logit is unfeasible, imputing ordered variables using MCMC with dummies is the next best alternative (P. Allison, personal communication, July 11, 2019). Although the assumption of multivariate normality might be unrealistic for categorical variables, simulation studies show normality violations are generally harmless for imputations of dichotomous variables, except in the case of extremely skewed

variables (i.e., 5% in one category and 95% in the other) (Allison, 2018). Upon reviewing my covariates, I decided to remove three binary covariates (i.e, “school supports high school students with AP/college/university courses”, “9th grader has repeated a grade”, and “9th grader's friend plans to go to college”) with too few cases in one category. Additionally, for the imputation models to run, I removed states with too few students.

Moderate levels of missingness may require no more than five imputation datasets for accurate parameter estimates and 20 imputation datasets meet the needs of most research applications (Allison, 2018). But a growing body of literature suggests a much larger number of imputation datasets may be needed (Allison, 2018; Enders, 2010; Harrel, 2007; Graham, Olchowski, & Gilreath, 2007; von Hippel, 2018). Recommendations for determining the number of imputations include multiplying the highest fraction of missing information (FMI) by 100 (White, Royston, & Wood, 2010) or selecting enough imputations to raise all degrees of freedom over 100 (Allison, 2018) or 200 (von Hippel, 2018). It is important to note that FMI is not identical to the proportion of missing data but in fact represents “the proportion of the total sampling variance that is due to missing data” (Enders, 2010, p.224).

Although calculating the number of imputations needed seems straightforward once FMI is known, the difficulty arises in that FMI is unknown before the imputation process. One strategy that addresses this conundrum is von Hippel’s (2018) two-stage procedure based on a quadratic rather than linear rule. Simply using the output FMI ignores that there is a 50% likelihood that the FMI is underestimated (von Hippel, 2018). In order to get a more accurate estimate of how many imputations are needed, von Hippel recommends conducting the imputation in two phases. During the first phase, the researcher conducts a small-scale pilot analysis to obtain a conservative estimate of FMI. The proportion of actual missing data is helpful in deciding the number of imputations for

the pilot analysis. Data with high levels of missingness (i.e., 75% of values are missing) benefit from the use of a large number of pilot imputations (i.e., 20 imputation datasets) (von Hippel, 2018). The conservative estimate obtained in the first stage uses the initial FMI value to generate a 95% confidence interval for FMI. During the second phase, the researcher incorporates the upper bound of the FMI confidence interval in calculating the number of final imputations needed.

To determine the number the imputations required for this study, I implemented von Hippel's (2018) two-stage procedure. In anticipation of a fairly high FMI, for each base analytic sample I conducted a pilot analysis with 20 imputations. Based on the initial FMI value, the recommended number of imputations was 35 for the high school analytic sample and 40 for the college analytic sample.

To ensure the imputation models were congenial with the analysis model, I incorporated all the covariates to be included in the analysis as well as the student-level analytic weight. Similar to the analyses, groups making up the reference categories were omitted. Consistent with expert recommendations that imputation should account for relationships between the imputed variables and the dependent variables (Allison, 2001; Graham, 2009), the imputation models included the dependent variables. However, the analysis models only used the values imputed on the independent variables; if a student is missing on the dependent variable, the student is excluded from the analysis. The imputation contained square terms for the number of household members, 9^{th} grade GPA, number of credits taken in 9^{th} grade, math assessment score, and total school enrollment. Known as the transform-then-impute approach, including the square terms in the imputation can yield inconsistencies between observed and imputed data but produces unbiased estimates and is preferred over the impute-then-transform approach (von Hippel, 2009).

Unfortunately, the high number of covariates in the model precluded me from including individual components of composite variables so the imputation only included the latter.

In light of the number of imputations recommended by the pilot analysis, I used the MCMC method with dummy variables to generate 35 imputation datasets for the high school base analytic sample and 40 imputation datasets for the college base analytic sample. The imputation converged to the correct distribution after 70 iterations in the high school analytic sample and 88 iterations in the college analytic sample. For every imputed variable, I also checked means and standards deviations within each imputation to verify convergence. A particularity of MCMC imputation of binary and ordinal variables is that resulting values may contain decimals. While decimals may seem inconsistent with the real data, rounding is likely to bias estimates and is to be avoided (Allison, 2018; Enders, 2010). Since decimal values obtained from multiple imputations posed no threat to analyses, I left them unaltered.

Treatment Variables

This study seeks to understand the effect of dual enrollment course location on high school graduation and college-going behaviors. Information about the treatment was collected in spring 2012 when most students were in eleventh grade. The 11th grade survey asked students "Other than AP and IB courses, have you taken/did you take any high school courses for college credit when you were in high school?" Roughly sixteen percent (n=3,490) of students attending a public school (n=20,570) reported they were taking or had taken at least one dual enrollment course during high school.

Respondents who indicated dual enrollment participation were then asked "Where have you taken high school courses for college credit other than AP and IB?" Response options included "on a college campus", "at your high school", "at a different high school", and "online". This study

compares outcomes between students who took dual enrollment courses on a college campus (i.e., treatment group) and students who took dual enrollment at their high school only (i.e., control group). In order to estimate the causal impact of taking dual enrollment courses on a college campus, the treatment variable is a binary indicator signaling whether the dual enrollment location is the college campus. Of all dual enrollment participants in the high school base analytic sample, 19% (n=430) responded they had taken dual enrollment course(s) on a college campus and 81% percent at their high school only (n=1,830). Location patterns were highly similar in the college base analytic sample.

Given that schools may offer several dual enrollment options and survey respondents could select multiple answers, I created two treatment versions. The first treatment version combines students who took dual enrollment courses on a college campus only or in multiple locations that included a college campus. Throughout the study, I refer to this treatment version as the less restrictive treatment identification. The second treatment version consists only of students who reported taking dual enrollment courses exclusively on a college campus. Tables 2 and 3 show the distribution of dual enrollment location in the high school and college base analytic samples. Additionally, the tables provide information about dual enrollment location responses that were excluded from the base analytic samples for representing dual enrollment locations outside the scope of this study.

Validation. Because the data used to create the treatment and control groups are self-reported, researchers may be concerned about measurement error affecting the treatment variable and rightfully so. Measurement error occurs when the true but unknown value of a measurement differs from the known value (Groves et al., 2009). In this case, measurement error refers to students who either said that 1) they took dual enrollment courses but, in reality, did not or 2) they

Table 2.

Distribution of DE Location in the High School Base Analytic Sample.

Group	DE location(s)	N	Percent
Control	At student's high school only	1,830	81.0%
Treatment	On a college campus only	220	9.7%
Treatment	On a college campus and online	40	1.8%
Treatment	On a college campus and at another high school	0[a]	N/A
Treatment	On a college campus, at another high school, and online	0[a]	N/A
Treatment	On a college campus and at student's high school	120	5.3%
Treatment	On a college campus, at student's high school, and online	30	1.3%
Treatment	On a college campus, at student's high school, and at another high school	10	0.4%
Treatment	On a college campus, at student's high school, at another high school, and online	10	0.4%
	Total:	2,260	100.0%
Not in analytic sample	At another high school only	80	17.8%
Not in analytic sample	Online only	50	11.1%
Not in analytic sample	At student's high school and online	130	28.9%
Not in analytic sample	At student's high school and at another high school	40	8.9%
Not in analytic sample	At student's high school, at another high school, and online	0[a]	N/A
Not in analytic sample	At another high school and online	0[a]	N/A
Not in analytic sample	In none of the 4 locations	110	24.4%
Not in analytic sample	Missing location	30	6.7%
	Total:	450	100.0%

Note. DE = dual enrollment. N = sample size. N/A = not applicable because sample size was too small. Sample sizes are rounded to the nearest tenth according to restricted-use data guidelines. Ns and percentages may not always sum up perfectly.

[a] Small sample sizes were suppressed to protect from disclosure.

SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), Second Follow-up Restricted-Use Data File.

Table 3.

Distribution of DE Location in the College Base Analytic Sample.

Group	DE location(s)	N	Percent
Control	At student's high school only	1,470	79.9%
Treatment	On a college campus only	180	9.8%
Treatment	On a college campus and online	40	2.2%
Treatment	On a college campus and at another high school	0[a]	N/A
Treatment	On a college campus, at another high school, and online	0[a]	N/A
Treatment	On a college campus and at student's high school	100	5.4%
Treatment	On a college campus, at student's high school, and online	20	1.1%
Treatment	On a college campus, at student's high school, and at another high school	10	0.5%
Treatment	On a college campus, at student's high school, at another high school, and online	10	0.5%
	Total:	1,840	100.0%
Not in analytic sample	At another high school only	60	16.2%
Not in analytic sample	Online only	40	10.8%
Not in analytic sample	At student's high school and online	110	29.7%
Not in analytic sample	At student's high school and at another high school	30	8.1%
Not in analytic sample	At student's high school, at another high school, and online	0[a]	N/A
Not in analytic sample	At another high school and online	0[a]	N/A
Not in analytic sample	In none of the 4 locations	100	27.0%
Not in analytic sample	Missing location	20	5.5%
	Total:	370	100.0%

Note. DE = dual enrollment. N = sample size. N/A = not applicable because sample size was too small. Sample sizes are rounded to the nearest tenth according to restricted-use data guidelines. Ns and percentages may not always sum up perfectly.

[a] Small sample sizes were suppressed to protect from disclosure.

SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), Second Follow-up Restricted-Use Data File.

did not take dual enrollment but, in fact, did. Although HSLS:09 collected high school transcripts, conversations with analysts involved in the coding revealed that transcripts were a highly unreliable source of information related to dual enrollment. Specifically, most schools do not report dual enrollment course information on transcripts resulting in a large number of false negatives (i.e., course may be coded as taken at the high school based solely on the absence of information specifying it took place on a college campus).

Consequently, I turned to alternative survey measures related to dual enrollment. The 11th grade survey asked counselors "Does your school offer a dual or concurrent enrollment program? A dual or concurrent enrollment program is an organized system with special guidelines that allows high school students to take college level courses, which may be taught on the campus of a postsecondary institution, through distance education, or on your high school campus. Please do not include Advanced Placement (AP) and International Baccalaureate (IB) programs." If students understood the question about dual enrollment, it is reasonable to assume that most dual enrollment participants would be enrolled in high schools that counselors reported as offering dual enrollment. To check if this assumption was true, I examined students who were enrolled in a public school, had participated in dual enrollment and had valid counselor response. Because the 11th grade counselor questionnaire was administered only at base year schools that still enrolled HSLS:09 students, I excluded students who had transferred or transitioned to being homeschooled and lacked counselor response. As indicated in Table 4, descriptive statistics show 94% (n=2,870) of dual enrollment participants were attending a high school reported to offer dual enrollment. These findings signal fairly high agreement between student and counselor self-report data regarding dual enrollment and suggest students displayed good overall comprehension of the associated survey question.

Outcome Variables

This study investigates several outcomes including high school graduation, FAFSA completion, number of college applications, and postsecondary enrollment immediately after high school or three years after high school.

Table 4.

Self-Reported Student DE by Counselor-Reported High School DE

	Counselor reports:		
	High school offers DE	High school does not offer DE	Total
Student reports taking DE	2,870	180	3,050
	94.1%	5.9%	100%

Note. DE = dual enrollment. Sample sizes are rounded to the nearest tenth per restricted-use data guidelines and may not always sum up perfectly.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), Second Follow-up Restricted-Use Data File.

High school completion. The first outcome variable is whether the student earned a high school credential (i.e., high school diploma, certificate of attendance, GED, or high school equivalency). HSLS:09 has an updated high school completion status variable that incorporates information from multiple sources including the 12th grade survey, transcripts, and GED testing. As a result of the update, high school completion status has excellent coverage and is available for all students in my analytic sample. Using the updated high school completion variable, I created a binary variable indicating whether a student had obtained a high school diploma or a GED, certificate of attendance, or other high school equivalent.

FAFSA completion. The second dependent variable is a yes/no indicator signaling whether a student completed the FAFSA as of November 2013.

Number of college applications. The third outcome measures the number of postsecondary institutions where the student applied or registered as of November 2013.

Postsecondary enrollment, immediately after high school. The 12th grade survey captures postsecondary enrollment immediately after high school. Thus, the fourth dependent variable indicates whether the student was taking or intended to take classes at "a college, university, community college, trade school, or other occupational school (such as a cosmetology school or a school of culinary arts)" as of November 2013.

Postsecondary enrollment, three years after high school. The fifth and last outcome of interest was captured when most students were in their third year of college and measures if student had ever enrolled in college by the end of February 2016.

Because FAFSA completion, college applications, and postsecondary enrollment are measures of college access and have little meaning absent core educational prerequisites (i.e., completion of high school diploma, GED, or other high school equivalency), analyses associated with these outcomes exclude high school non-completers. Additionally, during analyses, I dropped cases with missingness on the dependent variable. Tables 5 and 6 illustrate the distribution of the binary outcomes across the two treatment options and their associated control groups. Figure 4 illustrates the density plot for the count variable, number of college applications.

Balancing Covariates

At the core of propensity score methods lies the assumption that conditional on a set of observed covariates *X* that precede the intervention, potential outcomes are independent of participation in the treatment (Caliendo & Kopeinig, 2008; Guo & Fraser, 2015; Khandker, Koolwal, & Samad, 2010). While dual enrollment eligibility requirements vary widely, state- and

Table 5.

Distribution of Binary Outcomes When Treatment is DE on a College Campus (Less Restrictive Identification).

		DE on a college campus				
		T		C		
		Percent	N	Percent	N	Total
HS graduation	Yes	95.3%	410	96.6%	1,700	2,110
	No	4.7%	20	3.4%	60	80
	Total	100.0%	430	100.0%	1,760	2,190
FAFSA completion	Yes	77.5%	310	75.7%	1,280	1,590
	No	22.5%	90	24.3%	410	500
	Total	100.0%	400	100.0%	1,690	2,090
Postsecondary enrollment, immediately after HS	Yes	85.4%	350	83.5%	1,420	1,770
	No	14.6%	60	16.5%	280	340
	Total	100.0%	410	100.0%	1,700	2,110
Postsecondary enrollment, 3 years after HS	Yes	88.9%	320	85.7%	1,200	1,520
	No	11.1%	40	14.3%	200	240
	Total	100.0%	360	100.0%	1,400	1,760

Note. DE = dual enrollment. T = treatment group. C = control group. N = sample size. HS = high school. Sample sizes are rounded to the nearest tenth according to restricted-use data guidelines. Ns, percentages, and totals may not always sum up perfectly.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), Second Follow-up Restricted-Use Data File.

institution-level policies typically require that students have junior or senior class standing (Borden et al., 2013; WICHE, 2006). It is important to note that selecting covariates for the propensity model should avoid the "everything but the kitchen sink" approach. Although including all variables that could potentially affect selection may seem intuitive, overspecifying the propensity model can yield high standard errors and perfectly predict college-based dual enrollment participation (Khandker et al., 2010). Consequently, consistent with propensity score recommendations by Caliendo and Kopeinig (2008), I selected variables that were measured before the treatment (i.e., 9th grade questionnaires) and are deemed to "influence treatment assignment and potential outcomes simultaneously" (Caliendo & Kopeining, 2008, p.35).

Table 6.

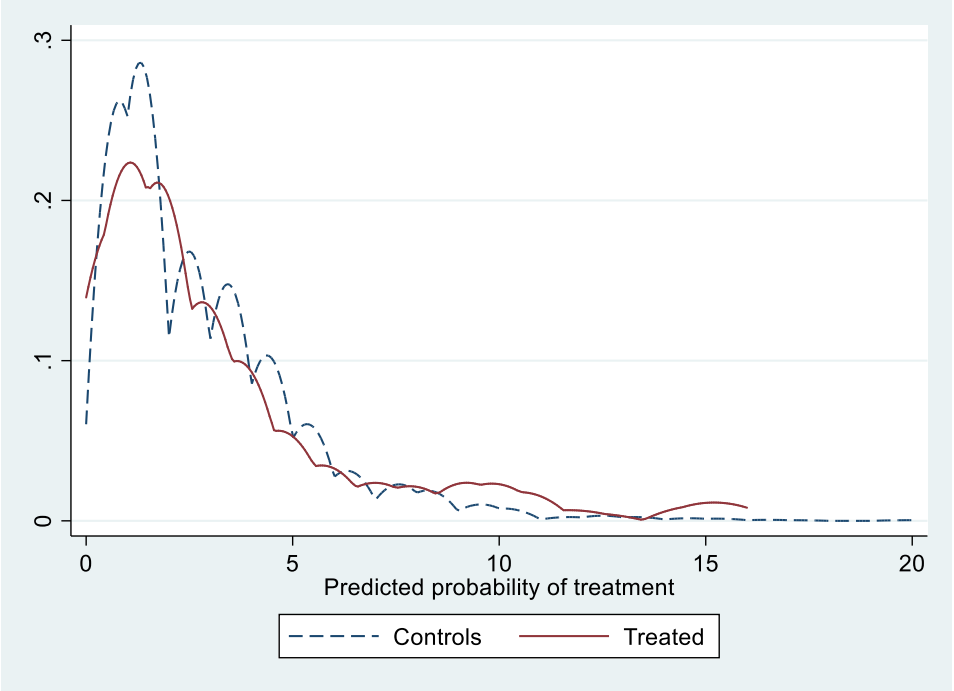
Distribution of Binary Outcomes When Treatment is DE Exclusively on a College Campus (More Restrictive Identification).

		DE exclusively on a college campus				
		T		C		
		Percent	N	Percent	N	Total
HS graduation	Yes	95.5%	210	96.6%	1,400	1,610
	No	4.5%	10	3.4%	50	60
	Total	100.0%	220	100.0%	1,450	1,670
FAFSA completion	Yes	76.2%	160	75.9%	1,040	1,200
	No	23.8%	50	24.1%	330	380
	Total	100.0%	210	100.0%	1,370	1,580
Postsecondary enrollment, immediately after HS	Yes	85.7%	180	83.6%	1,170	1,350
	No	14.3%	30	16.4%	230	260
	Total	100.0%	210	100.0%	1,400	1,610
Postsecondary enrollment, 3 years after HS	Yes	88.9%	160	85.8%	910	1,070
	No	11.1%	20	14.2%	150	170
	Total	100.0%	180	100.0%	1,060	1,240

Note. DE = dual enrollment. T = treatment group. C = control group. N = sample size. HS = high school. Sample sizes are rounded to the nearest tenth according to restricted-use data guidelines. Ns, percentages, and totals may not always sum up perfectly.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), Second Follow-up Restricted-Use Data File.

The selection of covariates for the propensity model is guided largely by findings from the literature, the proposed theory of change, and the identified mechanisms of selection into college-based dual enrollment. Accurate identification of the variables most likely to drive college-based dual enrollment participation and systematically different outcomes is crucial to establishing comparable treatment and control groups (Guo & Fraser, 2015). In line with previous research (An, 2013a; An, 2013b; Giani et al., 2014; Grubb et al., 2017; Kanny, 2014; Karp et al., 2007; Struhl & Vargas, 2012; Taylor, 2015), the selected matching covariates include demographic traits, attitudes and expectations, academic achievement, family background, school characteristics and resources, and state-level indicators which are likely to influence both

(a)



(b)

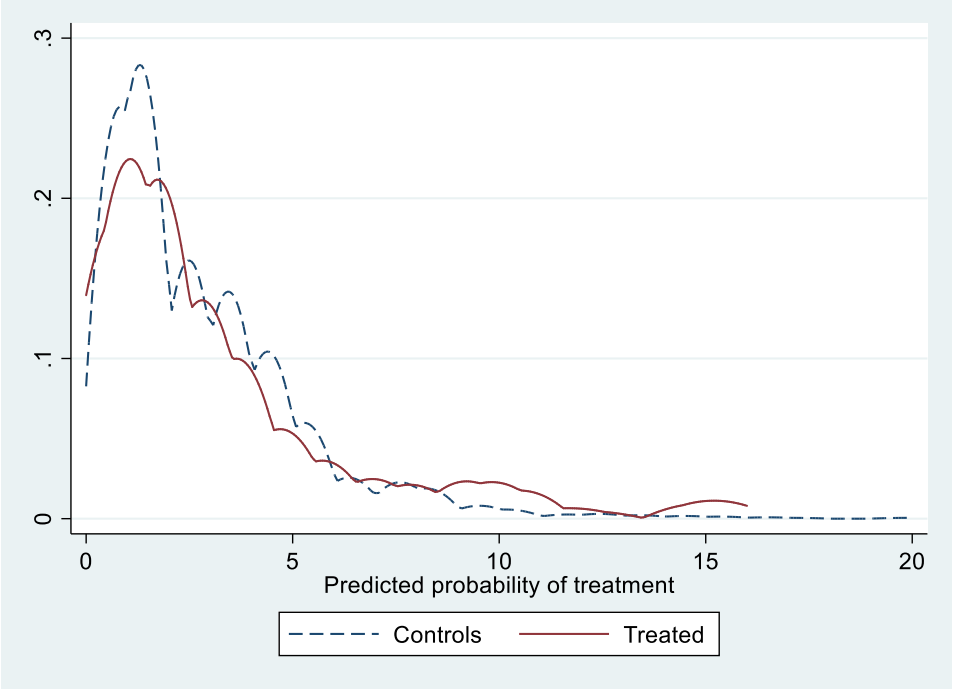


Figure 4. Density Plot for the Number of College Applications When the Treatment is Dual Enrollment on a College Campus (a) and Dual Enrollment Exclusively on a College Campus (b)

high school students' participation into college-based dual enrollment and their outcomes. In the sections below, I discuss covariates according to the constructs they represent.

Student-level covariates. Student-level covariates for the propensity model include several sets of variables representing demographics, academic achievement, cultural and social capital, and educational aspirations captured in the 9th grade survey.

Demographic characteristics. I represent student demographics with several indicators that capture students' sex and race. While recent HSLS:09 surveys distinguish between sex at birth and gender, the 9th grade survey used information from student and parent questionnaires and school rosters to create a dichotomous sex variable. Consequently, I created a binary indicator for sex with male as the reference category. Using the composite race variable, I created four indicators identifying whether a student is Asian, Black, Hispanic, or White. Because of low representation, I collapsed three racial categories (i.e., American Indian/Alaska Native, non-Hispanic, More than one race, non-Hispanic, and Native Hawaiian/Pacific Islander, non-Hispanic) into a fifth racial category. During analysis, White was the omitted category.

Family characteristics. Family background covariates convey information about multiple student influencers inherent in the family environment: native language, household structure, socioeconomic status, and parental aspirations, expectations, and involvement.

Language. A binary indicator distinguishes students whose first language is a non-English language only from students whose first language is English only or English and non-English equally.

Household structure. Two variables inform the models on family structure: number of household members and living in a single-parent household. The number of household members is a continuous measure representing how many people live in the student's household as

reported in the 9th grade parent survey. The single-parent household variable is a binary indicator that takes a value of one if student lives with only one biological or adoptive parent or guardian.

Socioeconomic status. Research has yet to reach consensus on how to best represent the construct of SES, with some researchers finding advantage in the consistency of a composite measure and others favoring the ability to identify each components' individual contribution (Perna, 2006). The HSLS:09 9th grade survey contains a composite variable for socioeconomic status generated from family income and parental education and occupation. Since my goal was to establish equivalence on the observables between my treatment and control groups, I chose to represent socioeconomic status through three distinct components: family income, parents' or guardians' highest level of education, and parent occupation prestige. HSLS:09 asked parents to provide the total family income in 2008 and created 13 income categories ranging from family income less than or equal to $15,000 to family income higher than $235,000. I created six indicators corresponding to the first six family income categories: 1) less than or equal to $15,000, 2) greater than $15,000 but less than or equal to $35,000, 3) greater than $35,000 but less than or equal to $55,000, 4) greater than $55,000 but less than or equal to $75,000, 5) greater than $75,000 but less than or equal to $95,000, and 6) greater than $95,000 but less than or equal to $115,000. Given the skewed distribution of income and the underrepresentation of students in the higher income categories, I collapsed the remaining family income categories into a seventh indicator representing family income higher than $115,000. I used family income of less than or equal to $15,000 as the reference group.

Derived from two measures (i.e, level of education for parent 1 and level of education for parent 2), the source variable for parents' or guardians' highest level of education consists of seven categories ranging from less than high school to Ph.D and other high level professional

degree. To avoid categories with too few cases, I created three indicators designating whether parents' or guardians' highest level of education is less than a bachelor's degree, a bachelor's degree, or a master's degree or higher. I then omitted the first category.

To generate the last SES component, parent occupation prestige, I used a measure of occupational prestige developed through the 2012 General Social Survey (GSS) and based on the 2010 Census occupation classification. In order to calculate the prestige score associated with each occupational code, the 2012 GSS had 1001 respondents rank 860 occupations using an "occupational prestige ladder" ranging from 1, the lowest position, to 9, the highest position (Smith & Son, 2014). Because parent occupations in the 9th grade survey were coded using the 2000 Standard Occupation Classification (SOC) System developed by the Bureau of Labor Statistics (BLS), I first converted parent occupations to the 2010 SOC codes using crosswalk information from BLS. Then, I merged occupation prestige scores onto the 2010 SOC codes using the Census-SOC crosswalk information also from BLS.

Parental aspirations and expectations. During the 9th grade survey, parents were asked "If there were no barriers, how far in school would you want your 9th-grader to go?". I derived three parental aspiration indicators corresponding to whether parents wanted their student to attain less than a bachelor's degree, a bachelor's degree, or a master's degree or higher. Parents were also asked "As things stand now, how far in school do you think [he/she] will actually get?". I derived three parental expectation indicators identifying whether parents expected their student to attain less than a bachelor's degree, a bachelor's degree, or a master's degree or higher. A fourth indicator designated "don't know" responses. For both parental aspirations and expectations, the less-than-bachelor's-degree indicator represented the omitted category.

Parental involvement. Given the HSLS:09 focus on family environment and parent influence, I was able to incorporate multiple measures of parental involvement. Parents were asked "During this school year, about how many days in an average week do you or another adult in your household help your 9th-grader with homework?" Using this measure, I created four binary indicators designating whether the parent helped the student with homework less than once a week, one or two days a week, three or more days a week, or never. The reference category is students whose parents never helped with homework. I also included a binary variable that captures whether the parent or anyone in the student's family talked to a counselor or teacher about postsecondary academic requirements.

Additionally, I derived two variables that indicate parents' engagement in school-level, respectively, student-level activities. Parents were asked to report if they had 1) "attended a general school meeting", 2) "attended a meeting of the parent-teacher organization or association", 3) "gone to a regularly scheduled parent-teacher conference", 4) "attended a school or class event such as a play, dance, sports event or science fair", 5) "served as a volunteer in [your 9th grader]'s classroom or elsewhere in the school teacher", 6) "participated in fundraising for the school", and 7) "met with a school counselor in person" during the 2009-10 school year. To mitigate the large number of covariates in the model, I created a summary count variable where a value of 0 suggests no parent engagement in school-based activities and values of 1 to 7 represent the number of activity types parents engaged in. Using a similar approach, I also generated a summary count variable indicating engagement in student-level activities as evidenced by reports that parent had 1) "visited a zoo, planetarium, natural history museum, transportation museum, or a similar museum", 2) "worked or played on a computer together", 3) "built or fixed something such as a vehicle or appliance", 4) "attended a school science fair", 5)

"helped [your 9th grader] with a school science fair project", 6) "discussed a program or article about math, science, or technology", 7) "visited a library", 8) "gone to a play, concert, or other live show", or 9) done "none of these" during the last 12 months.

Academic engagement, preparation, and achievement. To signal academic engagement, preparation, and achievement, I used multiple variables including school belonging and readiness, academic ability, level of math and science courses taken by 9th grader in the 8th grade, number of credits taken in 9th grade, 9th grade GPA and score on mathematics test.

Academic engagement. Measures of academic engagement include three scales of school belonging, school readiness, and student academic ability. School belonging is a scale that captures whether the 9th grader: 1) feels safe at school; 2) is proud to be part of his/her school; 3) feels that the school is often a waste of time; and 4) getting good grades is important to him/her. School readiness measures how often the 9th grader went to class late, without pencil or paper, without books, or without his/her homework done. Both variables are continuous with higher values corresponding to a stronger sense of belonging, respectively, school readiness. The coefficient of reliability (alpha) for the two scales is .65.

The third scale seeks to capture the influence of students' overall wellness on the decision to pursue college-based dual enrollment. The 9th grade survey asked parents "Compared with other 9th graders, would you say [your 9th grader] experiences a lot, a little, or no difficulty in the following areas: (1) learning, understanding, or paying attention, (2) speaking, communicating, or being understood, (3) feeling anxious or depressed, (4) behavior problems, such as acting-out, fighting, bullying, or arguing, (5) making and keeping friends?". To reduce dimensionality, I conducted a principal component analysis (PCA) of these five items to create a single continuous measure of student academic ability or wellness. Principal component analysis

is a data reduction technique commonly used to address variable dimensionality (O'Rourke & Hatcher, 2014). Because PCA typically relies on a Pearson's correlation matrix that implies interval or ratio data, ordinal data such as Likert-type items require the use of polychoric correlations, which assume that ordinal data represent unobserved continuous variables (Basto & Prereira, 2012). To this end, I first ran a polychoric correlation matrix and output it as a dataset. I then used the correlation matrix dataset as input data in the factor analysis procedure to produce a single measure with a coefficient of reliability (alpha) of .69.

Academic preparation. To capture academic preparation, I used most advanced math and science courses taken in 8th grade as well as the number of credits taken in 9th grade. I created three indicators designating whether the most advanced mathematics course taken in the 8th grade was lower than Algebra I, Algebra I, or higher than Algebra I. While mathematics courses are fairly easy to place in a sequence, science courses are less sequential so establishing a science pipeline is considerably more convoluted (Burkam & Lee, 2003). Given the opacity of 8th grade science pipeline and the unequal distribution of students across science courses, I created a binary variable where a one indicated that the most advanced 8th grade science course was General Science/General Science 8 or Science 8. I coded the remaining science courses (i.e., Biology, Life Science, Pre-AP or Pre-IB Biology, Chemistry, Earth Science, Environmental Science, Integrated Science, Principles of Technology, Physical Science, Physics, and Other science course) as zero. The final measure of academic preparation, number of credits taken in 9th grade is a continuous variable derived from high school transcript data and designating the total Carnegie credits earned in 9th grade. For this measure, I also included a quadratic term.

Academic achievement. In addition to measures of academic engagement and preparation, I also included two variables representing academic performance. The first variable, 9th grade

GPA, is a continuous measure constructed from high school transcript data and derived on a 4-point scale. The second variable, standardized math test score, another continuous measure, captures students' achievement on a math assessment relative to the entire population of fall 2009 9th graders (Ingels et al., 2011). Both measures of academic achievement have an accompanying quadratic term.

Educational aspirations. The HSLS:09 9th grade survey contains information about students' orientation towards college and postsecondary expectations which help define students' educational aspirations. To measure orientation towards college, I include four binary indicators. The first indicator combines information from individual source variables related to college examinations and signals whether the 9th grader planned to take the PSAT, SAT, or ACT. The second indicator combines source information related to AP and IB and captures whether the 9th grader planned to take an AP or IB test. I constructed the third binary indicator from five individual survey items to signal a student's participation in Talent Search, Upward Bound, Gear Up, Advancement in Individual Determination (AVID), or Mathematics, Engineering, Science Achievement (MESA). In the context in which these programs focus on college readiness and encourage students to pursue a postsecondary degree, they are likely to orient students towards college, encourage dual enrollment on a college campus, and boost postsecondary enrollment. Although combining all programs in one variable is less than ideal, including separate dummy variables for each program is problematic because of too few cases assigned to each distinct condition or program. Finally, the fourth and last binary measure representing orientation towards college captures whether 9th grader agrees that working is more important than attending college.

Next, I used four binary variables to convey information about students' postsecondary expectations. The 9th grade survey asked students "As things stand now, how far in school do you think you will get?". Similar to parental expectations, I created three binary indicators that signal whether a student's expected educational level was less than bachelor's degree, bachelor's degree, or a master's degree or higher. The fourth dichotomous variable identifies students who did not know how to respond to the question. Subsequent analyses used as reference group students who expected to attain less than a bachelor's degree.

Social influence. Two covariates measure social influence: academic discussions and peer influence. Students were asked "Since the beginning of the last school year (2008-2009), which of the following people have you talked with about going to college?". Response options included "your mother or female guardian", "your father or male guardian", "your friends", "a favorite teacher", and "a school counselor". Using these items, I created a summary academic discussions measure that equaled one if students has selected any single response option and five if they had endorsed all response options. The second covariate accounts for peer influence and is a binary indicator that measures whether the 9th grader's friend gets good grades. Initially I had also included a binary variable indicating whether the 9th grader's friend plans to go to college but I eventually dropped it because the variable was extremely skewed and had too few cases in one category.

Extracurricular activities. In addition to information about student and family characteristics, academics, educational aspirations, and social influence, the 9th grade survey also inquired about students' participation in extracurricular activities. Parents were asked to select the types of activities their students engaged in outside of school. Since parents could check multiple responses, I created a summary count variable indicating how many types of non-

academic extracurricular activities (i.e., performing or visual arts, organized sports, religious group, or scouting or another club activity) the 9th grader participated in. This summary variable had a value of zero is parents had participated in none of the activities and four if they had endorsed all of them. I initially derived a similar variable representing academic extracurriculars (i.e., academic instruction outside of school and math or science camp). However, because too few students had participated in both types of activities, I decided to simply include a binary indicator signaling whether a student had participated in any of the two academic extracurricular activities.

Two other HSLS:09 student items provide information about the number of hours students spent on extracurricular activities and working for pay. To capture the number of hours spent on extracurricular activities on a typical school day, I created five binary covariates indicating whether the student spent "less than 1 hour", "1 to 2 hours", "2 to 3 hours", "3 to 4 hours", or "4 or more hours". For the number of hours spent working for pay on a typical school day, I included three dichotomous variables indicating whether the student worked "less than 1 hour", "1 to 2 hours" or "2 or more hours". I used "less than 1 hour" as the omitted category.

This study uses a rich set of student-level covariates that capture information about student demographics, family characteristics, academic engagement, preparation and achievement, educational aspirations, social influence, and extracurricular activities. Table 7 provides descriptive statistics for student-level covariates in the high school analytic sample where dual enrollment taken exclusively on a college campus represents the treatment.

School-level covariates. Comparisons of randomized and non-randomized assignments suggest propensity score weighting is an inefficient bias-reducing strategy when propensity scores account only for the so-called *predictors of convenience* (i.e., gender, race/ethnicity, age,

Table 7.

Descriptives for Student-Level Covariates.

Student Covariates	Mean	SD	Minimum	Maximum	N
Demographics					
Sex					
Female	0.54	0.50	0.00	1.00	2,050
Race					
Asian	0.09	0.28	0.00	1.00	2,050
Black	0.10	0.30	0.00	1.00	2,050
Hispanic	0.14	0.34	0.00	1.00	2,050
White	0.58	0.49	0.00	1.00	2,050
Other	0.10	0.30	0.00	1.00	2,050
Family characteristics					
Language					
First language is not English	0.11	0.31	0.00	1.00	1,750
Family structure					
Number of household members	4.35	1.32	2.00	11.00	1,750
Single parent household	0.20	0.40	0.00	1.00	1,750
SES					
Family income: <= $15,000	0.07	0.25	0.00	1.00	1,750
Family income: > $15,000 and <=$35,000	0.16	0.37	0.00	1.00	1,750
Family income: > $35,000 and <=$55,000	0.17	0.38	0.00	1.00	1,750
Family income: > $55,000 and <=$75,000	0.16	0.37	0.00	1.00	1,750
Family income: > $75,000 and <=$95,000	0.12	0.33	0.00	1.00	1,750
Family income: > $95,000 and <=$115,000	0.09	0.29	0.00	1.00	1,750
Family income: > $115,001	0.22	0.41	0.00	1.00	1,750
Parents' highest level of education: Less than bachelor's degree	0.54	0.50	0.00	1.00	1,750

Table 7. (continued).

Parents' highest level of education: Bachelor's degree	0.27	0.45	0.00	1.00	1,750
Parents' highest level of education: Master's degree or higher	0.19	0.39	0.00	1.00	1,750
Parent occupation prestige	61.06	20.39	14.24	95.45	1,750
Parental aspirations and expectations					
Parental aspirations: Less than bachelor's degree	0.03	0.17	0.00	1.00	1,670
Parental aspirations: Bachelor's degree	0.18	0.38	0.00	1.00	1,670
Parental aspirations: Master's degree or higher	0.79	0.41	0.00	1.00	1,670
Parental expectations: Less than bachelor's degree	0.10	0.29	0.00	1.00	1,750
Parental expectations: Bachelor's degree	0.34	0.47	0.00	1.00	1,750
Parental expectations: Master's degree or higher	0.49	0.50	0.00	1.00	1,750
Parental expectations: Don't know	0.08	0.27	0.00	1.00	1,750
Parental involvement					
Parent helped 9th grader with homework: Never	0.22	0.42	0.00	1.00	1,670
Parent helped 9th grader with homework: Less than once a week	0.33	0.47	0.00	1.00	1,670
Parent helped 9th grader with homework: 1 or 2 days a week	0.31	0.46	0.00	1.00	1,670
Parent helped 9th grader with homework: 3 or more days a week	0.14	0.34	0.00	1.00	1,670
Family talked with counselor/teacher about postsecondary admission requirements	0.48	0.50	0.00	1.00	1,650
Number of school-level activity types parent engaged in	3.59	1.84	0.00	7.00	1,660
Number of student-level activity types parent engaged in	4.47	1.77	0.00	8.00	1,650
Academic engagement, preparation, and achievement					
Academic engagement					
School belonging	0.16	0.91	-3.16	1.59	1,980
School engagement	0.22	0.92	-3.08	1.39	2,000
Academic ability/wellness	-0.01	0.83	-0.43	6.61	1,640

Table 7. (continued).

Academic preparation					
Highest math in 8th grade: Lower than Algebra I	0.49	0.50	0.00	1.00	2,020
Highest math in 8th grade: Algebra I	0.41	0.49	0.00	1.00	2,020
Highest math in 8th grade: Higher than Algebra I	0.10	0.30	0.00	1.00	2,020
Highest science in 8th grade: General Science or Science 8	0.53	0.50	0.00	1.00	2,000
Number of credits taken in 9th grade	6.77	1.71	0.00	15.50	1,990
Academic achievement					
GPA 9th grade	3.04	0.76	0.21	4.00	1,940
Mathematics standardized theta score	54.29	9.31	24.58	82.19	2,040
Educational aspirations					
Orientation towards college					
9th grader plans to take PSAT, SAT, or ACT	0.78	0.42	0.00	1.00	1,990
9th grader plans to take AP or IB test	0.46	0.50	0.00	1.00	1,970
9th grader participated in college preparation program	0.13	0.34	0.00	1.00	1,910
Working is more important that attending college	0.08	0.27	0.00	1.00	2,000
Postsecondary expectations					
Less than bachelor's degree	0.13	0.34	0.00	1.00	2,040
Bachelor's degree	0.20	0.40	0.00	1.00	2,040
Master's degree or higher	0.52	0.50	0.00	1.00	2,040
Don't know	0.15	0.36	0.00	1.00	2,040
Social influence					
Discussions about college	2.60	1.31	0.00	5.00	2,010
9th graders friend gets good grades	0.90	0.29	0.00	1.00	2,010
Extracurriculars					
Number of non-academic extracurricular activity types	1.77	1.09	0.00	4.00	1,650
9th grader participated in academic extracurricular activities	0.17	0.38	0.00	1.00	1,650
Hours spent on extracurricular activities: Less than 1 hour	0.27	0.45	0.00	1.00	1,980

Table 7. (continued).

Hours spent on extracurricular activities: 1 to 2 hours	0.22	0.41	0.00	1.00	1,980
Hours spent on extracurricular activities: 2 to 3 hours	0.26	0.44	0.00	1.00	1,980
Hours spent on extracurricular activities: 3 to 4 hours	0.13	0.34	0.00	1.00	1,980
Hours spent on extracurricular activities: 4 or more hours	0.12	0.32	0.00	1.00	1,980
Hours spent working for pay: Less than 1 hour	0.76	0.43	0.00	1.00	1,920
Hours spent working for pay: 1 to 2 hours	0.13	0.34	0.00	1.00	1,920
Hours spent working for pay: 2 or more hours	0.11	0.32	0.00	1.00	1,920

Note: Descriptives are for students in the high school analytic sample where treatment was dual enrollment exclusively on a college campus (more restrictive treatment identification). SD = Standard deviation. N = number of non-missing cases in the sample.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), Second Follow-up Restricted-Use Data File.

etc.) (Shadish, Clark, & Steiner, 2008). Consequently, covariates used in the propensity model include school context measures including information about school demographics, schedule, resources, geography, and college-going culture. According to the HSLS:09 codebook, school-level derived variables were created using Common Core of Data (CCD) information associated with the year in which the initial sample was drawn (i.e., 2005-06). Consequently, in order to obtain information consistent with the year in which the 9th grade survey was conducted, I merged the survey data with 2009-10 CCD data and rederived the variables related to high school demographics.

Demographic characteristics. Six covariates provide information about high school size and racial composition. High school size is a continuous measure representing each school's total number of enrollments across all grades. To account for each school's racial make-up, I included four covariates capturing the percent of student body who are American Indian, Asian or Pacific Islander, Hispanic, or Black. Using CCD data, I calculated percentages associated with each racial group by dividing the total number of students in each racial group by the school's total enrollment. The percent of student body who are White makes up the omitted group.

Resources. I used five covariates to represent school-level resources. The first covariate is a continuous variable measuring the percent of 9th graders who receive free lunch, a proxy for socioeconomic status commonly used in education research (Dickson, 2006). The second covariate is another continuous measure representing the teacher-to-pupil ratio. Both continuous measures were derived from 2009-10 CCD data. The third covariate is an ordinal measure from the administrator 9th grade questionnaire and helps identify the extent to which the lack of resources is a problem in the student's school. School administrators were asked "To what degree is lack of resources and materials for teachers a problem at [school name]?". Response options

include “not a problem”, “minor problem”, “moderate problem”, and “serious problem”. Since there were too few cases in the last category, I collapsed “moderate problem” and “serious problem” responses into one category representing “moderate or serious problem”. Finally, the last two covariates are binary measures indicating the availability of courses not offered by the school at a community college, respectively, at a four-year college.

College-going culture. While students may self-select into college-based dual enrollment based on their individual and family background characteristics, high schools also create an environment that may be more or less supportive of college readiness. Three covariates capture high schools’ college-going culture and academic climate. The first covariate is a binary variable that indicates whether the school counseling program's primary goal is to “help with postsecondary schooling”. The second measure is a dichotomous indicator signaling whether the school has a guidance counselor designated for college readiness, selection, and application. Lastly, to capture high school academic climate, I include a continuous measure representing the percent of 9th graders who are repeating 9th grade.

Schedule. The HSLS:09 9th grade administrator questionnaire contains several variables identifying the course schedule and academic calendar the school uses. To reflect course schedule, I created an ordinal measure with three levels that indicate whether in scheduling academic or vocational/technical courses the student’s school used traditional scheduling only (i.e., no block scheduling), block-scheduled courses lasting less than 90 minutes, or block-scheduled courses of at least 90 minutes. Students in schools with traditional scheduling make up the omitted category. I also included a binary covariate indicating whether the school used a semester calendar.

Geography. Two covariates capture the influence of geography on students' participation in college-based dual enrollment: proximity to college and urbanicity. I derived urbanicity of the student's high school using urban-centric locale data from CCD. The CCD locale is a 12-category variable that divides city and suburb areas into large, mid-size, and small territories and town and rural into fringe, distant, and remote territories. I collapsed the territory groupings to create dummy variables designating whether a school's locale was city, suburb, or rural. The rural category represents the omitted group.

Proximity to a college campus is a crucial school-level covariate accounting for selection into college-based dual enrollment. Given that most dual enrollees attend dual enrollment courses on the campus of a public community college, I calculated the travel time to the closest community college. To this end, I obtained high school geographic coordinates from CCD and postsecondary institution geographic coordinates from the Integrated Postsecondary Education Data System (IPEDS), namely, the 2009-10 Institutional Characteristics survey. I subset IPEDS data to two-year degree-granting public postsecondary institutions that were open in 2009-10 year and located in one of the states represented in my sample. Next, I used the *georoute* command in Stata to calculate travel time between each high school and all potential community college partners in its state. The final travel time covariate is a continuous variable that measures travel time in minutes between each student's high school and the closest community college.

School-level covariates provide access to information about students' high school size, racial composition, resources, college-going culture, academic schedule, and geography. Similar to student-level covariates, Table 8 contains descriptive statistics for pre-imputation school-level covariates in the high school analytic sample where dual enrollment taken exclusively on a college campus represents the treatment.

Table 8.

Descriptives for School-Level Covariates

High School Covariates	Mean	SD	Minimum	Maximum	N
Demographics					
Size					
Total school enrollment	1464.91	773.69	43.00	4349.00	2,030
Racial composition					
Percent of student body: American Indian	0.73	3.37	0.00	99.40	2,030
Percent of student body: Asian/Pacific Islander/Hawaiian Native	4.04	5.97	0.00	56.69	2,030
Percent of student body: Hispanic	14.69	18.65	0.00	99.28	2,030
Percent of student body: Black	13.07	18.19	0.00	99.53	2,030
Percent of student body: White	66.05	27.09	0.00	99.56	2,030
Percent of student body: Unknown race or two or more races	1.42	3.91	0.00	77.60	2,030
Resources					
Percent of student body receiving free lunch	29.65	18.08	0.00	93.49	2,000
Pupil-to-teacher ratio	17.75	6.18	4.98	203.50	2,010
Lack of teacher resources and materials is a problem at school	1.86	0.75	1.00	3.00	1,750
Courses not offered by school available at community college	0.82	0.39	0.00	1.00	1,840
Courses not offered by school available at 4-year college	0.49	0.50	0.00	1.00	1,840
College-going culture					
Help with postsecondary schooling is counseling primary goal	0.49	0.50	0.00	1.00	1,830
School has counselor designated for college readiness	0.56	0.50	0.00	1.00	1,830
Percent of 9th graders repeating 9th grade	4.65	6.72	0.00	79.00	1,890
Schedule					
Block-scheduling: School uses traditional schedule	0.57	0.50	0.00	1.00	1,890
Block-scheduling: Block schedule is less than 90 minutes	0.08	0.28	0.00	1.00	1,880
Block-scheduling: Block schedule is at least 90 minutes	0.35	0.48	0.00	1.00	1,880
School uses semester calendar	0.76	0.43	0.00	1.00	1,930
Geography					
School urbanicity: City	0.25	0.43	0.00	1.00	2,050

Table 8. (continued).

School urbanicity: Suburb	0.30	0.46	0.00	1.00	2,050
School urbanicity: Town	0.15	0.35	0.00	1.00	2,050
School urbanicity: Rural	0.31	0.46	0.00	1.00	2,050
Travel time to the closest two-year institution	26.64	26.53	0.83	288.97	2,050

Note: Descriptives are for students in the high school analytic sample where treatment was dual enrollment exclusively on a college campus. SD = Standard deviation. N = number of non-missing cases in the sample.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), Second Follow-up Restricted-Use Data File.

State-level covariates. To account for state-level policies that may have affected students' likelihood of taking dual enrollment courses on a college campus instead of at their high school, I included fixed effects for all states in the samples.

Survey weight

Analyses of HSLS:09 student survey data that aim to generate estimates for the target population require the use of student weights (Ingels et al., 2011). The student longitudinal analytic weight for the 9th grade, 11th grade, and 12th grade surveys is W3W1W2STU. Alternately, the student longitudinal analytic weight for the 9th grade, 11th grade, 12th grade, and college surveys is W4W1W2W3STU. Consequently, I used W3W1W2STU analytic weight for the high school analytic samples and W4W1W2W3STU for the college analytic samples. Congruent with best practices of propensity scores applications to complex surveys, I incorporated the student survey weights as a standalone predictor in the treatment model and as part of a new composite weight representing the product of the survey weight and inverse probability weight in all outcome models (DuGoff, Schuler, & Stuart, 2014).

HSLS:09 is based on a complex survey design as evidenced by the use of a stratified two-stage sample design and poststratification and nonresponse weights (Groves et al., 2009). The sampling design influences the estimation of standard errors (Lee & Forthofer, 2006). Ideally, outcome models should include information about clusters and strata in order to account for the sampling design (DuGoff et al., 2014).

There are two methods of estimating variance with HSLS:09: balanced repeated replication (BRR) weights or Taylor series linearization (Ingels et al., 2011). Because outcome estimation using imputed data does not allow the use of BRR weights in Stata, I attempted implementing Taylor series linearization using primary sampling units (PSUs) and strata. However, in order to

incorporate PSUs and strata, each stratum must contain at least two PSUs. The low number of dual enrollment participants and dual enrollees who responded to the question about location caused significant data truncation. As a result, the analytic samples had many strata with only one PSU. To verify the implications of excluding information about clustering and stratification, I re-imputed the high school base analytic sample with PSU and strata information and then dropped all strata with only one PSU. Next, for each applicable outcome, I ran one estimation model that accounted for PSUs, strata, and composite weight and a second model with only the composite weight. The two models produced the same coefficients, but standard errors were slightly higher in the model with PSUs, strata, and composite weight. Because of the inability to account for the complex survey design, standard errors in the final estimation models are likely to be underestimated. However, as we will see in Chapter 4, analyses indicate largely null results, so this underestimation of standard errors is less problematic.

Analytic Strategy

This study uses a quasi-experimental design, propensity score weighting or inverse probability of treatment weights (IPTW) (Guo & Fraser, 2015), to reduce selection threats to internal validity and obtain causal estimates that accurately reflect the intervention or treatment.

Propensity score assumptions. Propensity score weighting relies on the Neyman-Rubin counterfactual framework or potential outcome model and assumes that every individual i in both the treatment and control groups has one observed and one unobserved outcome (Rosenbaum, 2005). Thus, an individual can either be treated or untreated but not simultaneously both and only one outcome may be observed at one time. For an individual who received an intervention, the unobserved outcome or counterfactual corresponds to that individual's outcome in the absence of the intervention or Y_{0i} (Angrist & Pishke, 2008; Guo & Fraser, 2015;

Rosenbaum, 2005). Conversely, the counterfactual for an individual who does not receive an intervention is that person's outcome in the presence of the intervention or Y_{1i}.

Propensity score methods use balancing scores to create comparable treatment and control groups in observational studies (Austin, 2011; Dehejia & Wahba, 1999). The propensity score is a balancing score or "the conditional probability of receiving the treatment rather than the control given the observed covariates" (Rosenbaum, 2005, p. 5). Its equation is given by

$$e(x) = pr(z=1|x)$$

where *e(x)* represents the propensity score, z=*1* is the treatment, and *x* is the observed covariates (Rosenbaum & Rubin, 1983).

One critical propensity score assumption is the ignorable treatment assignment assumption (ITAA). Also referenced to in the literature as *unconfoundedness*, *selection on observables*, *conditional independence*, or *exogeneity,* ITAA is often viewed as an extension of the stable unit treatment value assumption (SUTVA) (Guo & Fraser, 2015). Causal estimations satisfy ITAA when conditional on a set of covariates, a student's treatment assignment and outcomes are uncorrelated, thus resembling randomization (Guo & Fraser, 2015). ITAA violations may occur if an unobserved variable is causing some units to have higher or lower probability of treatment selection and may result in biased estimates. In this study, I seek to satisfy ITAA by including a rich set of covariates that aims to ensure equivalency between the treated and untreated.

A second propensity score assumption is the common support assumption. To meet the common support condition, units in the treatment and control groups must have overlapping distributions of propensity scores (Khandker et al., 2010). This assumption ensures that observed characteristics do not perfectly predict treatment participation (Caliendo & Kopeinig, 2005).

Limited areas of common support may cause biased estimates and large variance (Guo & Fraser, 2015). Trimming propensity scores helps establish strong overlap between the treatment and control groups in this study.

Successful applications of the counterfactual framework require satisfaction of SUTVA (Rubin, 1980). SUTVA refers to an "a priori assumption that the value of *Y* for unit *u* when exposed to treatment *t* will be the same no matter what mechanism is used to assign treatment *t* to unit *u* and no matter what treatments the other units receive" (Rubin, 1986, p.961). Violations of SUTVA may occur when there are multiple treatment versions or units are interacting with each other (Rubin, 1986). In the context of HSLS:09, this study assumes that college-based dual enrollment is implemented fairly uniform and there are no unrepresented versions of this treatment; I discuss the limitations of this assumption in chapter 5. While it is possible that students who reported taking high school-based dual enrollment in the 11th grade survey may have taken college-based dual enrollment in the 12th grade, it is more likely that the constraints driving their selection into high school-based dual enrollment would persist. Hence, if students took dual enrollment courses in 12th grade, it seems reasonable to assume they would have been more likely to take them in the same location as previously.

Another SUTVA consideration requires that a student's outcome should be independent of a different student's participation in college-based or high school-based dual enrollment. Considering that the 2,260 students in the base analytic sample represented more than 600 unique high schools, it is unlikely, though not impossible, that a student's dual enrollment location impacted another dual enrollee's outcomes.

Propensity score weighting. Propensity score weighting seeks to minimize selection bias and balance data by weighting the treated and untreated based on their conditional probability of

participating in the treatment (Guo & Fraser, 2015). Rather than rely on regression covariates to reduce selection bias, IPTW uses the estimated propensity scores as sampling weights in a regression model to eliminate bias and generate the counterfactuals. The literature suggests two approaches to estimating treatment effects using propensity score methods with imputed data. The first approach, also known as the within-method, consists of calculating propensities, matching the treated and untreated, and estimating a treatment effect all within each distinct imputation dataset (Mitra & Reiter, 2016). The resulting multiple treatment effects are then averaged to produce the final point estimate. The second strategy, known as the across-method, averages each individual's propensity score across all imputations and uses those averages to match the treated and untreated and produces a treatment effect estimate. Simulations using both the within-method and across-method with IPTW and imputed data indicate the former reduces bias considerably over the latter (Mitra & Reiter, 2016). Consequently, for each of the four analytic samples used in this study, I implemented Mitra and Reiter's within-method following the steps below:

1. Calculate each sample member's propensity scores within every imputation dataset produced.
2. Establish common support by averaging each individual's propensity scores across imputations and dropping values with no overlap.
3. Use propensity scores to generate an IPTW for each individual.
4. Estimate a treatment effect within each imputation dataset and produce the overall average effect.

Estimate propensity scores. Based on the observed covariates previously discussed, I used a logit model to estimate the predicted probability of participating in dual enrollment for

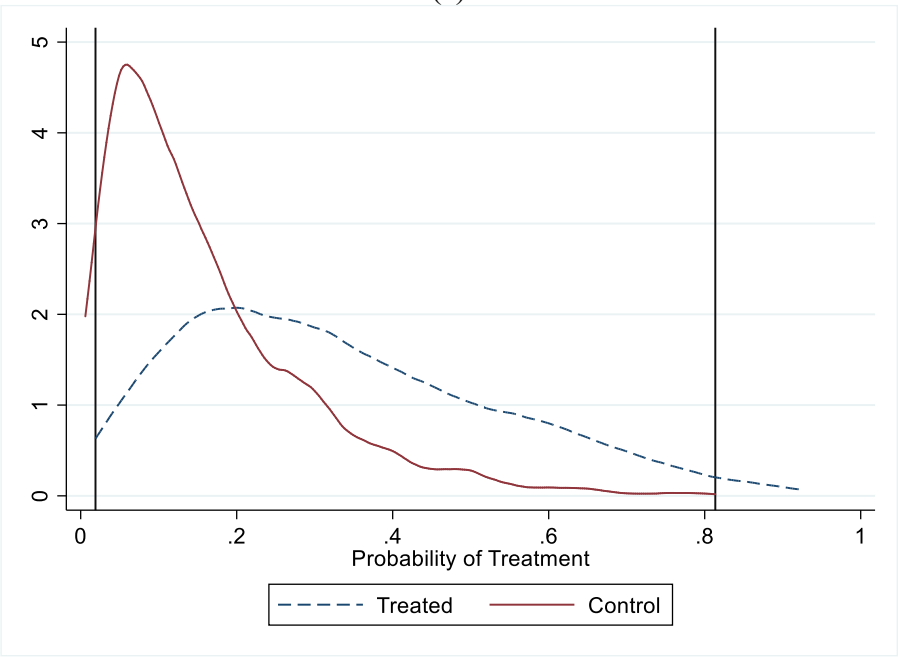
respondents in both the treated and untreated groups. In addition to the covariates, the propensity estimation model included quadratic terms for continuous covariates in order to account for non-linear relationships (Stock & Watson, 2007). Moreover, I included the student survey weight as a covariate to account for the complex survey design and strengthen the unconfounded treatment assignment assumption (DuGoff et al., 2014). To estimate propensity scores, I used the following logistic regression equation:

$$logit(COLLEGEDE = 1) = \beta_0 + \beta_k X_i + \beta_{k+1}\omega_i + \epsilon$$

where COLEGEDE is the probability of taking dual enrollment on a college campus, X_i is a vector of k covariates for student i, β_k is a vector of regression coefficients, and w_i is the longitudinal student-level analytic weight, and ϵ is an error term representing any unobserved variables that may influence a student's probability of taking dual enrollment on a college campus.

Following propensity score estimation, I graphed propensity scores to ensure the probability of treatment estimated for the treated and the untreated share a region of common support (Caliendo & Kopeinig, 2008; Guo & Fraser, 2015). Figures 5 and 6 show that all four analytic samples shared adequate common support. Initially I intended to drop cases with propensities below the highest minimum value and above the lowest maximum value across the treatment and control groups within each imputation dataset. However, implementing this step would have required dropping individuals with *any* propensity score outside the region of common support from all imputation datasets. In other words, if an individual had a propensity score outside the region of common support in one imputation dataset but within the region of common support in the remaining 40 imputation datasets, that individual would have been dropped from all 40 datasets. For considerations related to sample size, I chose to implement a

(a)



(b)

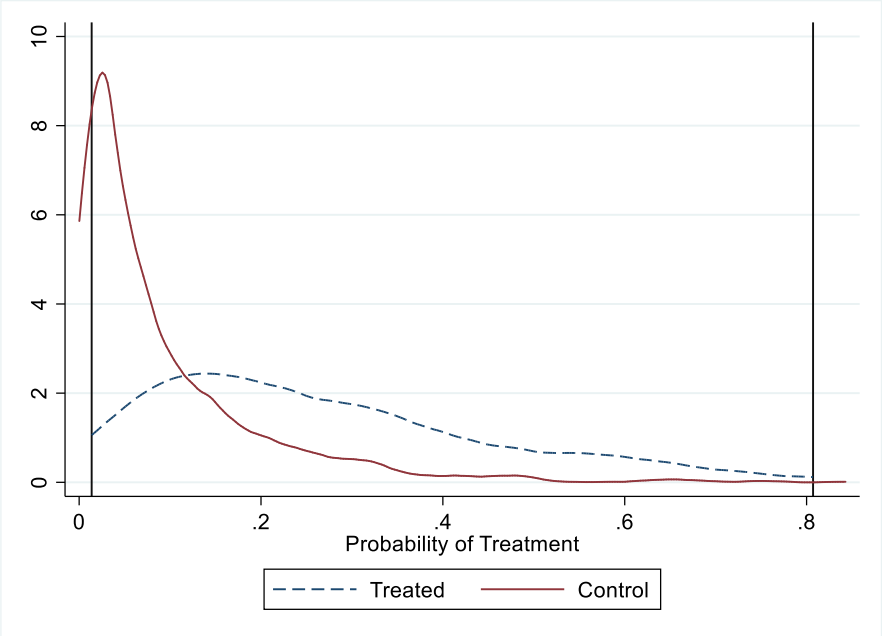
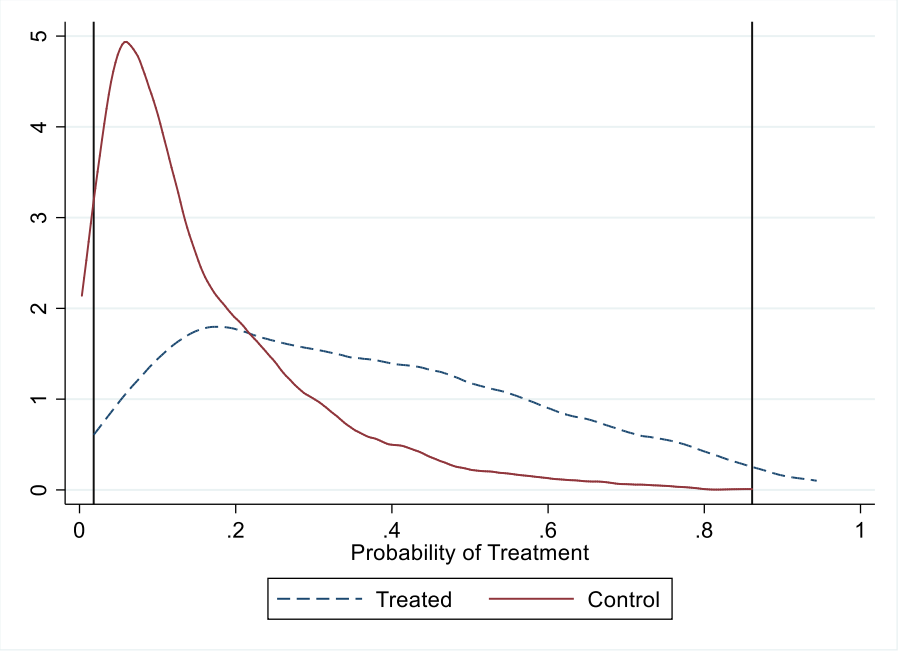


Figure 5. Histograms of Common Support for the High School Analytic Samples where the Treatment is Dual Enrollment on a College Campus (a) and Dual Enrollment Exclusively on a College Campus (b)

(a)



(b)

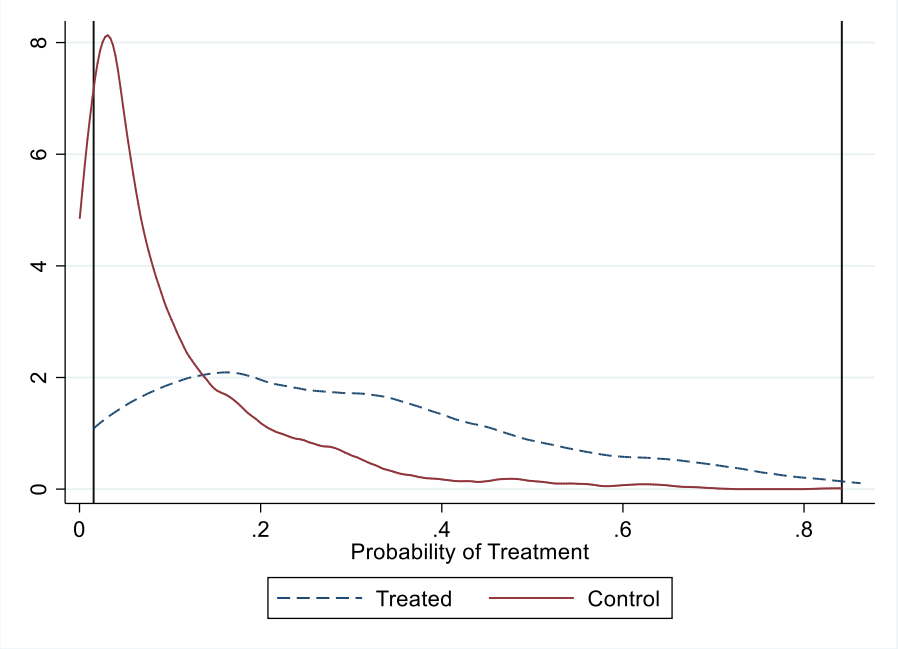


Figure 6. Histograms of Common Support for the College Analytic Samples where the Treatment is Dual Enrollment on a College Campus (a) and Dual Enrollment Exclusively on a College Campus (b)

slightly different approach: after calculating each individual's average propensity score across all imputations, I examined the region of common support of average propensities and then dropped observations with averages below the highest minimum value and above the lowest maximum value from all imputation datasets. These steps were implemented in all four analytic samples.

Calculate inverse probability of treatment weights. After modeling the probability of treatment, I used the propensity scores to calculate the inverse probability of treatment weights. From a policy perspective, decision-makers are most interested in whether an intervention benefits the individuals for whom it is intended (Guo & Fraser, 2015). Consequently, in this study I estimate the average treatment effect on the treated (ATT). In estimating the ATT, I used the inverse probability of treatment weights to pull the control group towards the treated and establish comparability between the groups. To this end, the treated received a weight of 1 and the untreated a weight equal to the predicted probability of treatment divided by one minus the predicted probability of treatment (Guo & Fraser, 2015; Thoemmes & Kim, 2011):

$$\text{Treatment group, } w = 1$$

$$\text{Control group, } w = \hat{e}(x) \,/\, 1 - \hat{e}(x)$$

Because large weights may inordinately affect results, trimming weights can enhance the precision of the estimates (Lee, Lessler, & Stuart, 2011). Therefore, I used descriptive statistics to check for large weights and recoded cases with weights larger than five as five. The overarching goal of IPTW is "to create balance between treated and control units in the weighted sample" (Imbens, 2004). I checked for balance by comparing the treated and untreated on several covariate statistics (i.e., mean, standard deviation, difference between means, standardized bias) measured pre- and post-weighting. The standardized difference uses units of standard deviation

to convey the difference in group means (Austin, 2009). The standardized difference is calculated as:

$$SD = \frac{\bar{X}_T - \bar{X}_C}{\sqrt{\frac{S_T^2 + S_C^2}{2}}}$$

where *SD* is the standardized difference, $\bar{X}_T$ and $\bar{X}_C$ represent the covariate sample means for the treatment and control groups, and S_T^2 and S_C^2 are the covariate variance for the two groups. For dichotomous covariates, the standardized difference is computed as:

$$SD = \frac{\hat{P}_T - \hat{P}_C}{\sqrt{\frac{\hat{P}_T(1 - \hat{P}_T) - \hat{P}_C(1 - \hat{P}_C)}{2}}}$$

where $\hat{P}_T$ and $\hat{P}_C$ represent covariate sample proportions for the treatment and control groups.

As illustrated in more detail in Chapter 4, IPTW was successful in that post-weighting standardized bias was lower. Finally, in line with recommendations for application of propensity weighting to complex surveys, I reduced the newly generated inverse probability of treatment weights and the survey weights to one weight by multiplying them (DuGoff et al., 2014).

Model outcomes. To estimate the causal effect of dual enrollment course location on high school graduation and college-going behaviors, I ran separate models for each outcome and treatment version. Models included a simple regression with no weights for the naïve treatment effect, a simple weighted regression, and a doubly robust estimation model that includes weights and covariates. Given that high school graduation, FAFSA application, and postsecondary enrollment immediately after high school or three years after high school are binary dependent variables, analyses models used logistic regression:

$$logit(BINARYDV_i) = \beta_0 + \beta_1 COLLEGEDE_i + \beta_i X_i + \epsilon_i$$

where *BINARYDV* is the binary outcome predicted for student *i* when $COLLEGEDE_i$ is the treatment, controlling for a set of covariates X_i. The error term, ϵ_i, represents additional factors that may drive the outcome but are not captured in the model.

To model the causal relationship between dual enrollment location and the number of college applications, I used a Poisson regression that is appropriate for count variables (Wooldridge, 2013):

$$APPNUM_i = \beta_0 + \beta_1 COLLEGEDE_i + \beta_i X_i + \epsilon_i$$

where *APPNUM* is the number of college applications predicted for student *i* when $COLLEGEDE_i$ is the treatment, controlling for a set of covariates X_i. As in the logistic models, the error term, ϵ_i, captures unobserved variables that may influence the outcome.

It should be noted that sample sizes vary across models. Sample size variations reflect data processing and preparation steps implemented with the base analytic samples including applying a more restrictive treatment definition, trimming propensity score averages, conditioning outcomes on high school graduation, eliminating states with no outcome or treatment variation, and dropping cases with missingness on the dependent variables. Figure 7 provides an overview of the steps taken and sample sizes used to estimate the effect of the less restrictive treatment option (i.e., taking dual enrollment on a college campus, potentially in combination with other locations) on high school graduation, FAFSA completion, number of college applications, and postsecondary enrollment immediately after high school. Similarly, Figure 8 shows the restriction criteria applied to the high school base analytic sample when estimating the same four outcomes based on the more restrictive treatment definition (i.e., taking dual enrollment exclusively on a college campus). Last but not least, Figure 9 illustrates how

sample sizes vary across the two treatment versions when estimating postsecondary enrollment three years after college.

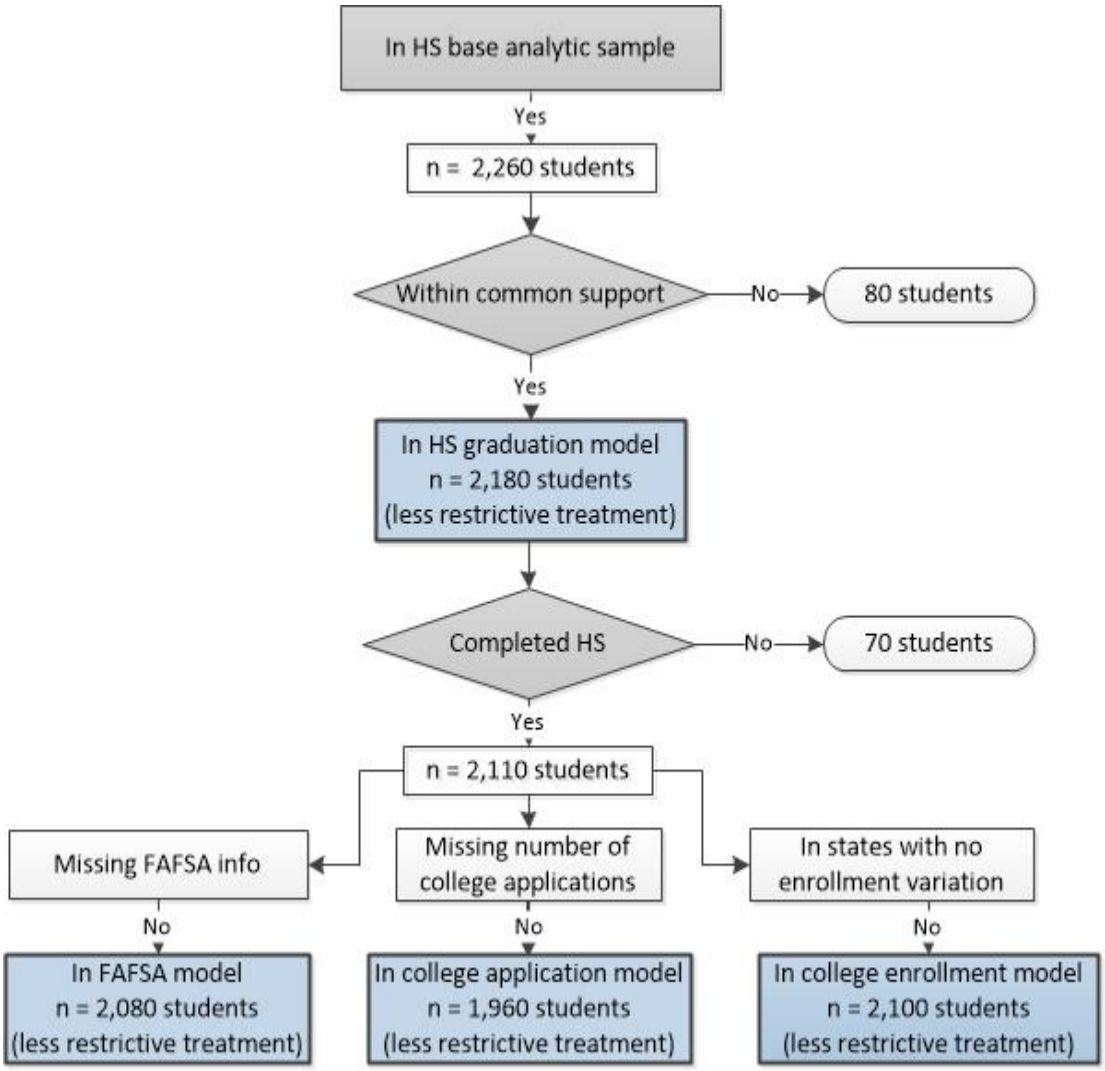


Figure 7. Sample Sizes for Outcome Models Using the High School Base Analytic Sample Where the Treatment Is Dual Enrollment on a College Campus (Less Restrictive Treatment Identification). HS = high school. DE = dual enrollment. n = sample size. Sample sizes are rounded to the nearest tenth according to restricted-use data guidelines and may not always sum up perfectly.

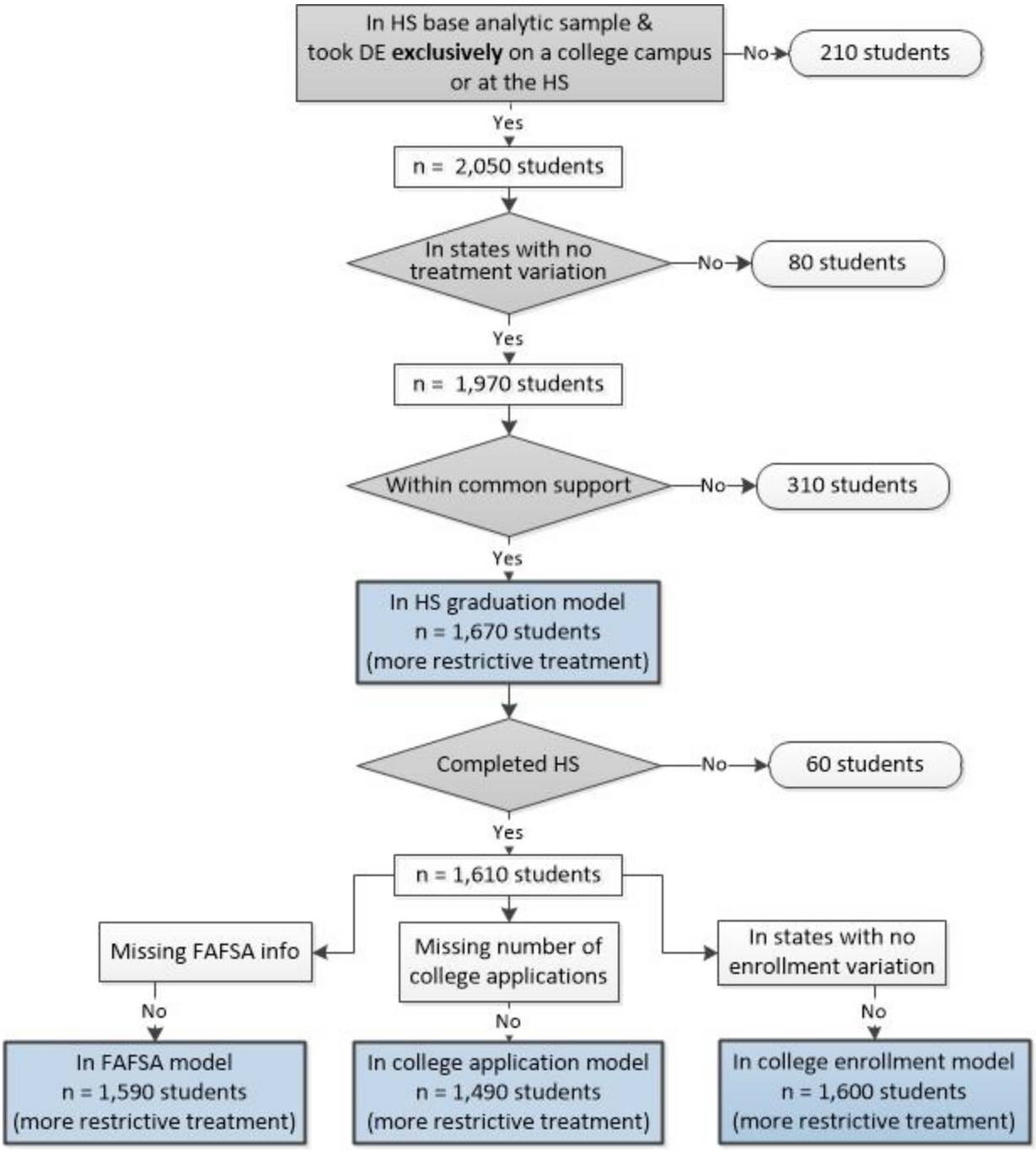


Figure 8. Sample Sizes for Outcome Models Using the High School Analytic Sample Where the Treatment Is Dual Enrollment Exclusively on a College Campus (More Restrictive Treatment Identification). HS = high school DE = dual enrollment. n = sample size. Sample sizes are rounded to the nearest tenth according to restricted-use data guidelines and may not always sum up perfectly.

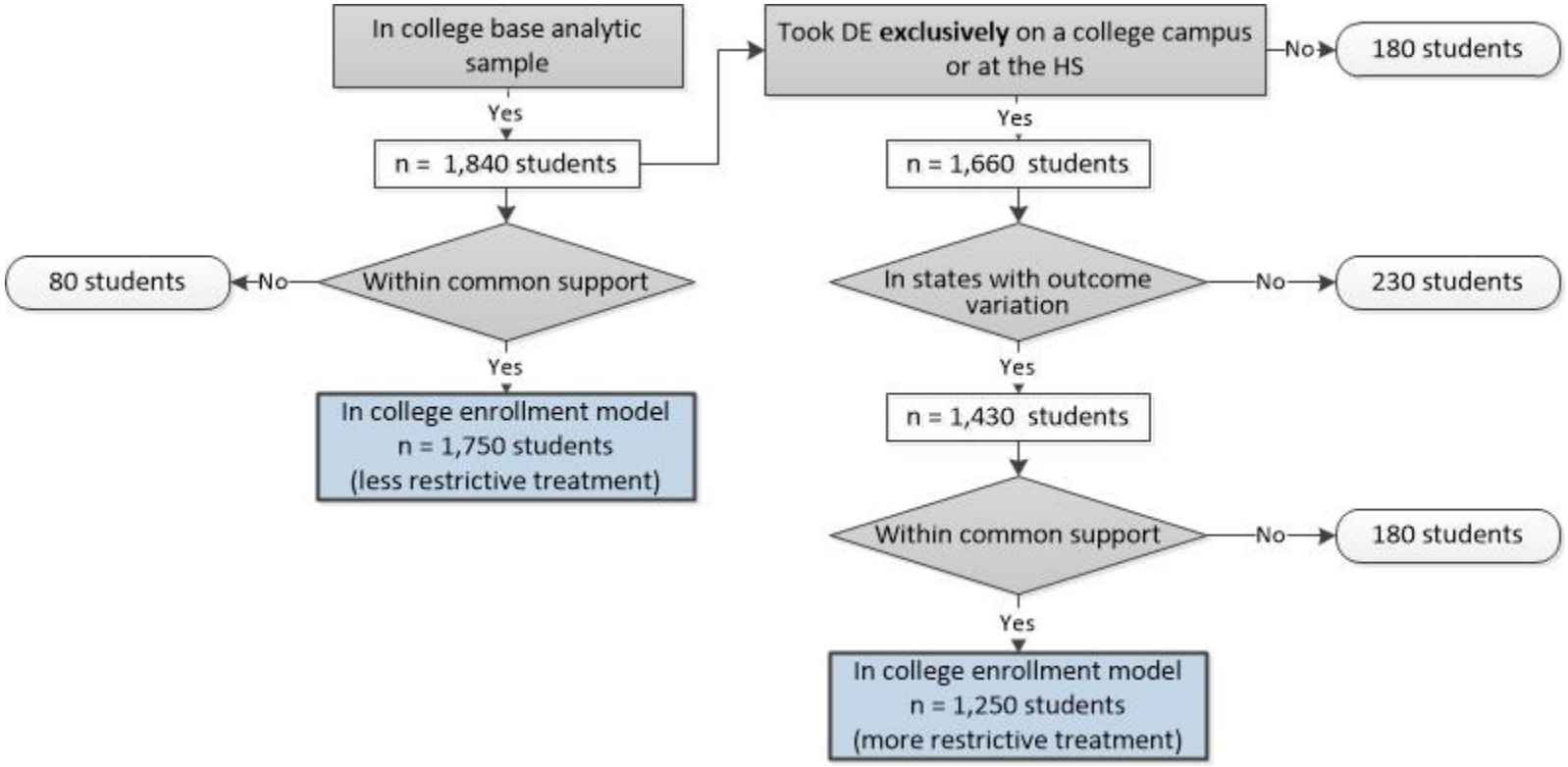


Figure 9. Sample Sizes for Outcome Models Using the College Analytic Samples. HS = high school. DE = dual enrollment. n = sample size. Sample sizes are rounded to the nearest tenth according to restricted-use data guidelines and may not always sum up perfectly.

CHAPTER 4: FINDINGS

Since students self-select into college-based or high school-based dual enrollment courses, systematic differences may exist between the treatment and control groups. As described in Chapter 3, I used inverse propensity score weights to weigh the control group towards the treated and balance the distribution of the baseline covariates across the two groups. If the treatment and control groups are successfully balanced, there should be little difference in the baseline covariates after weighting. There are typically two diagnostic tools used to assess balance: common support and standardized differences.

Descriptive Statistics Before and After Weighting

Although there is still some debate as to what value of the standardized difference suggests inadequate balance, some researchers deem standardized differences of 0.1 or more to be substantial indication of unbalanced covariates (Austin, 2009). Hence, in assessing and discussing the quality of covariates balance before and after weighting, I refer to a 0.10 (i.e., 10%) standardized difference threshold.

Table 9 provides an overview of the treatment and control groups' means, mean differences, and standardized differences before and after weighting, for the high school base analytic sample where taking dual enrollment on a college campus, regardless of combination (i.e., the less restrictive treatment identification) was the treatment. Before weighting, 29% (n = 32) of covariates had a mean standardized difference of 0.10 or greater or -0.10 or lower. Compared to high school-based dual enrollees, a greater proportion of students who indicated taking dual enrollment on a college campus attended a high school in the city, had completed an 8^{th} grade math course higher than Algebra I, and had higher 9^{th} grade GPA and standardized

Table 9.

Standardized Difference Before and After Weighting in the High School Analytic Sample where Treatment is DE on a College Campus (Less Restrictive Identification).

Covariates	Unweighted Sample				Weighted Sample			
	Mean		Mean Diff	Std. Diff	Mean		Mean Diff.	Std. Diff
	T	C			T	C		
Student sex: Female	0.56	0.54	0.02	0.044	0.56	0.55	0.01	0.024
Student race: Asian	0.10	0.09	0.01	0.015	0.10	0.09	0.01	0.007
Student race: Black	0.10	0.10	0.00	0.005	0.10	0.10	0.00	-0.012
Student race: Hispanic	0.14	0.14	0.00	0.018	0.14	0.14	0.00	0.022
Student race: Other	0.10	0.10	0.00	0.011	0.10	0.11	-0.01	-0.022
First language is not English	0.10	0.11	-0.01	-0.024	0.10	0.11	-0.01	-0.015
Number of household members	4.48	4.32	0.16	0.116	4.48	4.54	-0.06	-0.040
Number of household members: Square term	22.17	20.43	1.74	0.121	22.17	22.79	-0.62	-0.043
Single parent household	0.22	0.21	0.01	0.021	0.22	0.21	0.01	0.026
Family income: > $15,000 and <=$35,000	0.17	0.17	0.00	0.003	0.17	0.17	0.00	0.012
Family income: > $35,000 and <=$55,000	0.19	0.18	0.01	0.039	0.19	0.19	0.00	-0.005
Family income: > $55,000 and <=$75,000	0.17	0.16	0.01	0.011	0.17	0.17	0.00	-0.013
Family income: > $75,000 and <=$95,000	0.11	0.12	-0.01	-0.033	0.11	0.11	0.00	0.002
Family income: > $95,000 and <=$115,000	0.07	0.09	-0.02	-0.084	0.07	0.07	0.00	-0.016
Family income: > $115,001	0.21	0.20	0.01	0.031	0.21	0.21	0.00	0.014
Parents' highest level of education: BA	0.25	0.26	-0.01	-0.020	0.25	0.24	0.01	0.033
Parents' highest level of education: MA or higher	0.23	0.17	0.06	0.143	0.23	0.23	0.00	-0.002
Parent occupation prestige	62.66	60.03	2.63	0.128	62.66	62.20	0.46	0.022
Parental aspirations: Bachelor's degree	0.15	0.18	-0.03	-0.070	0.15	0.16	-0.01	-0.007
Parental aspirations: Master's degree or higher	0.82	0.78	0.04	0.091	0.82	0.82	0.00	0.013
Parental expectations: Bachelor's degree	0.30	0.34	-0.04	-0.068	0.30	0.31	-0.01	-0.006
Parental expectations: Master's degree or higher	0.53	0.48	0.05	0.099	0.53	0.52	0.01	0.013

Table 9. (continued).

Parental expectations: Don't know	0.09	0.08	0.01	0.024	0.09	0.08	0.01	0.010
Parent helped 9th grader with homework: Less than once a week	0.32	0.31	0.01	0.009	0.32	0.30	0.02	0.028
Parent helped 9th grader with homework: 1 or 2 days a week	0.30	0.32	-0.02	-0.032	0.30	0.30	0.00	0.006
Parent helped 9th grader with homework: 3 or more days a week	0.15	0.14	0.01	0.023	0.15	0.15	0.00	-0.010
Family talked with counselor/teacher about postsecondary admission requirements	0.53	0.46	0.07	0.142	0.53	0.52	0.01	0.033
Number of school-level activity types parent engaged in	3.85	3.51	0.34	0.177	3.85	3.81	0.04	0.022
Number of student-level activity types parent engaged in	4.59	4.43	0.16	0.088	4.59	4.56	0.03	0.018
School belonging	0.20	0.15	0.05	0.046	0.20	0.14	0.06	0.058
School engagement	0.26	0.22	0.04	0.048	0.26	0.24	0.02	0.030
Academic ability/wellness	0.06	0.01	0.05	0.060	0.06	0.13	-0.07	-0.083
Highest math in 8th grade: Algebra I	0.42	0.41	0.01	0.014	0.42	0.40	0.02	0.034
Highest math in 8th grade: Higher than Algebra I	0.16	0.10	0.06	0.189	0.16	0.17	-0.01	-0.024
Highest science taken in 8th grade: Gen Science/Gen Science 8 or Science 8	0.46	0.54	-0.08	-0.167	0.46	0.46	0.00	-0.015
Number of credits taken in 9th grade	6.79	6.78	0.01	0.006	6.79	6.72	0.07	0.041
Number of credits taken in 9th grade: Square term	49.08	48.86	0.22	0.011	49.08	48.48	0.60	0.029
GPA 9th grade	3.12	3.00	0.12	0.146	3.12	3.07	0.05	0.062
GPA 9th grade: Square term	10.50	9.69	0.81	0.187	10.50	10.29	0.21	0.049
Mathematics standardized theta score	55.88	54.06	1.82	0.188	55.88	55.64	0.24	0.025
Mathematics standardized theta score: Square term	3224.64	3008.44	216.20	0.204	3224.64	3205.08	19.56	0.018
9th grader plans to take PSAT, SAT, or ACT	0.79	0.77	0.02	0.060	0.79	0.79	0.00	0.016
9th grader plans to take AP or IB test	0.52	0.45	0.07	0.125	0.52	0.52	0.00	-0.006
9th grader participated in college prep program	0.18	0.13	0.05	0.126	0.18	0.18	0.00	-0.017
Working is more important that attending college	0.08	0.08	0.00	0.008	0.08	0.09	-0.01	-0.041
Student postsecondary expectations: BA	0.18	0.20	-0.02	-0.052	0.18	0.18	0.00	0.006

Table 9. (continued).

Student postsecondary expectations: MA or higher	0.59	0.51	0.08	0.152	0.59	0.57	0.02	0.026
Student postsecondary expectations: Don’t know	0.12	0.15	-0.03	-0.083	0.12	0.13	-0.01	-0.014
Discussions about going to college	2.67	2.60	0.07	0.053	2.67	2.67	0.00	-0.004
9th grader's friend gets good grades	0.91	0.90	0.01	0.031	0.91	0.90	0.01	0.032
Number of non-academic extracurricular activities types 9th grader participated in	1.80	1.72	0.08	0.071	1.80	1.78	0.02	0.018
9th grader participated in academic extracurricular activities	0.24	0.17	0.07	0.167	0.24	0.24	0.00	-0.001
Hours spent on extracurricular activities: 1 to 2	0.24	0.22	0.02	0.052	0.24	0.23	0.01	0.019
Hours spent on extracurricular activities: 2 to 3	0.21	0.26	-0.05	-0.102	0.21	0.21	0.00	0.012
Hours spent on extracurricular activities: 3 to 4	0.14	0.13	0.01	0.037	0.14	0.15	-0.01	-0.012
Hours spent on extracurricular activities: 4 or more	0.13	0.12	0.01	0.024	0.13	0.13	0.00	-0.012
Hours spent working for pay: 1 to 2	0.11	0.13	-0.02	-0.065	0.11	0.12	-0.01	-0.033
Hours spent working for pay: 2 or more	0.10	0.11	-0.01	-0.027	0.10	0.10	0.00	0.000
Total school enrollment	1404.99	1468.14	-63.15	-0.080	1404.99	1402.53	2.46	0.003
Total school enrollment: Square term	2605382.81	2760740.08	-155357.27	-0.056	2605382.81	2593160.54	12222.27	0.004
Percent of student body: American Indian	0.88	0.76	0.12	0.042	0.88	0.89	-0.01	-0.002
Percent of student body: Asian/Pacific Islander/Hawaiian Native	5.07	3.99	1.08	0.155	5.07	5.13	-0.06	-0.007
Percent of student body: Hispanic	14.54	15.27	-0.73	-0.039	14.54	14.46	0.08	0.004
Percent of student body: Black	13.26	12.83	0.43	0.024	13.26	13.52	-0.26	-0.015
Percent of student body: Unknown race or two or more races	1.60	1.44	0.16	0.046	1.60	1.51	0.09	0.027
Percent of student body receiving free lunch	30.91	30.07	0.84	0.047	30.91	30.93	-0.02	-0.001
Pupil-to-teacher ratio	18.35	17.80	0.55	0.097	18.35	18.57	-0.22	-0.039
Lack of teacher resources and materials is a problem at school	1.91	1.87	0.04	0.048	1.91	1.93	-0.02	-0.028
Courses not offered by school available at community college	0.85	0.82	0.03	0.064	0.85	0.86	-0.01	-0.032
Courses not offered by school available at 4-year college	0.51	0.48	0.03	0.053	0.51	0.51	0.00	-0.007

Table 9. (continued).

Help with postsecondary schooling is school counseling program's primary goal	0.44	0.49	-0.05	-0.101	0.44	0.43	0.01	0.012
School has counselor designated for college readiness/selection/application	0.57	0.55	0.02	0.049	0.57	0.57	0.00	0.013
Percent of 9th graders repeating 9th grade	4.83	4.65	0.18	0.026	4.83	5.04	-0.21	-0.030
Block schedule is less than 90 minutes	0.10	0.09	0.01	0.045	0.10	0.09	0.01	0.014
Block schedule is at least 90 minutes	0.36	0.36	0.00	-0.010	0.36	0.36	0.00	0.002
School uses semester calendar	0.73	0.77	-0.04	-0.083	0.73	0.74	-0.01	-0.022
School urbanicity: City	0.33	0.24	0.09	0.190	0.33	0.32	0.01	0.021
School urbanicity: Suburb	0.24	0.29	-0.05	-0.120	0.24	0.25	-0.01	-0.017
School urbanicity: Town	0.16	0.15	0.01	0.046	0.16	0.16	0.00	-0.004
Travel time to the closest two-year institution	32.08	26.01	6.07	0.185	32.08	31.63	0.45	0.014
Arizona	0.03	0.04	-0.01	-0.031	0.03	0.03	0.00	-0.008
Arkansas	0.01	0.01	0.00	0.025	0.01	0.01	0.00	-0.013
California	0.06	0.07	-0.01	-0.022	0.06	0.06	0.00	0.032
Colorado	0.03	0.02	0.01	0.070	0.03	0.03	0.00	-0.017
Florida	0.10	0.04	0.06	0.229	0.10	0.09	0.01	0.039
Georgia	0.05	0.02	0.03	0.134	0.05	0.04	0.01	0.034
Illinois	0.07	0.04	0.03	0.105	0.07	0.06	0.01	0.033
Indiana	0.02	0.05	-0.03	-0.192	0.02	0.02	0.00	0.003
Iowa	0.00	0.01	-0.01	-0.041	0.00	0.00	0.00	-0.001
Kansas	0.00	0.01	-0.01	-0.064	0.00	0.01	-0.01	-0.007
Kentucky	0.01	0.02	-0.01	-0.066	0.01	0.01	0.00	-0.003
Louisiana	0.00	0.01	-0.01	-0.034	0.00	0.01	-0.01	-0.006
Maryland	0.01	0.01	0.00	-0.060	0.01	0.01	0.00	-0.007
Massachusetts	0.00	0.01	-0.01	-0.034	0.00	0.00	0.00	0.000
Michigan	0.09	0.02	0.07	0.279	0.09	0.11	-0.02	-0.089
Minnesota	0.03	0.03	0.00	-0.015	0.03	0.03	0.00	0.001

Table 9. (continued).

Missouri	0.00	0.02	-0.02	-0.134	0.00	0.00	0.00	0.006
New Hampshire	0.00	0.01	-0.01	-0.072	0.00	0.00	0.00	0.000
New Jersey	0.02	0.03	-0.01	-0.070	0.02	0.02	0.00	-0.001
New York	0.01	0.06	-0.05	-0.256	0.01	0.01	0.00	0.009
North Carolina	0.04	0.05	-0.01	-0.050	0.04	0.04	0.00	0.003
Ohio	0.06	0.05	0.01	0.046	0.06	0.05	0.01	0.024
Oklahoma	0.01	0.00	0.01	0.033	0.01	0.01	0.00	-0.019
Oregon	0.02	0.03	-0.01	-0.069	0.02	0.02	0.00	-0.009
Pennsylvania	0.03	0.05	-0.02	-0.082	0.03	0.04	-0.01	-0.012
South Carolina	0.00	0.02	-0.02	-0.134	0.00	0.00	0.00	0.000
Tennessee	0.04	0.05	-0.01	-0.055	0.04	0.04	0.00	0.009
Texas	0.06	0.08	-0.02	-0.099	0.06	0.06	0.00	-0.002
Virginia	0.01	0.04	-0.03	-0.150	0.01	0.01	0.00	-0.002
Washington	0.15	0.09	0.06	0.192	0.15	0.16	-0.01	-0.032
West Virginia	0.00	0.01	-0.01	-0.059	0.00	0.00	0.00	0.009
			Mean Std. Diff.:	**0.078**			**Mean Std. Diff.:**	**0.018**

Note. DE = dual enrollment. T = treatment group. C = control group.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), Second Follow-up Restricted-Use Data File.

scores on the math assessment. Overall, the average standardized difference, calculated using the absolute values of all covariate standardized differences was 0.078 before weighting. After weighting, all standardized differences were lower than 0.10 or greater than -0.10 indicating adequate balance. The average standardized difference decreased to 0.018 suggesting the treatment and control groups were much more similar across all covariates and, thus, reducing bias.

Differences in covariates across treatment and control were very similar in the high school analytic sample using the more restrictive treatment identification (i.e., taking dual enrollment exclusively on a college campus). Before weighting, 27% (n = 29) of covariates had a mean standardized difference of 0.10 or greater or -0.10 or lower. Compared to students who took dual enrollment at their high school, more students who indicated taking dual enrollment exclusively on a college campus had taken an 8th grade math higher than Algebra I, completed a science course other than General Science/General Science 8 or Science 8, and had scored better on the math assessment. Based on the absolute values of all mean standardized differences, the average standardized difference before weighting equaled 0.077. After weighting, the average standardized difference decreased to 0.023 indicating balanced groups. Table 10 contains information about means, mean differences, and standardized differences for the high school analytic sample with the more restrictive treatment identification.

Next, I examined means and standardized differences between the treatment and control groups in the high school analytic sample where taking dual enrollment on a college campus, regardless of combination (i.e., less restrictive identification), was the treatment. Before weighting, 35% (n = 39) of covariates had a mean standardized difference of 0.10 or greater or -

Table 10.

Standardized Difference Before and After Weighting in the High School Analytic Sample where Treatment is DE Exclusively on a College Campus (More Restrictive Identification).

Covariates	Unweighted Sample				Weighted Sample			
	Mean		Mean Diff.	Std. Diff.	Mean		Mean Diff.	Std. Diff.
	T	C			T	C		
Student sex: Female	0.60	0.55	0.05	0.096	0.60	0.57	0.03	0.055
Student race: Asian	0.08	0.09	-0.01	-0.035	0.08	0.07	0.01	0.029
Student race: Black	0.08	0.09	-0.01	-0.040	0.08	0.09	-0.01	-0.024
Student race: Hispanic	0.17	0.15	0.02	0.054	0.17	0.15	0.02	0.033
Student race: Other	0.10	0.10	0.00	-0.022	0.10	0.11	-0.01	-0.040
First language is not English	0.08	0.10	-0.02	-0.068	0.08	0.08	0.00	0.014
Number of household members	4.55	4.37	0.18	0.135	4.55	4.62	-0.07	-0.050
Number of household members: Square term	22.87	20.81	2.06	0.138	22.87	23.55	-0.68	-0.046
Single parent household	0.19	0.20	-0.01	-0.024	0.19	0.18	0.01	0.035
Family income: > $15,000 and <=$35,000	0.16	0.17	-0.01	-0.021	0.16	0.14	0.02	0.039
Family income: > $35,000 and <=$55,000	0.21	0.18	0.03	0.075	0.21	0.23	-0.02	-0.052
Family income: > $55,000 and <=$75,000	0.18	0.17	0.01	0.017	0.18	0.17	0.01	0.023
Family income: > $75,000 and <=$95,000	0.12	0.12	0.00	0.000	0.12	0.12	0.00	0.000
Family income: > $95,000 and <=$115,000	0.08	0.09	-0.01	-0.052	0.08	0.08	0.00	-0.013
Family income: > $115,001	0.20	0.20	0.00	-0.001	0.20	0.20	0.00	0.012
Parents' highest level of education: BA	0.28	0.27	0.01	0.034	0.28	0.27	0.01	0.041
Parents' highest level of education: MA or higher	0.21	0.17	0.04	0.085	0.21	0.20	0.01	0.014
Parent occupation prestige	63.02	60.31	2.71	0.135	63.02	62.75	0.27	0.013
Parental aspirations: Bachelor's degree	0.15	0.18	-0.03	-0.076	0.15	0.16	-0.01	-0.009
Parental aspirations: Master's degree or higher	0.82	0.78	0.04	0.080	0.82	0.81	0.01	0.015
Parental expectations: Bachelor's degree	0.32	0.33	-0.01	-0.024	0.32	0.33	-0.01	-0.016
Parental expectations: Master's degree or higher	0.50	0.48	0.02	0.046	0.50	0.49	0.01	0.028

Table 10. (continued).

Parental expectations: Don't know	0.10	0.08	0.02	0.059	0.10	0.09	0.01	0.011
Parent helped 9th grader with homework: Less than once a week	0.36	0.32	0.04	0.073	0.36	0.34	0.02	0.041
Parent helped 9th grader with homework: 1 or 2 days a week	0.28	0.31	-0.03	-0.050	0.28	0.28	0.00	0.003
Parent helped 9th grader with homework: 3 or more days a week	0.12	0.15	-0.03	-0.066	0.12	0.14	-0.02	-0.038
Family talked with counselor/teacher about postsecondary admission requirements	0.54	0.48	0.06	0.112	0.54	0.52	0.02	0.028
Number of school-level activity types parent engaged in	3.84	3.56	0.28	0.148	3.84	3.79	0.05	0.025
Number of student-level activity types parent engaged in	4.49	4.43	0.06	0.031	4.49	4.49	0.00	-0.002
School belonging	0.16	0.15	0.01	0.009	0.16	0.12	0.04	0.048
School engagement	0.26	0.21	0.05	0.060	0.26	0.28	-0.02	-0.024
Academic ability/wellness	0.07	0.04	0.03	0.043	0.07	0.12	-0.05	-0.051
Highest math in 8th grade: Algebra I	0.41	0.42	-0.01	-0.013	0.41	0.41	0.00	0.000
Highest math in 8th grade: Higher than Algebra I	0.17	0.10	0.07	0.212	0.17	0.18	-0.01	-0.018
Highest science taken in 8th grade: Gen Science/Gen Science 8 or Science 8	0.42	0.53	-0.11	-0.213	0.42	0.42	0.00	0.019
Number of credits taken in 9th grade	6.65	6.73	-0.08	-0.045	6.65	6.60	0.05	0.029
Number of credits taken in 9th grade: Square term	47.61	48.30	-0.69	-0.032	47.61	47.05	0.56	0.026
GPA 9th grade	3.09	3.00	0.09	0.111	3.09	3.03	0.06	0.075
GPA 9th grade: Square term	10.40	9.69	0.71	0.161	10.40	10.12	0.28	0.063
Mathematics standardized theta score	56.68	54.37	2.31	0.241	56.68	56.41	0.27	0.028
Mathematics standardized theta score: Square term	3308.96	3043.09	265.87	0.252	3308.96	3279.40	29.56	0.028
9th grader plans to take PSAT, SAT, or ACT	0.81	0.77	0.04	0.092	0.81	0.81	0.00	0.014
9th grader plans to take AP or IB test	0.54	0.47	0.07	0.142	0.54	0.55	-0.01	-0.028
9th grader participated in college prep program	0.15	0.13	0.02	0.060	0.15	0.15	0.00	0.021
Working is more important that attending college	0.08	0.08	0.00	-0.015	0.08	0.10	-0.02	-0.062
Student postsecondary expectations: BA	0.19	0.20	-0.01	-0.042	0.19	0.19	0.00	-0.004

Table 10. (continued).

Student postsecondary expectations: MA or higher	0.60	0.52	0.08	0.145	0.60	0.59	0.01	0.012
Student postsecondary expectations: Don't know	0.13	0.14	-0.01	-0.038	0.13	0.12	0.01	0.023
Discussions about going to college	2.68	2.61	0.07	0.055	2.68	2.65	0.03	0.025
9th grader's friend gets good grades	0.94	0.92	0.02	0.112	0.94	0.95	-0.01	-0.031
Number of non-academic extracurricular activities types 9th grader participated in	1.77	1.72	0.05	0.045	1.77	1.72	0.05	0.044
9th grader participated in academic extracurricular activities	0.21	0.17	0.04	0.105	0.21	0.22	-0.01	-0.018
Hours spent on extracurricular activities: 1 to 2	0.25	0.22	0.03	0.062	0.25	0.24	0.01	0.014
Hours spent on extracurricular activities: 2 to 3	0.22	0.26	-0.04	-0.074	0.22	0.21	0.01	0.033
Hours spent on extracurricular activities: 3 to 4	0.15	0.13	0.02	0.054	0.15	0.14	0.01	0.025
Hours spent on extracurricular activities: 4 or more	0.10	0.11	-0.01	-0.030	0.10	0.11	-0.01	-0.028
Hours spent working for pay: 1 to 2	0.10	0.13	-0.03	-0.089	0.10	0.11	-0.01	-0.040
Hours spent working for pay: 2 or more	0.11	0.12	-0.01	-0.010	0.11	0.11	0.00	0.013
Total school enrollment	1399.07	1479.47	-80.40	-0.101	1399.07	1397.71	1.36	0.002
Total school enrollment: Square term	2586278.79	2825909.33	-239630.54	-0.082	2586278.79	2581552.41	4726.38	0.002
Percent of student body: American Indian	0.94	0.81	0.13	0.041	0.94	0.89	0.05	0.015
Percent of student body: Asian/Pacific Islander/Hawaiian Native	4.74	4.29	0.45	0.065	4.74	4.77	-0.03	-0.003
Percent of student body: Hispanic	12.66	15.18	-2.52	-0.147	12.66	12.06	0.60	0.035
Percent of student body: Black	12.37	12.86	-0.49	-0.028	12.37	12.34	0.03	0.002
Percent of student body: Unknown race or two or more races	1.45	1.32	0.13	0.052	1.45	1.39	0.06	0.024
Percent of student body receiving free lunch	28.43	29.60	-1.17	-0.067	28.43	28.01	0.42	0.024
Pupil-to-teacher ratio	18.23	18.01	0.22	0.041	18.23	18.30	-0.07	-0.013
Lack of teacher resources and materials is a problem at school	1.83	1.87	-0.04	-0.052	1.83	1.85	-0.02	-0.028
Courses not offered by school available at community college	0.85	0.85	0.00	-0.016	0.85	0.86	-0.01	-0.033
Courses not offered by school available at 4-year college	0.56	0.50	0.06	0.125	0.56	0.58	-0.02	-0.042

Table 10. (continued).

Help with postsecondary schooling is school counseling program's primary goal	0.46	0.49	-0.03	-0.073	0.46	0.44	0.02	0.027
School has counselor designated for college readiness/selection/application	0.59	0.55	0.04	0.090	0.59	0.58	0.01	0.018
Percent of 9th graders repeating 9th grade	4.72	4.56	0.16	0.023	4.72	4.62	0.10	0.014
Block schedule is less than 90 minutes	0.08	0.08	0.00	0.018	0.08	0.08	0.00	0.018
Block schedule is at least 90 minutes	0.31	0.36	-0.05	-0.092	0.31	0.31	0.00	0.018
School uses semester calendar	0.73	0.77	-0.04	-0.093	0.73	0.74	-0.01	-0.015
School urbanicity: City	0.29	0.25	0.04	0.086	0.29	0.28	0.01	0.021
School urbanicity: Suburb	0.28	0.29	-0.01	-0.030	0.28	0.30	-0.02	-0.040
School urbanicity: Town	0.18	0.15	0.03	0.098	0.18	0.17	0.01	0.047
Travel time to the closest two-year institution	34.53	26.88	7.65	0.213	34.53	34.46	0.07	0.002
Arizona	0.03	0.04	-0.01	-0.056	0.03	0.03	0.00	0.000
Arkansas	0.00	0.01	-0.01	-0.022	0.00	0.01	-0.01	-0.012
California	0.07	0.08	-0.01	-0.023	0.07	0.07	0.00	0.009
Colorado	0.02	0.02	0.00	-0.002	0.02	0.02	0.00	-0.005
Florida	0.11	0.05	0.06	0.191	0.11	0.10	0.01	0.016
Georgia	0.07	0.03	0.04	0.198	0.07	0.06	0.01	0.045
Illinois	0.06	0.05	0.01	0.047	0.06	0.06	0.00	0.004
Indiana	0.01	0.03	-0.02	-0.128	0.01	0.01	0.00	0.016
Louisiana	0.00	0.01	-0.01	-0.046	0.00	0.00	0.00	-0.002
Maryland	0.01	0.01	0.00	-0.038	0.01	0.01	0.00	-0.009
Massachusetts	0.01	0.01	0.00	0.002	0.01	0.01	0.00	-0.007
Michigan	0.10	0.03	0.07	0.305	0.10	0.12	-0.02	-0.076
Minnesota	0.04	0.03	0.01	0.015	0.04	0.04	0.00	-0.017
Missouri	0.00	0.02	-0.02	-0.112	0.00	0.00	0.00	0.011
New Jersey	0.02	0.03	-0.01	-0.078	0.02	0.02	0.00	-0.007
New York	0.01	0.03	-0.02	-0.141	0.01	0.01	0.00	0.028

Table 10. (continued).

North Carolina	0.02	0.05	-0.03	-0.149	0.02	0.02	0.00	0.016
Ohio	0.06	0.06	0.00	-0.007	0.06	0.05	0.01	0.029
Oklahoma	0.00	0.00	0.00	-0.004	0.00	0.01	-0.01	-0.012
Oregon	0.02	0.03	-0.01	-0.078	0.02	0.02	0.00	-0.016
Pennsylvania	0.05	0.06	-0.01	-0.049	0.05	0.05	0.00	-0.025
South Carolina	0.01	0.02	-0.01	-0.109	0.01	0.01	0.00	-0.012
Tennessee	0.05	0.06	-0.01	-0.039	0.05	0.04	0.01	0.029
Texas	0.03	0.08	-0.05	-0.205	0.03	0.03	0.00	0.025
Virginia	0.01	0.03	-0.02	-0.128	0.01	0.01	0.00	0.001
Washington	0.13	0.11	0.02	0.071	0.13	0.13	0.00	-0.019
West Virginia	0.00	0.01	-0.01	-0.039	0.00	0.00	0.00	0.020
			Mean Std. Diff:	**0.077**			**Mean Std. Diff:**	**0.023**

Note. DE = dual enrollment. T = treatment group. C = control group.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), Second Follow-up Restricted-Use Data File.

0.10 or lower. Compared to students who took dual enrollment at their high school, a greater proportion of students who took dual enrollment on a college campus had higher 9th grade GPA and standardized scores on the math assessment, completed an 8th grade math course higher than Algebra I, attended a high school in the city, and expected to earn a master's degree. The average standardized difference before weighting was 0.087. After weighting, the average standardized difference decreased to 0.024 indicating balanced covariates across treatment and control groups.

Finally, I reviewed the means and standardized differences across group covariates in the college analytic sample where taking dual enrollment exclusively on a college campus (i.e., the more restrictive identification) was the treatment. Before weighting, 32% (n = 33) of covariates had a mean standardized difference of 0.10 or greater or -0.10 or lower. Compared to students who took dual enrollment at their high school, more students who indicated taking dual enrollment exclusively on a college campus had higher 9th grade GPA and standardized scores on the math assessment, completed an 8th grade math course higher than Algebra I or a science course other than General Science/General Science 8 or Science 8, expected to obtain a master's degree or higher, and planned to take a college examination. Overall, the average standardized difference for the raw covariates was 0.084. After weighting, the average standardized difference decreased to 0.008 suggesting improved balance of covariates between treatment and control groups. Tables 11 and 12 contain information related to group means, mean differences and standardized differences, and overall average standardized differences for the high school analytic sample.

Table 11.

Standardized Difference Before and After Weighting in the College Analytic Sample where Treatment is DE on a College Campus (Less Restrictive Identification).

	Unweighted Sample				Weighted Sample			
	Mean		Mean	Std.	Mean		Mean	Std.
	T	C	Diff.	Diff.	T	C	Diff.	Diff.
Student sex: Female	0.57	0.56	0.01	0.022	0.57	0.57	0.00	-0.005
Student race: Asian	0.09	0.09	0.00	0.011	0.09	0.10	-0.01	-0.001
Student race: Black	0.10	0.10	0.00	0.012	0.10	0.10	0.00	-0.011
Student race: Hispanic	0.15	0.14	0.01	0.024	0.15	0.15	0.00	-0.002
Student race: Other	0.09	0.09	0.00	0.001	0.09	0.10	-0.01	-0.018
First language is not English	0.10	0.11	-0.01	-0.021	0.10	0.12	-0.02	-0.058
Number of household members	4.49	4.35	0.14	0.101	4.49	4.54	-0.05	-0.038
Number of household members: Square term	22.33	20.64	1.69	0.115	22.33	22.97	-0.64	-0.043
Single parent household	0.23	0.20	0.03	0.075	0.23	0.23	0.00	0.018
Family income: > $15,000 and <=$35,000	0.17	0.16	0.01	0.011	0.17	0.17	0.00	-0.011
Family income: > $35,000 and <=$55,000	0.17	0.17	0.00	0.002	0.17	0.17	0.00	-0.002
Family income: > $55,000 and <=$75,000	0.19	0.17	0.02	0.042	0.19	0.20	-0.01	-0.035
Family income: > $75,000 and <=$95,000	0.11	0.13	-0.02	-0.039	0.11	0.11	0.00	0.022
Family income: > $95,000 and <=$115,000	0.07	0.09	-0.02	-0.069	0.07	0.07	0.00	-0.007
Family income: > $115,001	0.21	0.21	0.00	-0.001	0.21	0.20	0.01	0.030
Parents' highest level of education: BA	0.24	0.27	-0.03	-0.055	0.24	0.23	0.01	0.034
Parents' highest level of education: MA or higher	0.25	0.19	0.06	0.146	0.25	0.24	0.01	0.020
Parent occupation prestige	62.89	60.60	2.29	0.110	62.89	61.58	1.31	0.063
Parental aspirations: Bachelor's degree	0.13	0.18	-0.05	-0.122	0.13	0.14	-0.01	-0.015
Parental aspirations: Master's degree or higher	0.85	0.79	0.06	0.161	0.85	0.85	0.00	0.019
Parental expectations: Bachelor's degree	0.30	0.34	-0.04	-0.090	0.30	0.30	0.00	-0.003
Parental expectations: Master's degree or higher	0.56	0.49	0.07	0.133	0.56	0.56	0.00	0.008

Table 11. (continued).

Parental expectations: Don't know	0.08	0.07	0.01	0.036	0.08	0.09	-0.01	-0.014
Parent helped 9th grader with homework: Less than once a week	0.33	0.32	0.01	0.021	0.33	0.32	0.01	0.025
Parent helped 9th grader with homework: 1 or 2 days a week	0.29	0.31	-0.02	-0.034	0.29	0.29	0.00	-0.001
Parent helped 9th grader with homework: 3 or more days a week	0.14	0.15	-0.01	-0.016	0.14	0.13	0.01	0.037
Family talked with counselor/teacher about postsecondary admission requirements	0.54	0.47	0.07	0.148	0.54	0.52	0.02	0.041
Number of school-level activity types parent engaged in	3.85	3.52	0.33	0.174	3.85	3.81	0.04	0.023
Number of student-level activity types parent engaged in	4.67	4.42	0.25	0.134	4.67	4.61	0.06	0.030
School belonging	0.19	0.17	0.02	0.024	0.19	0.18	0.01	0.010
School engagement	0.31	0.24	0.07	0.076	0.31	0.26	0.05	0.050
Academic ability/wellness	0.01	-0.02	0.03	0.033	0.01	0.06	-0.05	-0.071
Highest math in 8th grade: Algebra I	0.42	0.42	0.00	0.005	0.42	0.40	0.02	0.044
Highest math in 8th grade: Higher than Algebra I	0.17	0.10	0.07	0.213	0.17	0.18	-0.01	-0.031
Highest science taken in 8th grade: Gen Science/Gen Science 8 or Science 8	0.46	0.54	-0.08	-0.165	0.46	0.47	-0.01	-0.015
Number of credits taken in 9th grade	6.86	6.81	0.05	0.028	6.86	6.76	0.10	0.055
Number of credits taken in 9th grade: Square term	49.81	49.16	0.65	0.031	49.81	48.93	0.88	0.042
GPA 9th grade	3.20	3.06	0.14	0.175	3.20	3.16	0.04	0.046
GPA 9th grade: Square term	10.91	9.98	0.93	0.223	10.91	10.75	0.16	0.040
Mathematics standardized theta score	56.59	54.52	2.07	0.214	56.59	56.50	0.09	0.009
Mathematics standardized theta score: Square term	3303.87	3056.33	247.54	0.232	3303.87	3299.67	4.20	0.004
9th grader plans to take PSAT, SAT, or ACT	0.82	0.78	0.04	0.100	0.82	0.82	0.00	0.007
9th grader plans to take AP or IB test	0.52	0.45	0.07	0.135	0.52	0.52	0.00	-0.006
9th grader participated in college prep program	0.19	0.13	0.06	0.150	0.19	0.19	0.00	-0.017
Working is more important that attending college	0.07	0.07	0.00	-0.033	0.07	0.07	0.00	-0.026
Student postsecondary expectations: BA	0.19	0.20	-0.01	-0.027	0.19	0.19	0.00	0.005

Table 11. (continued).

Student postsecondary expectations: MA or higher	0.61	0.52	0.09	0.177	0.61	0.60	0.01	0.017
Student postsecondary expectations: Don’t know	0.11	0.15	-0.04	-0.134	0.11	0.12	-0.01	-0.034
Discussions about going to college	2.68	2.60	0.08	0.060	2.68	2.72	-0.04	-0.026
9th grader's friend gets good grades	0.90	0.90	0.00	0.001	0.90	0.89	0.01	0.058
Number of non-academic extracurricular activities types 9th grader participated in	1.82	1.74	0.08	0.073	1.82	1.81	0.01	0.015
9th grader participated in academic extracurricular activities	0.23	0.17	0.06	0.163	0.23	0.24	-0.01	-0.014
Hours spent on extracurricular activities: 1 to 2	0.25	0.22	0.03	0.069	0.25	0.23	0.02	0.033
Hours spent on extracurricular activities: 2 to 3	0.21	0.26	-0.05	-0.132	0.21	0.20	0.01	0.011
Hours spent on extracurricular activities: 3 to 4	0.14	0.13	0.01	0.035	0.14	0.15	-0.01	-0.017
Hours spent on extracurricular activities: 4 or more	0.13	0.11	0.02	0.053	0.13	0.14	-0.01	-0.021
Hours spent working for pay: 1 to 2	0.10	0.13	-0.03	-0.099	0.10	0.12	-0.02	-0.060
Hours spent working for pay: 2 or more	0.10	0.11	-0.01	-0.016	0.10	0.10	0.00	0.001
Total school enrollment	1391.33	1466.25	-74.92	-0.097	1391.33	1375.53	15.80	0.020
Total school enrollment: Square term	2554778.67	2735548.02	-180769.35	-0.067	2554778.67	2508793.33	45985.34	0.017
Percent of student body: American Indian	0.82	0.68	0.14	0.055	0.82	0.82	0.00	0.001
Percent of student body: Asian/Pacific Islander/Hawaiian Native	5.11	3.91	1.20	0.168	5.11	5.27	-0.16	-0.023
Percent of student body: Hispanic	14.28	14.85	-0.57	-0.032	14.28	14.53	-0.25	-0.014
Percent of student body: Black	13.39	12.89	0.50	0.028	13.39	13.54	-0.15	-0.008
Percent of student body: Unknown race or two or more races	1.60	1.37	0.23	0.078	1.60	1.55	0.05	0.018
Percent of student body receiving free lunch	31.42	29.53	1.89	0.106	31.42	31.65	-0.23	-0.013
Pupil-to-teacher ratio	18.43	17.70	0.73	0.155	18.43	18.49	-0.06	-0.014
Lack of teacher resources and materials is a problem at school	1.91	1.87	0.04	0.048	1.91	1.96	-0.05	-0.067
Courses not offered by school available at community college	0.85	0.82	0.03	0.064	0.85	0.86	-0.01	-0.034
Courses not offered by school available at 4-year college	0.52	0.49	0.03	0.061	0.52	0.52	0.00	-0.005

Table 11. (continued).

Help with postsecondary schooling is school counseling program's primary goal	0.42	0.50	-0.08	-0.144	0.42	0.43	-0.01	-0.004
School has counselor designated for college readiness/selection/application	0.57	0.55	0.02	0.038	0.57	0.55	0.02	0.035
Percent of 9th graders repeating 9th grade	4.87	4.59	0.28	0.040	4.87	5.25	-0.38	-0.055
Block schedule is less than 90 minutes	0.10	0.08	0.02	0.066	0.10	0.10	0.00	0.007
Block schedule is at least 90 minutes	0.35	0.35	0.00	-0.010	0.35	0.33	0.02	0.028
School uses semester calendar	0.73	0.76	-0.03	-0.067	0.73	0.75	-0.02	-0.026
School urbanicity: City	0.32	0.23	0.09	0.196	0.32	0.30	0.02	0.046
School urbanicity: Suburb	0.24	0.29	-0.05	-0.119	0.24	0.25	-0.01	-0.015
School urbanicity: Town	0.15	0.14	0.01	0.019	0.15	0.16	-0.01	-0.012
Travel time to the closest two-year institution	33.17	26.02	7.15	0.218	33.17	30.59	2.58	0.079
Arizona	0.02	0.04	-0.02	-0.080	0.02	0.02	0.00	-0.013
California	0.06	0.07	-0.01	-0.019	0.06	0.06	0.00	0.032
Colorado	0.02	0.01	0.01	0.060	0.02	0.02	0.00	0.002
Florida	0.11	0.05	0.06	0.233	0.11	0.09	0.02	0.080
Georgia	0.05	0.03	0.02	0.128	0.05	0.04	0.01	0.029
Illinois	0.07	0.05	0.02	0.081	0.07	0.06	0.01	0.049
Indiana	0.02	0.05	-0.03	-0.164	0.02	0.02	0.00	-0.007
Iowa	0.01	0.01	0.00	-0.036	0.01	0.01	0.00	-0.007
Kentucky	0.01	0.02	-0.01	-0.051	0.01	0.01	0.00	-0.005
Louisiana	0.00	0.01	-0.01	-0.077	0.00	0.00	0.00	-0.004
Maryland	0.01	0.01	0.00	-0.056	0.01	0.01	0.00	-0.013
Massachusetts	0.00	0.01	-0.01	-0.070	0.00	0.00	0.00	-0.001
Michigan	0.09	0.02	0.07	0.300	0.09	0.11	-0.02	-0.059
Minnesota	0.03	0.03	0.00	-0.043	0.03	0.02	0.01	0.009
Missouri	0.01	0.02	-0.01	-0.134	0.01	0.00	0.01	0.008
New Hampshire	0.00	0.01	-0.01	-0.062	0.00	0.00	0.00	-0.003

Table 11 (continued).

New Jersey	0.02	0.03	-0.01	-0.055	0.02	0.02	0.00	-0.007
New York	0.01	0.06	-0.05	-0.267	0.01	0.01	0.00	-0.005
North Carolina	0.04	0.05	-0.01	-0.065	0.04	0.03	0.01	0.012
Ohio	0.06	0.05	0.01	0.067	0.06	0.06	0.00	0.034
Oklahoma	0.01	0.00	0.01	0.018	0.01	0.01	0.00	-0.046
Oregon	0.02	0.03	-0.01	-0.060	0.02	0.02	0.00	-0.020
Pennsylvania	0.04	0.05	-0.01	-0.072	0.04	0.04	0.00	-0.024
South Carolina	0.01	0.02	-0.01	-0.099	0.01	0.01	0.00	-0.005
Tennessee	0.04	0.05	-0.01	-0.029	0.04	0.04	0.00	0.008
Texas	0.06	0.09	-0.03	-0.113	0.06	0.06	0.00	-0.006
Virginia	0.01	0.04	-0.03	-0.148	0.01	0.01	0.00	0.000
Washington	0.15	0.09	0.06	0.186	0.15	0.17	-0.02	-0.081
West Virginia	0.00	0.01	-0.01	-0.070	0.00	0.00	0.00	0.007
			Mean Std. Diff.:	**0.087**			**Mean Std. Diff.:**	**0.024**

Note. DE = dual enrollment. T = treatment group. C = control group.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), Second Follow-up Restricted-Use Data File.

Table 12.

Standardized Difference Before and After Weighting in the College Analytic Sample where Treatment is DE Exclusively on a College Campus (More Restrictive Identification).

	Unweighted Sample				Weighted Sample			
	Mean		Mean Diff.	Std. Diff.	Mean		Mean Diff.	Std. Diff.
	T	C			T	C		
Student sex: Female	0.60	0.56	0.04	0.093	0.60	0.57	0.03	0.067
Student race: Asian	0.08	0.09	-0.01	-0.020	0.08	0.08	0.00	0.029
Student race: Black	0.08	0.09	-0.01	-0.033	0.08	0.09	-0.01	-0.015
Student race: Hispanic	0.17	0.14	0.03	0.077	0.17	0.16	0.01	0.032
Student race: Other	0.09	0.10	-0.01	-0.042	0.09	0.09	0.00	0.009
First language is not English	0.10	0.11	-0.01	-0.056	0.10	0.10	0.00	-0.014
Number of household members	4.55	4.38	0.17	0.122	4.55	4.59	-0.04	-0.029
Number of household members: Square term	23.01	20.87	2.14	0.140	23.01	23.37	-0.36	-0.023
Single parent household	0.21	0.20	0.01	0.016	0.21	0.19	0.02	0.037
Family income: > $15,000 and <=$35,000	0.15	0.15	0.00	-0.008	0.15	0.14	0.01	0.033
Family income: > $35,000 and <=$55,000	0.21	0.17	0.04	0.099	0.21	0.22	-0.01	-0.022
Family income: > $55,000 and <=$75,000	0.19	0.17	0.02	0.046	0.19	0.20	-0.01	-0.035
Family income: > $75,000 and <=$95,000	0.12	0.13	-0.01	-0.048	0.12	0.12	0.00	-0.011
Family income: > $95,000 and <=$115,000	0.08	0.09	-0.01	-0.039	0.08	0.08	0.00	0.000
Family income: > $115,001	0.20	0.21	-0.01	-0.038	0.20	0.18	0.02	0.041
Parents' highest level of education: BA	0.29	0.28	0.01	0.021	0.29	0.29	0.00	-0.006
Parents' highest level of education: MA or higher	0.21	0.18	0.03	0.074	0.21	0.21	0.00	0.012
Parent occupation prestige	62.76	60.94	1.82	0.089	62.76	61.74	1.02	0.050
Parental aspirations: Bachelor's degree	0.14	0.17	-0.03	-0.072	0.14	0.17	-0.03	-0.084
Parental aspirations: Master's degree or higher	0.83	0.80	0.03	0.095	0.83	0.80	0.03	0.082
Parental expectations: Bachelor's degree	0.31	0.33	-0.02	-0.030	0.31	0.33	-0.02	-0.036
Parental expectations: Master's degree or higher	0.52	0.50	0.02	0.039	0.52	0.50	0.02	0.036

Table 12. (continued).

Parental expectations: Don't know	0.11	0.08	0.03	0.099	0.11	0.10	0.01	0.011
Parent helped 9th grader with homework: Less than once a week	0.36	0.34	0.02	0.056	0.36	0.35	0.01	0.026
Parent helped 9th grader with homework: 1 or 2 days a week	0.28	0.30	-0.02	-0.034	0.28	0.27	0.01	0.022
Parent helped 9th grader with homework: 3 or more days a week	0.11	0.15	-0.04	-0.100	0.11	0.11	0.00	0.015
Family talked with counselor/teacher about postsecondary admission requirements	0.53	0.47	0.06	0.108	0.53	0.50	0.03	0.051
Number of school-level activity types parent engaged in	3.76	3.55	0.21	0.112	3.76	3.73	0.03	0.017
Number of student-level activity types parent engaged in	4.48	4.41	0.07	0.037	4.48	4.46	0.02	0.007
School belonging	0.17	0.18	-0.01	-0.012	0.17	0.14	0.03	0.031
School engagement	0.31	0.23	0.08	0.082	0.31	0.29	0.02	0.016
Academic ability/wellness	0.08	0.02	0.06	0.070	0.08	0.15	-0.07	-0.081
Highest math in 8th grade: Algebra I	0.41	0.43	-0.02	-0.031	0.41	0.41	0.00	0.008
Highest math in 8th grade: Higher than Algebra I	0.18	0.11	0.07	0.211	0.18	0.21	-0.03	-0.077
Highest science taken in 8th grade: Gen Science/Gen Science 8 or Science 8	0.44	0.53	-0.09	-0.183	0.44	0.42	0.02	0.046
Number of credits taken in 9th grade	6.72	6.75	-0.03	-0.015	6.72	6.53	0.19	0.112
Number of credits taken in 9th grade: Square term	48.36	48.37	-0.01	0.000	48.36	46.88	1.48	0.069
GPA 9th grade	3.17	3.06	0.11	0.136	3.17	3.12	0.05	0.069
GPA 9th grade: Square term	10.82	10.00	0.82	0.191	10.82	10.59	0.23	0.052
Mathematics standardized theta score	57.40	54.88	2.52	0.265	57.40	57.42	-0.02	-0.002
Mathematics standardized theta score: Square term	3390.86	3096.40	294.46	0.279	3390.86	3391.52	-0.66	-0.001
9th grader plans to take PSAT, SAT, or ACT	0.85	0.78	0.07	0.165	0.85	0.84	0.01	0.028
9th grader plans to take AP or IB test	0.55	0.47	0.08	0.165	0.55	0.54	0.01	0.022
9th grader participated in college prep program	0.17	0.13	0.04	0.112	0.17	0.15	0.02	0.047
Working is more important that attending college	0.05	0.07	-0.02	-0.088	0.05	0.06	-0.01	-0.041
Student postsecondary expectations: BA	0.21	0.21	0.00	-0.010	0.21	0.20	0.01	0.015

Table 12. (continued).

Student postsecondary expectations: MA or higher	0.63	0.54	0.09	0.176	0.63	0.61	0.02	0.038
Student postsecondary expectations: Don’t know	0.10	0.13	-0.03	-0.123	0.10	0.12	-0.02	-0.064
Discussions about going to college	2.69	2.63	0.06	0.039	2.69	2.65	0.04	0.024
9th grader's friend gets good grades	0.94	0.92	0.02	0.108	0.94	0.93	0.01	0.062
Number of non-academic extracurricular activities types 9th grader participated in	1.81	1.74	0.07	0.063	1.81	1.73	0.08	0.073
9th grader participated in academic extracurricular activities	0.21	0.17	0.04	0.090	0.21	0.20	0.01	0.011
Hours spent on extracurricular activities: 1 to 2	0.24	0.21	0.03	0.068	0.24	0.22	0.02	0.043
Hours spent on extracurricular activities: 2 to 3	0.22	0.26	-0.04	-0.094	0.22	0.21	0.01	0.021
Hours spent on extracurricular activities: 3 to 4	0.15	0.14	0.01	0.033	0.15	0.14	0.01	0.035
Hours spent on extracurricular activities: 4 or more	0.12	0.11	0.01	0.018	0.12	0.12	0.00	-0.017
Hours spent working for pay: 1 to 2	0.07	0.11	-0.04	-0.145	0.07	0.08	-0.01	-0.039
Hours spent working for pay: 2 or more	0.12	0.11	0.01	0.028	0.12	0.12	0.00	-0.002
Total school enrollment	1410.54	1496.86	-86.32	-0.112	1410.54	1381.22	29.32	0.038
Total school enrollment: Square term	2582386.90	2843595.89	-261208.99	-0.092	2582386.90	2512905.02	69481.88	0.025
Percent of student body: American Indian	0.87	0.75	0.12	0.040	0.87	0.85	0.02	0.006
Percent of student body: Asian/Pacific Islander/Hawaiian Native	5.01	4.42	0.59	0.081	5.01	5.03	-0.02	-0.002
Percent of student body: Hispanic	12.62	14.59	-1.97	-0.118	12.62	12.12	0.50	0.030
Percent of student body: Black	12.69	12.58	0.11	0.006	12.69	12.29	0.40	0.023
Percent of student body: Unknown race or two or more races	1.52	1.47	0.05	0.023	1.52	1.47	0.05	0.022
Percent of student body receiving free lunch	29.23	28.57	0.66	0.037	29.23	28.63	0.60	0.034
Pupil-to-teacher ratio	18.35	18.13	0.22	0.054	18.35	18.37	-0.02	-0.005
Lack of teacher resources and materials is a problem at school	1.81	1.89	-0.08	-0.103	1.81	1.84	-0.03	-0.038
Courses not offered by school available at community college	0.85	0.86	-0.01	-0.040	0.85	0.84	0.01	0.039
Courses not offered by school available at 4-year college	0.57	0.52	0.05	0.097	0.57	0.60	-0.03	-0.067

Table 12. (continued).

Help with postsecondary schooling is school counseling program's primary goal	0.45	0.50	-0.05	-0.104	0.45	0.43	0.02	0.036
School has counselor designated for college readiness/selection/application	0.59	0.55	0.04	0.079	0.59	0.59	0.00	0.002
Percent of 9th graders repeating 9th grade	4.94	4.30	0.64	0.088	4.94	4.82	0.12	0.016
Block schedule is less than 90 minutes	0.09	0.08	0.01	0.009	0.09	0.09	0.00	0.007
Block schedule is at least 90 minutes	0.30	0.34	-0.04	-0.089	0.30	0.27	0.03	0.061
School uses semester calendar	0.73	0.78	-0.05	-0.120	0.73	0.74	-0.01	-0.031
School urbanicity: City	0.28	0.25	0.03	0.073	0.28	0.26	0.02	0.040
School urbanicity: Suburb	0.28	0.30	-0.02	-0.047	0.28	0.29	-0.01	-0.026
School urbanicity: Town	0.16	0.13	0.03	0.089	0.16	0.17	-0.01	-0.028
Travel time to the closest two-year institution	33.85	27.01	6.84	0.210	33.85	35.60	-1.75	-0.054
Arizona	0.02	0.04	-0.02	-0.112	0.02	0.02	0.00	0.003
California	0.07	0.08	-0.01	-0.032	0.07	0.07	0.00	0.002
Colorado	0.00	0.02	-0.02	-0.180	0.00	0.01	-0.01	-0.077
Florida	0.12	0.06	0.06	0.206	0.12	0.11	0.01	0.032
Georgia	0.07	0.03	0.04	0.175	0.07	0.06	0.01	0.049
Illinois	0.06	0.06	0.00	-0.020	0.06	0.05	0.01	0.021
Indiana	0.02	0.04	-0.02	-0.141	0.02	0.01	0.01	0.014
Maryland	0.01	0.02	-0.01	-0.041	0.01	0.01	0.00	-0.008
Massachusetts	0.01	0.01	0.00	-0.053	0.01	0.01	0.00	-0.003
Michigan	0.11	0.03	0.08	0.307	0.11	0.13	-0.02	-0.097
Minnesota	0.04	0.04	0.00	-0.005	0.04	0.04	0.00	-0.009
New Jersey	0.02	0.03	-0.01	-0.068	0.02	0.02	0.00	-0.008
North Carolina	0.03	0.05	-0.02	-0.132	0.03	0.02	0.01	0.027
Ohio	0.06	0.06	0.00	0.000	0.06	0.05	0.01	0.039
Oklahoma	0.01	0.01	0.00	0.000	0.01	0.01	0.00	-0.041
Oregon	0.02	0.03	-0.01	-0.073	0.02	0.03	-0.01	-0.025

Table 12. (continued).

Pennsylvania	0.05	0.06	-0.01	-0.057	0.05	0.06	-0.01	-0.039
South Carolina	0.01	0.02	-0.01	-0.075	0.01	0.01	0.00	-0.022
Tennessee	0.06	0.06	0.00	0.007	0.06	0.05	0.01	0.037
Texas	0.03	0.07	-0.04	-0.196	0.03	0.02	0.01	0.034
Virginia	0.01	0.03	-0.02	-0.137	0.01	0.01	0.00	0.005
Washington	0.13	0.11	0.02	0.066	0.13	0.14	-0.01	-0.027
West Virginia	0.01	0.01	0.00	-0.023	0.01	0.00	0.01	0.014
			Mean Std. Diff.:	**0.084**			**Mean Std. Diff.:**	**0.008**

Note. DE = dual enrollment. T = treatment group. C = control group.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), Second Follow-up Restricted-Use Data File.

Outcome Models

To examine the effect of dual enrollment location on student outcomes, I modeled five outcomes across two treatment versions and their corresponding analytic samples. I present the results in the sections below.

Taking Dual Enrollment on a College Campus. Using the high school and college base analytic samples, I first estimated the effect of the less restrictive treatment option, taking dual enrollment on a college campus, exclusively or in combination with other locations. I modeled high school graduation, FAFSA completion, the number of college applications, and postsecondary enrollment immediately after high school using the base high school analytic sample, the largest and most inclusive analytic sample. For all outcomes but high school graduation, I estimated coefficients with three different regression analyses: a simple naïve estimation, a simple weighted estimation without covariates, and a doubly robust estimation that included covariates. The naïve regression analysis helps establish a baseline estimate for the models incorporating the weights and controls. Because the distribution of high school graduation is highly skewed (i.e., 97% of students completed high school), it was not possible to run an analysis that included all the covariates.

Table 13 presents the results of the regression analyses using the high school base analytic sample with the less restrictive treatment identification. Regression coefficients for high school graduation, FAFSA application, and postsecondary enrollment immediately after high school are not statistically significant. The lack of significance suggests students who take dual enrollment on a college campus graduate from high school, complete FAFSA applications, and attend postsecondary education immediately after high school at the same rate as students who take dual enrollment only at their high school. The naïve estimation suggests the number of

college applications may be 0.11 higher for students who take dual on a college campus. The effect was significant at p<0.01. However, the effect of taking dual enrollment on a college campus becomes statistically insignificant in the simple weighted regression model and the weighted model with covariates. Results are similar when estimating the number of college applications using regular regression instead of Poisson regression, albeit coefficients and standard errors increase.

Table 13.

Model Results for the High School Analytic Sample where Treatment is DE on a College Campus (Less Restrictive Identification).

		Took DE on a College Campus	
Outcome	**Model**	β	**SE**
High school graduation	Naïve estimation	-0.179	(0.289)
	Simple weighted regression	0.742	(0.473)
	Doubly robust estimation	_[a]	_[a]
FAFSA application	Naïve estimation	0.107	(0.133)
	Simple weighted regression	0.011	(0.226)
	Doubly robust estimation	-0.139	(0.207)
Number of college applications	Naïve estimation	0.109***	(0.033)
	Simple weighted regression	0.107	(0.097)
	Doubly robust estimation	0.048	(0.052)
Postsecondary enrollment, immediately after high school	Naïve estimation	0.206	(0.158)
	Simple weighted regression	0.300	(0.278)
	Doubly robust estimation	0.001	(0.283)

Note: *** p<.01. DE = dual enrollment. SE = standard error.
[a] Because of the highly skewed distribution of high school graduation, it was not possible to estimate a model that included all the covariates.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), Second Follow-up Restricted-Use Data File.

Next, I examined the effect of taking dual enrollment on college campus, potentially in combination with other location, on postsecondary enrollment three years after high school. Table 14 presents the results of the regression analyses using the college base analytic sample with the less restrictive treatment identification. Coefficients from three logit models representing the naïve estimation, simple weighted regression, and weighted regression with control were statistically insignificant. The absence of significance indicates that three years after finishing high school, students who take dual enrollment on a college campus and students who took dual enrollment at their high school only did not differ in rates of postsecondary enrollment.

Table 14.

Model Results for the College Analytic Sample where Treatment is DE on a College Campus (Less Restrictive Identification).

		Took DE on a College Campus	
Outcome	**Model**	***β***	**SE**
Postsecondary enrollment, 3 years after high school	Naïve estimation	0.281	(0.184)
	Simple weighted regression	-0.342	(0.326)
	Doubly robust estimation	-0.268	(0.382)

Note. DE = dual enrollment. SE = standard error.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), Second Follow-up Restricted-Use Data File.

Taking Dual Enrollment Exclusively on a College Campus. I also estimated the outcomes using the more restrictive treatment identification, taking dual enrollment courses exclusively on a college campus. After dropping students who reported taking dual enrollment both on a college campus and in other locations (i.e., online, at their high school, or at another high school) from the high school and college base analytic samples, I computed new regression coefficients using the new analytic samples.

Table 15 contains the results of the regression analyses using the high school analytic sample with the more restrictive treatment identification. Similar to the models using the less restrictive sample and treatment identification, regression coefficients indicate no statistically significant difference in high school graduation, FAFSA completion, and postsecondary enrollment immediately after high school between students who took dual enrollment courses exclusively on a college campus and students who took dual enrollment courses at their high

Table 15.

Model Results for the High School Analytic Sample where Treatment is DE Exclusively on a College Campus (More Restrictive Identification).

		Took DE Exclusively on a College Campus	
Outcome	**Model**	β	**SE**
High school graduation	Naïve estimation	-0.207	(0.370)
	Simple weighted regression	0.153	(0.584)
	Doubly robust estimation	—[a]	—[a]
FAFSA application	Naïve estimation	0.064	(0.176)
	Simple weighted regression	0.215	(0.278)
	Doubly robust estimation	0.091	(0.271)
Number of college applications	Naïve estimation	0.148***	(0.043)
	Simple weighted regression	0.174	(0.120)
	Doubly robust estimation	0.089	(0.058)
Postsecondary enrollment, immediately after high school	Naïve estimation	0.179	(0.213)
	Simple weighted regression	0.464	(0.343)
	Doubly robust estimation	0.416	(0.352)

Note: *** p<.01. DE = dual enrollment. SE = standard error.
[a] Because of the highly skewed distribution of high school graduation, it was not possible to estimate a model that included all the covariates.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), Second Follow-up Restricted-Use Data File.

school only. The lack of significance remained constant across both regression analyses for the high school graduation and across all three regression analyses for FAFSA completion and postsecondary enrollment immediately after high school. The effect of taking dual enrollment exclusively on a college campus on the number of college applications was statistically significant in the naïve estimation, $p<0.01$. Students in the treatment group appeared to submit 0.15 more college applications that students on the control group. However, the effect was no longer statistically significant once I added the IPTW weights and controls. As in the case of the less restrictive treatment identification, regular regression models produced larger coefficients and standard errors than Poisson models but yielded similar findings.

Finally, I investigated the effect of taking dual enrollment exclusively on college campus on postsecondary enrollment three years after high school. Table 16 reflects the results of the regression analyses using the college analytic sample with the more restrictive treatment identification. Results from the naïve estimation, simple weighted regression, and weighted regression with control were statistically insignificant. The lack of significance suggests that three years after finishing high school, there is no difference in postsecondary enrollment between students who take dual enrollment exclusively on a college campus and students who take dual enrollment at their high school only.

Table 16.

Model Results for the College Analytic Sample where Treatment is DE Exclusively on a College Campus (More Restrictive Identification).

Outcome	Model	Took DE Exclusively on a College Campus	
		β	**SE**
Postsecondary enrollment, 3 years after high school	Naïve estimation	0.406	(0.263)
	Simple weighted regression	0.158	(0.398)
	Doubly robust estimation	0.561	(0.397)

Note. DE = dual enrollment. SE = standard error.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), Second Follow-up Restricted-Use Data File.

CHAPTER 5: DISCUSSION

In this chapter I briefly revisit the underpinnings of this study and synthesize the research questions, methods, and findings described in the previous chapters. I then discuss how this study fits in the larger body of research on dual enrollment and discuss its potential implications as well as its limitations. Finally, I share potential ideas for future research on dual enrollment and closing remarks.

Overview

Using data from HSLS:09, a nationally representative longitudinal survey of 9th graders, this study investigated the effect of dual enrollment course location on students' high school graduation and college-going behaviors. Leaning on theories of role rehearsal, my proposed theory of action posited that taking dual enrollment on a college campus would provide high school students with authentic postsecondary experiences that help them practice the role of college student and propel their transition to postsecondary education. Results suggest no differences in high school graduation, FAFSA completion, number of college applications, and postsecondary enrollment between high school-based and college-based dual enrollees. The absence of differences in high school completion and college-going behaviors between students who took dual enrollment courses on a college campus and those who took dual enrollment at their high school may be an encouraging signal that college-based and high school-based dual enrollment courses are equivalent in rigor and produce high school graduates and college students at the same rate.

Discussion of Findings

Studies indicate dual enrollment promotes college readiness as evidenced by gains in three of Conley's four college readiness indicators: cognitive strategies, key content knowledge,

and key learning skills and techniques (An & Taylor, 2015). Students who take college-based dual enrollment taught by college faculty have a more authentic experience and reap more benefits (Karp, 2007). I expected that college-based dual enrollment courses would provide high school students with better exposure to a postsecondary environment, rigorous instruction, and diverse interactions with regular college students which would facilitate high school students' understanding and internalizing of college student roles, norms, and behaviors. Moreover, I anticipated increased familiarity with the postsecondary environment and standards would help students feel more prepared for college and confident in their ability to successfully transition to college which would translate in higher rates of high school completions and college-going behaviors.

High school graduation. This study finds no difference in high school graduation rates between college-based and high school-based dual enrollment. Overall, the evidence on the link between dual enrollment and high school graduation is mixed. Studies indicate dual enrollment participation may increase (Karp et al., 2007) or decrease (Cowan & Goldhaber, 2014) the likelihood of obtaining a high school diploma. And sometimes dual enrollment participation makes no difference at all (Speroni, 2011b). Research that investigates specifically the effect of dual credit on student outcomes by instruction location finds no significant difference in the percentage of high school completions across college and high school-based dual credit (Villarreal, 2018). Results from this study seem to confirm Villarreal's (2018) findings and lend support to prior qualitative claims that college-based and high school-based dual enrollment courses are equally rigorous (Friedman et al., 2017).

College-going behaviors. In addition to no differences in high school completion, I find no difference in college-going behaviors between college-based and high school-based dual

enrollees. While overall participation in dual enrollment has been linked to increased likelihood of postsecondary enrollment (Cowan & Goldhaber, 2014; Karp et al., 2007; Struhl & Vargas, 2012), investigations focused on heterogenous effects by dual enrollment setting find no statistically distinct differences in college applications and enrollment (Villarreal, 2018).

Some education scholars have expressed concern that dual enrollment models may be diluting the quality of education and experiences typically associated with college learning (Thomson, 2017; Zimmerman, 2012). A recent article penned by a college history professor summarizes a sentiment often shared by dual enrollment critics:

> If there were (…) real similarities between concurrent courses and actual college courses, then it might be worth using public money to make concurrent enrollment available to all collegebound students. But these courses are taught in high schools, to high-school students, by high-school teachers. They are high-school courses." (Gilbert, 2017).

Findings from this study suggest high school-based dual enrollment courses may be indeed similar to college courses. Whether students take dual enrollment courses on a college campus or in their high school, the end result appears to be similar high school graduation and college-going behaviors. This interpretation would suggest that concerns about high school students' lack of maturity and unsuccessful integration in the college environment may be unfounded (Catron, 2001). Furthermore, this interpretation may also alleviate concerns that school districts' difficulties in hiring high school instructors qualified to teach dual enrollment may jeopardize the quality of dual enrollment courses by suggesting high school-based dual enrollment may be equivalent to what students would receive on a college campus (Barnett, 2003).

Another possible interpretation is that the theory-of-change mechanisms through which I expected college-based dual enrollment to impact student outcomes may not work as expected.

One assumption inherent in the theory of change relates to peer interaction. I posited that taking dual enrollment courses on a college campus would expose high school students to more mature and diverse students. Through interactions with college peers, I anticipated that high school students would learn about college norms and behaviors, intensify their academic efforts, and model their actions after their peers'. Together, all these experiences would help demystify college and shape a vision of the future that involves becoming a college student. However, it is possible that high school students taking a course with regular college students on a college campus may have a different experience. When high school students take dual enrollment at their high school, they are likely to be in classrooms with peers they know. The average high school student reports having at least six friends in a dual enrollment course (Martell et al., 2006). In contrast, roughly one in three regular college students knows someone in their college class and one in ten has a friend in the class. Being among familiar faces in a fairly homogenous environment may account for higher levels of social interactions in the high school setting (Martell et al., 2006).

A second assumption made by the theory of change is that taking college-based dual enrollment courses would help high school students navigate the college campus and benefit from its resources. High school students who attend dual enrollment courses on a college campus have the same access to campus services and resources (i.e., library, academic advising, tutoring, personal and career counseling, recreation and wellness, etc.) as regular college students. However, given that high school students receive most of their college advising from high school counselors (Miller et al., 2018), the extent to which students actually utilize the college-based services and resources is highly uncertain (Atchison, Mohammed, Zeiser, Levin, & Knight,

2019). If high school students do not utilize college resources, they have fewer opportunities to familiarize themselves with the college campus and rehearse the role of college student.

It is also important to consider that college-based and high school-based dual enrollment courses may differ on a salient component: class size. The average class size for college courses is 28.4, whereas the average class size for high school-based dual enrollment courses is 15.7, almost half that of college courses (Friedman et al., 2011). There is compelling evidence supporting academic gains associated with smaller class size, especially for students from under-resourced backgrounds (Hedges, 2000; Mosteller, 1995). However, the effect of class size varies considerably and is highly susceptible to school context influences (Konstantopoulos, 2011). Insofar as high school-based dual enrollees are enrolled in smaller classes, it is possible they may receive more individualized instruction which may offset the lack of exposure to college campus and interaction with college faculty and students. While sample constraints in the current study do not allow me to conduct subgroup analyses, future studies could investigate if college-based dual enrollment has differential impacts for various student subgroups (e.g., students from economically disadvantaged backgrounds and/or students of color).

Finally, there have been claims that some college faculty are resistant to teaching high school students and may be unprepared to handle high school students (Golann & Hughes, 2008). In fact, some college faculty have been vocal in expressing skepticism related to high school-based dual enrollment rigor and quality (Gilbert, 2017; Thomson, 2017; Zimmerman, 2012). Although not all college instructors may distinguish dual enrollment participants from regular college students in college-based dual enrollment courses (Lile et al., 2017), it is likely some of them do. If college faculty can identify high school dual enrollment students and are not

open to providing instruction to this student group, they may adopt a differential attitude towards high school students and potentially diminish the quality of the college learning experience.

Implications for Dual Enrollment Stakeholders

This study utilizes a quasi-experimental design to investigate the effect of dual enrollment course location on students' high school graduation and college-going behaviors. Results indicate no differences in outcomes between students who take dual enrollment at their high school and students who take dual enrollment courses on a college campus. However, the lack of randomization of treatment assignment signals these findings should be interpreted with caution. Despite inherent limitations, this study contributes to the scarce literature on the effects of core dual enrollment implementation features by documenting how dual enrollment settings may impact students. Consequently, findings may have relevant implications for the various dual enrollment stakeholders.

Across the nation, states have reduced support for elementary and secondary schools post-recession and funding continues to drop years later (Leachman, Albares, Masterson, & Wallace, 2016). Policymakers seeking to expand dual enrollment opportunities amidst constantly shrinking resources must pay close attention to which dual enrollment components minimize costs while maximizing benefits. If the benefits that accrue to students from taking dual enrollment on a college campus are the same as the benefits that accrue from taking dual enrollment at the students' high schools, then policymakers should consider investing public money in dual enrollment models that incorporate the more low-cost delivery setting.

Establishing which dual enrollment delivery setting has the least costly implementation calls forth the thoughtful evaluation of costs from multiple perspectives representing multiple stakeholders. An early dual enrollment guide for policymakers (Hoffman et al., 2008) notes that

even when high-school based dual enrollment courses are taught by a college or adjunct professor, savings in regular or discounted tuition costs should make them a more affordable alternative to college-based dual enrollment courses. Indeed, average annual wages for secondary teachers trail salaries for college faculty across two and four-year institutions (Bureau of Labor Statistics, 2019). However, while it may seem intuitive, this expectation that high school-based dual is less expensive than college-based dual enrollment is not rooted in a systematic analysis of dual enrollment costs.

Determining the effectiveness of educational policies is of great importance. Yet responsible decision-making compels policymakers to also examine the effects of an intervention or policy in the context of scarce resources. Economic evaluations in education can inform decision-makers and practitioners on how to use resources more efficiently and maximize goal attainment within existing budgetary constraints (Levin, McEwan, Belfield, Bowden, & Shand, 2018).

Rigorous economic evaluations use the *ingredients method* to identify all the resources or ingredients needed to implement an intervention, appraise the pecuniary value of these ingredients, and estimate the total cost within the framework provided by the theory of change (Levin et al., 2018). Estimating dual enrollment costs entails accounting for all the personnel and non-personnel resources that are used to provide dual enrollment courses and would otherwise be unnecessary to deliver regular high school classes (Miller et al., 2018). Moreover, analyses of dual enrollment costs require evaluators to consider costs from the perspectives of the three main dual enrollment stakeholders: community colleges, school districts, and students and their families. Two recent cost studies use the ingredients method to estimate costs associated with dual credit (Miller et al., 2018) and Early College High Schools (Atchison et al., 2019) in Texas.

Given that Early Colleges are considerably different from traditional dual enrollment, I rely on Miller et al.'s (2018) economic evaluation to help shape my discussion of costs associated with dual enrollment.

Community colleges. The bulk of dual enrollment costs borne by the community college is associated with two main cost categories: 1) college administration and advising and 2) instructional personnel (Miller et al., 2018). For the most part, administration and advising expenses are related to staff that act as liaisons with school districts and high schools, engage with high school counselors, and deliver dual enrollment information sessions. Costs associated with non-personnel resources such as travel to and from district high school partners make up only a small share of administration costs. Whether dual enrollment courses are taught in high schools mostly by high school teachers or in college by mainly college faculty, administration and advising costs seem relatively similar and range between $40 and $50 per semester credit hour (SCH).

Consistent with prior expectations (Hoffman et al., 2008), dual enrollment courses taught by full-time college faculty are associated with higher instructional personnel costs than dual enrollment courses taught by high school teachers (Miller et al., 2018). The average cost per SCH associated with having a dual enrollment course taught by a full-time college faculty is about $87, more than five times the $14 per SCH associated with a high school teacher delivering the course.

Cost estimates that account for the predominant type of instructor indicate substantial differences in overall cost per dual enrollment SCH. Dual enrollment partnerships where courses are primarily taught by full-time college faculty cost, on average, $109 per SCH. Waiving tuition and fees places responsibility for 98% of costs with community colleges. A scenario that

assumes a $40 tuition and fees charge would result in a 37% reduction in costs to community colleges. In contrast, the average cost per SCH is $126 when courses are taught mainly by high school teachers. Compared to dual enrollment partnerships where courses are taught primarily by high school instructors, the costs to community colleges are considerably lower. Thus, community colleges would pay about 40% of costs in a no-tuition scenario and 10% in a $40 tuition and fees scenario. Dual enrollment partnerships where courses are taught primarily by high school instructors are typically high school-based, whereas dual enrollment partnerships where courses are taught primarily by full-time college faculty tend to be college-based.

Given this discussion of the distribution of costs, it is reasonable to assume community colleges may find more advantageous partnerships where either dual enrollment courses are provided in a high school setting by high school teachers or colleges can charge tuition and fees, even if at a discounted rate. There is indication that community college enrollments have been declining in recent years (AACC, 2019). The expansion of dual enrollment programs has helped community colleges make up for the diminished enrollments with dual enrollment students (AACC, 2019). If college-based dual enrollment students were more likely to enroll in college, it may make sense for community colleges to invest in college-based dual enrollment, even if more expensive than the alternative. However, if there is no difference in college-going behaviors and choices between college-based and high school-based dual enrollment students, then community colleges may be more open to high school-based dual enrollment partnerships. While this study cannot establish whether college-based dual enrollees are more likely to persist at community colleges after high school, future research could help community colleges better understand enrollment and persistence patterns among students who take dual enrollment on a community college campus.

School districts and high schools. Similar to community colleges, the highest dual enrollment costs for school districts seem related to administration and advising and personnel costs. Unlike community colleges, school district administrative costs sometimes exceed instructional personnel costs. District size appears to matter when examining costs. Larger districts have lower administrative costs per SCH, whereas smaller districts having higher administrative costs. The difference seems to stem from the scale of operations. Interestingly, school district urbanicity does not appear to make meaningful contributions to costs. Whether community colleges partner with rural or urban schools, costs related to travel to and from the college appear insignificant.

When dual enrollment courses are taught by college faculty, which typically implies a college-based dual enrollment model, school districts tend to have lower dual enrollment costs and may even save money. Assuming a regular high school instructor typically teaches ten courses per year and the average class size is 24 students, a high school may reduce staffing by one teacher for every 720 SCHs of dual enrollment delivered by a college faculty (Miller et al., 2018). The extent of the costs savings depends on the number of dual enrollment credits students take: the higher the number of dual enrollment credits taught by college faculty, the lower the number of high school teachers needed and the larger the potential savings.

College-based dual enrollment scenarios where instructors are primarily college faculty seem to benefit school districts the most. When tuition is waived, school districts may report negative amounts due to savings from teaching staff reductions. Even if the school district assumed responsibility for a $40 tuition and fees charge per SCH, the proportion of dual enrollment costs to be picked up by the school district appears less than 30%. In contrast, when instructors are primarily high school teachers, which is typically the case for high school-based

dual enrollment, school districts are responsible for roughly half of pre-tuition dual enrollment costs. If the college were to charge $40 in tuition and fees per SCH and the school district chose to pay it, the proportion of average dual enrollment costs per SCH to be borne by the school district would rise to 80%.

With an average cost of $126 per SCH, dual enrollment partnerships where instructors are mostly high school teachers, as is typically the case in high school-based dual enrollment, are the most expensive (Miller et al., 2018). School districts and high schools bear a large portion of costs, especially if tuition is required. Small school districts may be particularly vulnerable to high costs mainly because of administrative expenses. Under college-based dual enrollment partnerships, high schools might be able to reduce teaching staffing and lower the average cost per dual enrollment SCH. The fact that high school-based and college-based dual enrollment students may not differ in college-going behaviors and outcomes suggests school districts' decision to enter a high school-based or college-based dual enrollment partnership may give more weight to economic (i.e., costs of dual enrollment) and logistical (i.e., proximity to community college) considerations. From an economic standpoint, school districts are likely to find college-based dual enrollment partnerships more beneficial.

Students. According to high school counselors, costs related to textbooks and tuition and fees are frequent barriers to high school students' participation in dual enrollment (Miller et al., 2018). Some community colleges charge discounted tuition or even waive tuition, particularly for low-income students (Miller et al., 2018). Some school districts choose to fully or partially pay for textbooks, testing, and/or tuition and fees. Even when tuition is waived, many school districts split dual enrollment costs with students and their families. In twenty-four states, students and their families are at least partially responsible for costs associated with textbooks

and tuition and fees (ECS, 2016). While school districts may sometimes provide transportation, many dual enrollment students must make their own transportation arrangements.

Interestingly, when tuition is waived, dual enrollment costs to students appear to be the same regardless of the setting in which the dual enrollment course is delivered (Miller et al., 2018). The average costs to students before applying tuition are $13. While $13 per SCH may seem fairly inexpensive, that amount can rise if tuition is not waived. If schools choose to split tuition costs with students and their families, the average costs to students per SCH are $33 (Miller et al., 2018). And when school districts pass on to students the full tuition charged, the average costs to students amount to $53 per SCH.

If students take more than one dual enrollment course per year, their dual enrollment costs could amount to hundreds of dollars and place students and their families under financial strain. Even when tuition and fees are waived, students from economically disadvantaged backgrounds may be unable to pay the $13 per SCH or secure transportation to and from the college campus and may find themselves restricted from accessing dual enrollment (Edwards et al., 2011; Hoffman, 2003).

Although the average costs to students per SCH are the same regardless of dual enrollment setting, students' dual enrollment costs will ultimately be shaped by the specific provisions of the partnership between their school district and the community college. High school-based dual enrollment may be more accessible to students and thus allow more students to try on college. If students have the option to choose between the two delivery settings, findings from this study suggests selecting high school-based dual enrollment may not result in lower likelihood of completing high school or going to college. Taking dual enrollment courses

at the high school may be high school students' more practical and convenient dual enrollment choice.

States. Traditionally, policymaking has been preoccupied with estimating the individual and social benefits associated with the quantity of schooling (Hanushek, 2012). Increasingly though, discussions around educational policies have shifted to integrate the quality of schooling and its effect on workforce outcomes and national growth. Providing quality education within the boundaries of limited fiscal resources entails a decision-making process centered on the optimization of resources (Hanushek, 2012). Yet extensive national and international research shows an inconsistent effect of resources on student outcomes. The absence of a consistent and easily generalizable impact of resource policies does not imply that resources make no difference. Instead, inconsistent evidence suggests broad policies originating from a centralized governing entity may induce both the adequate and inadequate use of resources and cancel out the outcomes (Hanushek, 2012).

Dual enrollment courses incur both public (i.e., community colleges and school districts) and private (i.e., students and families) costs. A rigorous cost evaluation (Miller et al., 2018) focused on dual credit in Texas provides a framework for discussing dual enrollment costs and their distribution across multiple stakeholders. By far, expenses associated with the personnel needed to implement dual enrollment courses account for most of the dual enrollment costs, regardless of the setting in which the courses take place. Additionally, costs associated with traditional dual enrollment and their distribution across stakeholders are driven primarily by two factors: the type of instructor delivering the course and the size of the school district (Miller et al., 2018).

However, the costs estimated by Miller et al. (2018) must be interpreted with caution as they are likely reflective of contextual dual enrollment characteristics. Perhaps the most important take-away from Miller et al.' (2018) economic evaluation is that dual enrollment costs are highly nuanced and show considerable variation. Although funding is often at the center of decisions related to where dual enrollment is offered, who can have access, what courses are delivered and who teaches them, estimations of costs associated with various dual enrollment components and models are extremely rare. As states look to expand dual enrollment, more economic evaluations are needed to clarify the costs of college-based dual enrollment relative to their benefits within multiple contexts and for multiple stakeholders.

States have been long facing the dilemma of increasing dual enrollment participation without exhausting available resources (Bailey & Karp, 2005). Trade-offs between broadening access to schooling and improving the quality of schooling are common concerns in educational policymaking (Hanushek, 2012). This study suggests that opening access to dual enrollment may not necessarily occur at the expense of academic rigor.

Effective implementation is built on trust among partners and shared goals (Howley et al., 2013). Nevertheless, reaching a common understanding of goals can be challenging because of financial underpinnings of dual enrollment (Howley et al., 2013). The most financially advantageous dual enrollment arrangement for school districts seems to be one where dual enrollment instructors are primarily college faculty and tuition is waived (Miller et al., 2018). Conversely, the most financially advantageous dual enrollment arrangement for community colleges appears to be one where dual enrollment instructors are primarily high school instructors and tuition is not waived. The first scenario shifts the bulk of dual enrollment costs to community colleges, whereas the second scenario shifts the fiscal burden to school districts. To

alleviate the financial strain, both community colleges and school districts are likely to impose eligibility requirements or pass on costs to students, thus limiting access (Bailey & Karp, 2005).

Findings from this study suggest high school-based and college-based dual enrollment may have similar effects on high school students' college-going behaviors and enrollment. While one of the goals of dual enrollment is to broaden access to postsecondary education, particularly for underrepresented students, if community colleges and school districts focus only on maximizing resources, economically disadvantaged students may find themselves restricted from participating in dual enrollment (Edwards et al., 2011; Hoffman, 2003). To ensure equity, state policymakers should encourage partnerships between college and school districts that account for contextual factors and subsidize the costs of dual enrollment for minority and low-income students.

Moreover, states should fund and promote dual enrollment partnerships that include opportunities for social interactions among high school teachers and college faculty. In many states, community colleges and school districts receive no funds to facilitate engagement activities (Borden et al., 2013). Yet enabling high school teachers and college faculty to engage with each other could facilitate a mutual understanding of teaching practices and student expectations and support the successful implementation of dual enrollment courses across different settings (Taylor et al., 2015).

Limitations

This study has several limitations. One limitation is that the data used in this study is largely self-reported. Although HSLS:09 collects some of the data from transcripts, institutional records, and national databases, this study relies mainly on information reported by survey respondents themselves. To the extent that the self-reported data may be affected by high

variability in the comprehension, memory retrieval, and judgment of factual and attitudinal survey questions (Tourangeau, Rips, & Rasinski, 2000), they may not accurately measure respondents' experiences.

Additionally, the data used in this study are obtained from secondary sources, primarily survey instruments. Despite the complexity and richness of HSLS:09, one challenge inherent in using secondary data is the low representativeness of specific groups (Perna, 2006). Low representativeness of student subgroups is further accentuated by the data truncation resulting from the sample identification. As such, examining the differential effect of college-based dual enrollment for various student groups (e.g., low-income and/or racial minority students) is not feasible in this study. For example, given the small sample size and the traditionally limited number of American Indian or Pacific Islander students in nationally representative surveys, understanding how the impact of dual enrollment location may vary for this group is not possible.

A core assumption of the counterfactual framework, SUTVA, posits that there are no unrepresented versions of the treatment (Rubin, 1986). Under this assumption, a student's participation in college-based dual enrollment is assumed to not have affected other students' outcomes. However, high school students are likely to be influenced by their peers. It is possible that high school students may have had friends who participated in college-based dual enrollment and shared information about college academic standards and norms, thus influencing high school-based dual enrollees' behaviors and biasing estimates downward.

Finally, the success and accuracy of the propensity score model relies on the extent to which "selection is solely based on observable characteristics and that all variables that influence treatment assignment and potential outcomes simultaneously are observed by the researcher"

(Caliendo & Kopeinig, 2005, p.4). Although HSLS:09 provides access to a rich set of student and institutional data, it is possible that relevant variables associated with dual enrollment location may have been omitted. Omitting relevant characteristics that predict participation or treatment may lead to biased and unreliable coefficient estimates (Khandker et al., 2010). If any unobserved characteristics drive treatment participation the ITAA assumption may not hold and propensity score methods may be ill-suited.

Despite inherent limitations, this research investigation has several strengths relative to existing studies. This study applies rigorous quasi-experimental methods to reduce bias and accurately estimate the difference in outcomes between college-based and high school-based dual enrollment students. In doing so, this research expands the limited knowledge on the effects of dual enrollment settings on student outcomes and helps inform further implementation decisions. Additionally, the HSLS:09 data used here contain rich information about student and family characteristics that play an important role in shaping student outcomes (e.g., family structure, parental education, postsecondary aspirations and expectations, extracurricular activities, etc.) and are typically not available in administrative data. Access to rich information about students and their families allowed me to match students in treatment group with similar students in the control group and create comparable groups. Last but not least, the use of nationally representative data enabled me to capture out-of-state student outcomes that may be challenging to record in administrative data.

Implications for Research

While this study seeks to shed light on how dual enrollment setting impacts students, there are many questions it cannot answer. The sections below describe potential ideas on how to expand the current study and research on dual enrollment location.

Quantitative research. Current data availability constrains me to define the treatment as an overall participation in college-based dual enrollment courses without accounting for more granular information such as course content or number of dual enrollment credits accumulated. Research suggests the choice of dual enrollment courses matters. Students who take a college algebra course have higher likelihood of attending college and earning an associate's or bachelor's degree (Speroni, 2011b). Research on how student outcomes compare across similar courses but different dual enrollment settings is inconclusive or uses less rigorous methods (Flores, 2012; Martin, 2014). Research using random assignment or quasi-experiments could advance out understanding of how the same course subject taken across different dual enrollment setting may impact student outcomes. For instance, it would be interesting to know if taking a Chemistry dual enrollment course on a college campus as opposed to at a high school would result in better academic performance and lower remediation in future college Chemistry courses. Similar investigations could be extrapolated to other subjects.

In addition to inquiries related to course subject, it would be also helpful to investigate the heterogenous effects of the number of dual enrollment credits by location. High school students who enter college with at least six college credits earned from rigorous instruction are more likely to successfully navigate the first year of college (Adelman, 2006). The extra credits appear to provide students with academic momentum and help them remain in college and complete their degree (Adelman, 1999; Adelman, 2006; Allen & Dadgar, 2012; Eimers & Mullen, 2003; Struhl & Vargas, 2012; Swanson, 2008). It is uncertain whether the setting in which these credits are earned matters. Future studies should investigate how the number of dual enrollment credits through college-based dual enrollment may impact students, particularly with respect to persistence, degree completion, and time to degree.

Future research could also build on this study using information from HSLS:09 postsecondary transcripts to confirm or disprove current findings and explore other outcomes. Access to postsecondary transcripts would provide the researcher with information about dual enrollment course subjects, number of dual enrollment credits earned, as well as transferability. Additionally, the transcripts should contain details about the number of college credits accumulated during each academic year, remedial courses, GPA, enrollment, and completion, thus providing opportunities to paint a more complete picture of college-based and high school-based dual enrollees' college success.

While this study allows comparisons of high school graduation and college-going behaviors between high school- and college-based dual enrollment students, it does not offer opportunities to investigate the extent to which taking dual enrollment courses on a college campus may impact specific components of college readiness. The literature on dual enrollment could benefit from research on how dual enrollment delivery settings may influence the development of individual markers of college readiness such as academic skills, academic behaviors and habits, social and interpersonal characteristics, personal habits and traits and college knowledge.

Qualitative research. While the theory of change underlying this study assumes college-based dual enrollment embodies higher academic standards and rigor which are deemed to promote education quality, HSLS:09 does not contain information about the quality of instruction. Comparisons of college-based and high school-based dual enrollment courses typically operationalize academic rigor in terms of academic performance (Arnold et al., 2017; Flores, 2012; Martin, 2014). More thorough evaluations use course syllabi, student assignments, graded student work, and instructor survey to assess academic rigor defined through course

content, demonstration of skills, instructional strategies, and assessment of student learning and performance (Miller et al., 2018). However, these studies do not include classroom observations or explicitly capture the quality of instruction.

Qualitative research seeks to understand individuals' behaviors and actions within their natural setting (Creswell, 2013). As such, face-to-face interactions are key to gaining insight about people and processes. Future qualitative research should conduct classroom observations of college-based and high school-based dual enrollment to collect key information about the quality of instruction and social interactions. Scholars have expressed concerns that the presence of high school students in college classrooms and their underdeveloped maturity may potentially clash with regular college students and negatively impact the college learning experience (Dougan, 2005). Being immersed in the classroom setting would help researchers collect direct evidence about high school students' interactions and engagement with regular college students and identify how the presence of high school students may influence academic discourse and learning in college-based dual enrollment courses. Moreover, qualitative researchers could investigate regular college students' perceptions and experiences in college-based dual enrollment courses.

There are claims that high school-based dual enrollment instructors face more issues related to discipline and classroom management than on a college campus (Martell et al., 2006). Qualitative research could collect rich data about the extent to which high school- and college-based dual enrollment instructors engage in disciplinary activities and how they differ in attitudes and approaches to teaching high school students, classroom expectations and norms, and skill development and emphasis. All this information could be used to better understand the

implementation of dual enrollment and develop a theory that explicates how students experience and interact with the different components of dual enrollment.

Conclusion

A growing body of literature indicates students who participate in dual enrollment are more prepared for college (An & Taylor, 2015), have a better understanding of what it means to be a college student (Karp, 2012), attend college at higher rates (Cowan & Goldhaber, 2014; Giani et al., 2014; Struhl & Vargas, 2012), have higher college GPA (Karp et al., 2007), earn more credits in the first year of college (Allen & Dadgar, 2012), and are more likely to persist (Swanson, 2008) and obtain a college degree (An, 2013a; Blankenberger et al., 2017). States have been quick to adopt policies proliferating dual enrollment. But these policies vary greatly in how prescriptive they are as to who can participate in dual enrollment, who pays for it, where students can take it, which dual enrollment courses can be provided, who teaches them, and what type of credit they carry (ECS, 2019). This abundance of program component permutations has spurred remarks that, administratively, dual enrollment is reminiscent of the Wild West (Reed, 2019). Most importantly though, policymakers, administrators, educators, parents, and students face making dual enrollment decisions in a context where rigorous research elucidating how specific dual enrollment settings impact student experiences and success is vastly missing (Lile et al., 2017).

As the dual enrollment movement continues to grow, gaining more insight into how the individual features of dual enrollment affect students is key to successful and cost-effective implementation. Findings from this study suggest that dual enrollment courses taught in high schools to high school students by high school teachers may indeed be quite similar to actual college courses and yield similar student outcomes. These results echo prior reports that high

school-based and college-based dual enrollment courses display comparable rigor (Friedman et al., 2017; Miller et al, 2018). In the context where race and socioeconomic status continue to drive education choices and outcomes, dual enrollment brings the promise of broader college access and success (Hoffman, 2003). But participating in college-based dual enrollment may raise barriers related to costs and transportation logistics (Hoffman, 2003). If high school- and college-based dual enrollment students graduate from high school at the same rate and display similar college-going behaviors, then decisions around dual enrollment implementation and its components could be less restrictive. In this context, the decision-making could focus on which delivery setting works best given the goals, needs, and resources of all stakeholders involved.

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APPENDICES

Appendix A: Source Variables and Datasets for Student-Level Covariates

STUDENT COVARIATES	COVARIATE VALUES	SOURCE VARIABLE(S)	SOURCE DATA
Demographics			
Sex			
Female	0 = “no”, 1 = “yes”	X1SEX	HSLS:09 BY
Race			
Asian	0 = “no”, 1 = “yes”	X1RACE	HSLS:09 BY
Black	0 = “no”, 1 = “yes”	X1RACE	HSLS:09 BY
Hispanic	0 = “no”, 1 = “yes”	X1RACE	HSLS:09 BY
White	0 = “no”, 1 = “yes”	X1RACE	HSLS:09 BY
Other	0 = “no”, 1 = “yes”	X1RACE	HSLS:09 BY
Family characteristics			
Language			
First language is not English	0 = “no”, 1 = “yes”	X1DUALLANG	HSLS:09 BY
Family structure			
Number of household members	Continuous	X1HHNUMBER	HSLS:09 BY
Single parent household	0 = “no”, 1 = “yes”	X1PARPATTERN	HSLS:09 BY
SES			
Family income: <= $15,000	0 = “no”, 1 = “yes”	X1FAMINCOME	HSLS:09 BY
Family income: > $15,000 and <=$35,000	0 = “no”, 1 = “yes”	X1FAMINCOME	HSLS:09 BY
Family income: > $35,000 and <=$55,000	0 = “no”, 1 = “yes”	X1FAMINCOME	HSLS:09 BY
Family income: > $55,000 and <=$75,000	0 = “no”, 1 = “yes”	X1FAMINCOME	HSLS:09 BY
Family income: > $75,000 and <=$95,000	0 = “no”, 1 = “yes”	X1FAMINCOME	HSLS:09 BY
Family income: > $95,000 and <=$115,000	0 = “no”, 1 = “yes”	X1FAMINCOME	HSLS:09 BY
Family income: > $115,001	0 = “no”, 1 = “yes”	X1FAMINCOME	HSLS:09 BY

STUDENT COVARIATES	COVARIATE VALUES	SOURCE VARIABLE(S)	SOURCE DATA
Parents' highest level of education: Less than bachelor's degree	0 = “no”, 1 = “yes”	X1PAREDU	HSLS:09 BY
Parents' highest level of education: Bachelor's degree	0 = “no”, 1 = “yes”	X1PAREDU	HSLS:09 BY
Parents' highest level of education: Master's degree or higher	0 = “no”, 1 = “yes”	X1PAREDU	HSLS:09 BY
Parent occupation prestige	Continuous	X1PAR1OCC6, X1PAR2OCC6, PRESTG10PLUS	HSLS:09 BY, GSS 2012
Parental aspirations and expectations			
Parental aspirations: Less than bachelor's degree	0 = “no”, 1 = “yes”	P1EDUASPIRE	HSLS:09 BY
Parental aspirations: Bachelor's degree	0 = “no”, 1 = “yes”	P1EDUASPIRE	HSLS:09 BY
Parental aspirations: Master's degree or higher	0 = “no”, 1 = “yes”	P1EDUASPIRE	HSLS:09 BY
Parental expectations: Less than bachelor's degree	0 = “no”, 1 = “yes”	X1PAREDEXPCT	HSLS:09 BY
Parental expectations: Bachelor's degree	0 = “no”, 1 = “yes”	X1PAREDEXPCT	HSLS:09 BY
Parental expectations: Master's degree or higher	0 = “no”, 1 = “yes”	X1PAREDEXPCT	HSLS:09 BY
Parental expectations: Don't know	0 = “no”, 1 = “yes”	X1PAREDEXPCT	HSLS:09 BY
Parental involvement			
Parent helped 9th grader with homework: Never	0 = “no”, 1 = “yes”	P1HWOFTEN	HSLS:09 BY
Parent helped 9th grader with homework: Less than once a week	0 = “no”, 1 = “yes”	P1HWOFTEN	HSLS:09 BY
Parent helped 9th grader with homework: 1 or 2 days a week	0 = “no”, 1 = “yes”	P1HWOFTEN	HSLS:09 BY
Parent helped 9th grader with homework: 3 or more days a week	0 = “no”, 1 = “yes”	P1HWOFTEN	HSLS:09 BY
Family talked with counselor/teacher about postsecondary admission requirements	0 = “no”, 1 = “yes”	P1ADMITREQ	HSLS:09 BY
Number of school-level activity types parent engaged in	Continuous	P1SCHMTG, P1PTOMTG, P1PTCONFER, P1SCHEVENT, P1VOLUNTEER, P1FUNDRAISE, P1COUNSELOR	HSLS:09 BY

STUDENT COVARIATES	COVARIATE VALUES	SOURCE VARIABLE(S)	SOURCE DATA
Number of student-level activity types parent engaged in	Continuous	P1MUSEUM, P1COMPUTER, P1FIXED, P1SCIFAIR, P1SCIPROJ, P1STEMDISC, P1LIBRARY, P1SHOW	HSLS:09 BY
Academic engagement, preparation, and achievement			
Academic engagement			
School belonging	Continuous	X1SCHOOLBEL	HSLS:09 BY
School engagement	Continuous	X1SCHOOLENG	HSLS:09 BY
Academic ability/wellness	Continuous	P1LEARN, P1SPEAK, P1MOOD, P1ACTOUT, P1FRIEND	HSLS:09 BY
Academic preparation			
Highest math in 8th grade: Lower than Algebra I	0 = “no”, 1 = “yes”	S1M8	HSLS:09 BY
Highest math in 8th grade: Algebra I	0 = “no”, 1 = “yes”	S1M8	HSLS:09 BY
Highest math in 8th grade: Higher than Algebra I	0 = “no”, 1 = “yes”	S1M8	HSLS:09 BY
Highest science in 8th grade: General Science or Science 8	0 = “no”, 1 = “yes”	S1S8	HSLS:09 BY
Number of credits taken in 9th grade	Continuous	X3TCRED9TH	HSLS:09 BY
Academic achievement			
GPA 9th grade	Continuous	X3TGPA9TH	HSLS:09 BY
Mathematics standardized theta score	Continuous	X1TXMTSCOR	HSLS:09 BY
Educational aspirations			
Orientation towards college			
9th grader plans to take PSAT, SAT, or ACT	0 = “no”, 1 = “yes”	S1PSAT, S1SAT, S1ACT	HSLS:09 BY
9th grader plans to take AP or IB test	0 = “no”, 1 = “yes”	S1IBTEST, S1AP	HSLS:09 BY
9th grader participated in college preparation program	0 = “no”, 1 = “yes”	S1TALENTSRCH, S1UPWARDBND, S1GEARUP, S1AVID, S1MESA	HSLS:09 BY
Working is more important that attending college	0 = “no”, 1 = “yes”	S1WORKING	HSLS:09 BY

STUDENT COVARIATES	COVARIATE VALUES	SOURCE VARIABLE(S)	SOURCE DATA
Postsecondary expectations			
Less than bachelor's degree	0 = “no”, 1 = “yes”	X1STUEDEXPCT	HSLS:09 BY
Bachelor's degree	0 = “no”, 1 = “yes”	X1STUEDEXPCT	HSLS:09 BY
Master's degree or higher	0 = “no”, 1 = “yes”	X1STUEDEXPCT	HSLS:09 BY
Don't know	0 = “no”, 1 = “yes”	X1STUEDEXPCT	HSLS:09 BY
Social influence			
Discussions about college	Continuous	S1MOMTALKCLG, S1DADTALKCLG, S1TCHTALKCLG, S1CNSLTLKCLG, S1FRNDTLKCLG	HSLS:09 BY
9th graders friend gets good grades	0 = “no”, 1 = “yes”	S1FRNDGRADES	HSLS:09 BY
Extracurriculars			
Number of non-academic extracurricular activity types	Continuous	P1ARTS, P1SPORTS, P1RELIGGRP, P1CLUB	HSLS:09 BY
9th grader participated in academic extracurricular activities	0 = “no”, 1 = “yes”	P1ACADEMIC, P1CAMPMS	HSLS:09 BY
Hours spent on extracurricular activities: Less than 1 hour	0 = “no”, 1 = “yes”	S1HRACTIVITY	HSLS:09 BY
Hours spent on extracurricular activities: 1 to 2 hours	0 = “no”, 1 = “yes”	S1HRACTIVITY	HSLS:09 BY
Hours spent on extracurricular activities: 2 to 3 hours	0 = “no”, 1 = “yes”	S1HRACTIVITY	HSLS:09 BY
Hours spent on extracurricular activities: 3 to 4 hours	0 = “no”, 1 = “yes”	S1HRACTIVITY	HSLS:09 BY
Hours spent on extracurricular activities: 4 or more hours	0 = “no”, 1 = “yes”	S1HRACTIVITY	HSLS:09 BY
Hours spent working for pay: Less than 1 hour	0 = “no”, 1 = “yes”	S1HRWORK	HSLS:09 BY
Hours spent working for pay: 1 to 2 hours	0 = “no”, 1 = “yes”	S1HRWORK	HSLS:09 BY
Hours spent working for pay: 2 or more hours	0 = “no”, 1 = “yes”	S1HRWORK	HSLS:09 BY

Appendix B: Source Variables and Datasets for School-Level Covariates

HIGH SCHOOL COVARIATES	COVARIATE VALUES	SOURCE VARIABLE(S)	SOURCE DATA
Demographics			
Size			
Total school enrollment	Continuous	MEMBER09	CCD09
Racial composition			
Percent of student body: Hispanic	Continuous	AM09, MEMBER09	CCD09
Percent of student body: Asian/Pacific Islander/Hawaiian Native	Continuous	ASIAN09, PACIFIC09, MEMBER09	CCD09
Percent of student body: Hispanic	Continuous	HISP09, MEMBER09	CCD09
Percent of student body: Black	Continuous	BLACK09, MEMBER09	CCD09
Percent of student body: White	Continuous	WHITE09, MEMBER09	CCD09
Percent of student body: Unknown race or two or more races	Continuous	TOTETH09, TR09, MEMBER09	CCD09
Resources			
Percent of student body receiving free lunch	Continuous	FRELCH09, MEMBER09	CCD09
Pupil-to-teacher ratio	Continuous	FTE09, MEMBER09	CCD09
Lack of teacher resources and materials is a problem at school	1 = “not a problem”, 2 = “minor problem”, 3 = “moderate or serious problem”	A1RESOURCES	HSLS:09 BY
Courses not offered by school available at community college	0 = “no”, 1 = “yes”	C1COMCLG	HSLS:09 BY
Courses not offered by school available at 4-year college	0 = “no”, 1 = “yes”	C14YRCLG	HSLS:09 BY
College-going culture			
Help with postsecondary schooling is counseling primary goal	0 = “no”, 1 = “yes”	C1GOAL1	HSLS:09 BY
School has counselor designated for college readiness	0 = “no”, 1 = “yes”	C1CLGPREP	HSLS:09 BY
Percent of 9th graders repeating 9th grade		A1REPEATG9	HSLS:09 BY
Schedule			

HIGH SCHOOL COVARIATES	COVARIATE VALUES	SOURCE VARIABLE(S)	SOURCE DATA
Block-scheduling: School uses traditional schedule	0 = “no”, 1 = “yes”	A1ACADBLOCK, A1VOCBLOCK, A1ABLOCKMINS, A1VBLOCKMINS	HSLS:09 BY
Block-scheduling: Block schedule is less than 90 minutes	0 = “no”, 1 = “yes”	A1ACADBLOCK, A1VOCBLOCK, A1ABLOCKMINS, A1VBLOCKMINS	HSLS:09 BY
Block-scheduling: Block schedule is at least 90 minutes	0 = “no”, 1 = “yes”	A1ACADBLOCK, A1VOCBLOCK, A1ABLOCKMINS, A1VBLOCKMINS	HSLS:09 BY
School uses semester calendar	0 = “no”, 1 = “yes”	A1CALENDAR	HSLS:09 BY
Geography			
School urbanicity: City	0 = “no”, 1 = “yes”	ULOCAL09	CCD09
School urbanicity: Suburb	0 = “no”, 1 = “yes”	ULOCAL09	CCD09
School urbanicity: Town	0 = “no”, 1 = “yes”	ULOCAL09	CCD09
School urbanicity: Rural	0 = “no”, 1 = “yes”	ULOCAL09	CCD09
Travel time to the closest two-year institution	Continuous	LATCOD09, LONCOD09, LATITUDE, LONGITUD	CCD09, IPEDS09

Appendix C: Covariate Missingness in the High School Base Analytic Sample Where Treatment Is DE on a College Campus

Covariate	N Missing	Percent Missing	N Non-missing	Percent Non-missing
Student sex: Female	0	0.0%	2,260	100.0%
Student race: Asian	0	0.0%	2,260	100.0%
Student race: Black	0	0.0%	2,260	100.0%
Student race: Hispanic	0	0.0%	2,260	100.0%
Student race: White	0	0.0%	2,260	100.0%
Student race: Other	0	0.0%	2,260	100.0%
First language is not English	0	0.0%	2,260	100.0%
School urbanicity: City	0	0.0%	2,260	100.0%
School urbanicity: Suburb	0	0.0%	2,260	100.0%
School urbanicity: Town	0	0.0%	2,260	100.0%
School urbanicity: Rural	0	0.0%	2,260	100.0%
Travel time to the closest community college	0	0.0%	2,260	100.0%
Math standardized theta score	10	0.4%	2,250	99.6%
Student postsecondary expectations: Less than BA	10	0.4%	2,250	99.6%
Student postsecondary expectations: BA	10	0.4%	2,250	99.6%
Student postsecondary expectations: MA or higher	10	0.4%	2,250	99.6%
Student postsecondary expectations: Don’t know	10	0.4%	2,250	99.6%
Total school enrollment	20	0.9%	2,240	99.1%
Percent of student body: American Indian	20	0.9%	2,240	99.1%
Percent of student body: Asian/Pacific Islander/Hawaiian Native	20	0.9%	2,240	99.1%
Percent of student body: Hispanic	20	0.9%	2,240	99.1%
Percent of student body: Black	20	0.9%	2,240	99.1%
Percent of student body: White	20	0.9%	2,240	99.1%
Percent of student body: Unknown race or two or more races	20	0.9%	2,240	99.1%
Highest math in 8th grade: < Algebra I	30	1.3%	2,230	98.7%
Highest math in 8th grade: Algebra I	30	1.3%	2,230	98.7%
Highest math in 8th grade: > Algebra I	30	1.3%	2,230	98.7%
Pupil-to-teacher ratio	40	1.8%	2,220	98.2%
9th grader’s friend gets good grades	40	1.8%	2,220	98.2%
Discussions about going to college	40	1.8%	2,210	97.8%
Percent of student body receiving free lunch	50	2.2%	2,210	97.8%
Highest science in 8th grade: Gen Science/Gen Science 8/Science 8	50	2.2%	2,210	97.8%

Covariate	N Missing	Percent Missing	N Non-missing	Percent Non-missing
School engagement	50	2.2%	2,200	97.3%
9th grader agrees that working is more important that attending college	60	2.7%	2,200	97.3%
9th grader plans to take PSAT, SAT, or ACT	60	2.7%	2,200	97.3%
Number of credits taken in 9th grade	60	2.7%	2,200	97.3%
Hours spent on extracurricular activities: Less than 1 hour	80	3.5%	2,180	96.5%
Hours spent on extracurricular activities: 1 to 2 hours	80	3.5%	2,180	96.5%
Hours spent on extracurricular activities: 2 to 3 hours	80	3.5%	2,180	96.5%
Hours spent on extracurricular activities: 3 to 4 hours	80	3.5%	2,180	96.5%
Hours spent on extracurricular activities: 4 or more hours	80	3.5%	2,180	96.5%
School belonging	80	3.5%	2,180	96.5%
9th grader plans to take AP or IB test	90	4.0%	2,170	96.0%
GPA 9th grade	120	5.3%	2,140	94.7%
School uses semester calendar	130	5.8%	2,130	94.2%
Hours spent working for pay: Less than 1 hour	140	6.2%	2,120	93.8%
Hours spent working for pay: 1 to 2 hours	140	6.2%	2,120	93.8%
Hours spent working for pay: 2 or more hours	140	6.2%	2,120	93.8%
9th grader participated in college preparation program	150	6.6%	2,110	93.4%
Percent of 9th graders repeating 9th grade	170	7.5%	2,080	92.0%
School uses traditional schedule	180	8.0%	2,080	92.0%
Block schedule is less than 90 minutes	180	8.0%	2,080	92.0%
Block schedule is at least 90 minutes	180	8.0%	2,080	92.0%
Courses not offered by school available at community college	220	9.7%	2,040	90.3%
Courses not offered by school available at 4-year college	220	9.7%	2,040	90.3%
Help with postsecondary schooling is school counseling primary goal	230	10.2%	2,030	89.8%
School has counselor designated for college readiness/selection/application	240	10.6%	2,020	89.4%
Lack of teacher resources and materials is a problem at school	320	14.2%	1,940	85.8%
Number of household members	330	14.6%	1,930	85.4%
Single parent household	330	14.6%	1,930	85.4%
Family income: <= $15,000	330	14.6%	1,930	85.4%
Family income: > $15,000 and <=$35,000	330	14.6%	1,930	85.4%
Family income: > $35,000 and <=$55,000	330	14.6%	1,930	85.4%
Family income: > $55,000 and <=$75,000	330	14.6%	1,930	85.4%

Covariate	N Missing	Percent Missing	N Non-missing	Percent Non-missing
Family income: > $75,000 and <=$95,000	330	14.6%	1,930	85.4%
Family income: > $95,000 and <=$115,000	330	14.6%	1,930	85.4%
Family income: > $115,001	330	14.6%	1,930	85.4%
Parents' highest level of education: Less than BA	330	14.6%	1,930	85.4%
Parents' highest level of education: BA	330	14.6%	1,930	85.4%
Parents' highest level of education: MA or higher	330	14.6%	1,930	85.4%
Parental expectations: Less than BA	330	14.6%	1,930	85.4%
Parental expectations: BA	330	14.6%	1,930	85.4%
Parental expectations: MA	330	14.6%	1,930	85.4%
Parental expectations: Don't know	330	14.6%	1,930	85.4%
Parent occupation prestige	350	15.5%	1,900	84.1%
Parent helped 9th grader with homework: Never	410	18.1%	1,850	81.9%
Parent helped 9th grader with homework: Less than once a week	410	18.1%	1,850	81.9%
Parent helped 9th grader with homework: 1 or 2 days a week	410	18.1%	1,850	81.9%
Parent helped 9th grader with homework: 3 or more days a week	410	18.1%	1,850	81.9%
Parental aspirations: Less than BA	420	18.6%	1,840	81.4%
Parental aspirations: BA	420	18.6%	1,840	81.4%
Parental aspirations: MA or higher	420	18.6%	1,840	81.4%
Number of school-level activity types parent engaged in	430	19.0%	1,830	81.0%
Number of student-level activity types parent engaged in	440	19.5%	1,820	80.5%
Family talked with counselor/teacher about postsecondary admission	440	19.5%	1,820	80.5%
Number of non-academic extracurricular activities types 9th grader participated in	440	19.5%	1,820	80.5%
9th grader participated in academic extracurricular activities	440	19.5%	1,820	80.5%
Academic ability/wellness	450	19.9%	1,810	80.1%

Note. DE = dual enrollment. Sample sizes are rounded to the nearest tenth according to restricted-use data guidelines. Ns and percentages may not always sum up perfectly.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), Second Follow-up Restricted-Use Data File.

Appendix D: Covariate Missingness in the College Base Analytic Sample Where Treatment Is DE on a College Campus

Label	N Missing	Percent Missing	N Non-missing	Percent Not Missing
Student sex: Female	0	0.0%	1,840	100.0%
Student race: Asian	0	0.0%	1,840	100.0%
Student race: Black	0	0.0%	1,840	100.0%
Student race: Hispanic	0	0.0%	1,840	100.0%
Student race: White	0	0.0%	1,840	100.0%
Student race: Other	0	0.0%	1,840	100.0%
First language is not English	0	0.0%	1,840	100.0%
School urbanicity: City	0	0.0%	1,840	100.0%
School urbanicity: Suburb	0	0.0%	1,840	100.0%
School urbanicity: Town	0	0.0%	1,840	100.0%
School urbanicity: Rural	0	0.0%	1,840	100.0%
Travel time to the closest community college	0	0.0%	1,840	100.0%
Math standardized theta score	10	0.5%	1,830	99.5%
Student postsecondary expectations: Less than BA	10	0.5%	1,830	99.5%
Student postsecondary expectations: BA	10	0.5%	1,830	99.5%
Student postsecondary expectations: MA or higher	10	0.5%	1,830	99.5%
Student postsecondary expectations: Don’t know	10	0.5%	1,830	99.5%
Total school enrollment	20	1.1%	1,820	98.9%
Percent of student body: American Indian	20	1.1%	1,820	98.9%
Percent of student body: Asian/Pacific Islander/Hawaiian Native	20	1.1%	1,820	98.9%
Percent of student body: Hispanic	20	1.1%	1,820	98.9%
Percent of student body: Black	20	1.1%	1,820	98.9%
Percent of student body: White	20	1.1%	1,820	98.9%
Percent of student body: Unknown race or two or more races	20	1.1%	1,820	98.9%
Highest math in 8th grade: < Algebra I	20	1.1%	1,810	98.4%
Highest math in 8th grade: Algebra I	20	1.1%	1,810	98.4%
Highest math in 8th grade: > Algebra I	20	1.1%	1,810	98.4%
9th grader’s friend gets good grades	30	1.6%	1,810	98.4%
Discussions about going to college	30	1.6%	1,810	98.4%
Pupil-to-teacher ratio	30	1.6%	1,800	97.8%
Percent of student body receiving free lunch	40	2.2%	1,800	97.8%
School engagement	40	2.2%	1,800	97.8%

Label	N Missing	Percent Missing	N Non-missing	Percent Not Missing
Highest science in 8th grade: Gen Science/Gen Science 8/Science 8	40	2.2%	1,800	97.8%
Working is more important that attending college	40	2.2%	1,800	97.8%
9th grader plans to take PSAT, SAT, or ACT	40	2.2%	1,790	97.3%
Number of credits taken in 9th grade	50	2.7%	1,790	97.3%
Hours spent on extracurricular activities: Less than 1 hour	60	3.3%	1,780	96.7%
Hours spent on extracurricular activities: 1 to 2 hours	60	3.3%	1,780	96.7%
Hours spent on extracurricular activities: 2 to 3 hours	60	3.3%	1,780	96.7%
Hours spent on extracurricular activities: 3 to 4 hours	60	3.3%	1,780	96.7%
Hours spent on extracurricular activities: 4 or more hours	60	3.3%	1,780	96.7%
School belonging	60	3.3%	1,780	96.7%
9th grader plans to take AP or IB test	60	3.3%	1,780	96.7%
GPA 9th grade	90	4.9%	1,740	94.6%
School uses semester calendar	100	5.4%	1,740	94.6%
Hours spent working for pay: Less than 1 hour	100	5.4%	1,740	94.6%
Hours spent working for pay: 1 to 2 hours	100	5.4%	1,740	94.6%
Hours spent working for pay: 2 or more hours	100	5.4%	1,740	94.6%
9th grader participated in college preparation program	110	6.0%	1,720	93.5%
Percent of 9th graders repeating 9th grade	140	7.6%	1,700	92.4%
School uses traditional schedule	140	7.6%	1,700	92.4%
Block schedule is less than 90 minutes	140	7.6%	1,690	91.8%
Block schedule is at least 90 minutes	140	7.6%	1,690	91.8%
Courses not offered by school available at community college	180	9.8%	1,650	89.7%
Courses not offered by school available at 4-year college	180	9.8%	1,650	89.7%
Help with postsecondary schooling is school counseling primary goal	190	10.3%	1,640	89.1%
School has counselor designated for college readiness/selection/application	200	10.9%	1,640	89.1%
Number of household members	250	13.6%	1,590	86.4%
Single parent household	250	13.6%	1,590	86.4%
Family income: <= $15,000	250	13.6%	1,590	86.4%
Family income: > $15,000 and <=$35,000	250	13.6%	1,590	86.4%
Family income: > $35,000 and <=$55,000	250	13.6%	1,590	86.4%
Family income: > $55,000 and <=$75,000	250	13.6%	1,590	86.4%
Family income: > $75,000 and <=$95,000	250	13.6%	1,590	86.4%

Label	N Missing	Percent Missing	N Non-missing	Percent Not Missing
Family income: > $95,000 and <=$115,000	250	13.6%	1,590	86.4%
Family income: > $115,001	250	13.6%	1,590	86.4%
Parents' highest level of education: Less than BA	250	13.6%	1,590	86.4%
Parents' highest level of education: BA	250	13.6%	1,590	86.4%
Parents' highest level of education: MA or higher	250	13.6%	1,590	86.4%
Parental expectations: Less than BA	250	13.6%	1,590	86.4%
Parental expectations: BA	250	13.6%	1,590	86.4%
Parental expectations: MA	250	13.6%	1,590	86.4%
Parental expectations: Don't know	250	13.6%	1,590	86.4%
Lack of teacher resources and materials is a problem at school	250	13.6%	1,590	86.4%
Parent occupation prestige	270	14.7%	1,570	85.3%
Parent helped 9th grader with homework: Never	310	16.8%	1,530	83.2%
Parent helped 9th grader with homework: Less than once a week	310	16.8%	1,530	83.2%
Parent helped 9th grader with homework: 1 or 2 days a week	310	16.8%	1,530	83.2%
Parent helped 9th grader with homework: 3 or more days a week	310	16.8%	1,530	83.2%
Parental aspirations: Less than BA	320	17.4%	1,520	82.6%
Parental aspirations: BA	320	17.4%	1,520	82.6%
Parental aspirations: MA or higher	320	17.4%	1,520	82.6%
Number of school-level activity types parent engaged in	320	17.4%	1,520	82.6%
Number of student-level activity types parent engaged in	330	17.9%	1,510	82.1%
Family talked with counselor/teacher about postsecondary admission	330	17.9%	1,510	82.1%
Number of non-academic extracurricular activities types 9th grader participated in	330	17.9%	1,500	81.5%
9th grader participated in academic extracurricular activities	330	17.9%	1,500	81.5%
Wellness	340	18.5%	1,500	81.5%

Note. DE = dual enrollment. Sample sizes are rounded to the nearest tenth according to restricted-use data guidelines. Ns and percentages may not always sum up perfectly.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), Second Follow-up Restricted-Use Data File.

Appendix E: Results of the Doubly Robust Estimation Models

Where Treatment Is DE on a College Campus

VARIABLES	FAFSA completion	Number of college applications	Postsecondary enrollment, immediately after high school	Postsecondary enrollment, 3 years after high school
TREATMENT				
Took DE on a college campus	-0.139	0.048	0.001	-0.268
	(0.207)	(0.052)	(0.283)	(0.382)
STUDENT COVARIATES				
Demographics				
Sex				
Student sex: Female	0.386*	0.136**	0.451*	0.629*
	(0.226)	(0.060)	(0.271)	(0.356)
Race				
Student race: Asian	0.943*	0.169	-1.127*	-0.831
	(0.488)	(0.142)	(0.607)	(1.205)
Student race: Black	1.242***	0.169	1.315**	0.808
	(0.438)	(0.126)	(0.566)	(0.609)
Student race: Hispanic	1.110***	0.062	0.313	1.628***
	(0.368)	(0.090)	(0.455)	(0.626)
Student race: Other	0.749*	0.079	-0.085	0.035
	(0.388)	(0.094)	(0.426)	(0.510)
Family characteristics				
Language				
First language is not English	-0.660	0.166	1.220**	-0.153
	(0.407)	(0.104)	(0.565)	(0.645)
Family structure				
Number of household members	0.142	0.031	0.620	-0.995*
	(0.377)	(0.095)	(0.402)	(0.562)

VARIABLES	FAFSA completion	Number of college applications	Postsecondary enrollment, immediately after high school	Postsecondary enrollment, 3 years after high school
Number of household members: Square term	-0.011	0.002	-0.063*	0.081
	(0.034)	(0.009)	(0.036)	(0.050)
Single parent household	-0.270	0.049	-0.013	0.680
	(0.369)	(0.094)	(0.408)	(0.540)
SES				
Family income: > $15,000 and <=$35,000	-0.036	-0.084	-0.089	-0.256
	(0.485)	(0.131)	(0.502)	(0.583)
Family income: > $35,000 and <=$55,000	0.280	-0.006	-0.103	1.573**
	(0.516)	(0.133)	(0.516)	(0.674)
Family income: > $55,000 and <=$75,000	-0.676	-0.145	-0.456	-0.063
	(0.576)	(0.137)	(0.609)	(0.747)
Family income: > $75,000 and <=$95,000	-0.456	-0.013	0.070	0.722
	(0.586)	(0.149)	(0.650)	(0.923)
Family income: > $95,000 and <=$115,000	-1.017	-0.086	-0.763	0.463
	(0.699)	(0.165)	(0.712)	(1.017)
Family income: > $115,001	-1.543***	0.148	0.427	0.125
	(0.556)	(0.152)	(0.751)	(1.009)
Parents' highest level of education: BA	-0.022	-0.044	0.443	0.007
	(0.310)	(0.078)	(0.396)	(0.517)
Parents' highest level of education: MA or higher	0.255	0.086	0.796	0.916
	(0.370)	(0.092)	(0.546)	(0.864)
Parent occupation prestige	-0.010	0.001	-0.004	0.011
	(0.008)	(0.002)	(0.009)	(0.011)
Parental aspirations and expectations				
Parental aspirations: Bachelor's degree	1.038	0.187	0.033	2.203**
	(0.756)	(0.285)	(0.890)	(1.050)
Parental aspirations: MA or higher	0.587	0.208	-0.419	1.379
	(0.723)	(0.290)	(0.744)	(0.902)
Parental expectations: BA	0.042	0.197	-0.232	0.155

VARIABLES	FAFSA completion	Number of college applications	Postsecondary enrollment, immediately after high school	Postsecondary enrollment, 3 years after high school
	(0.487)	(0.173)	(0.547)	(0.673)
Parental expectations: MA or higher	0.540	0.411**	-0.061	-0.515
	(0.513)	(0.175)	(0.538)	(0.697)
Parental expectations: Don't know	0.410	0.413**	-0.271	-0.477
	(0.585)	(0.188)	(0.683)	(0.742)
Parental involvement				
Parent helped 9th grader with homework: Less than once a week	0.112	-0.060	0.534	-0.012
	(0.318)	(0.079)	(0.487)	(0.578)
Parent helped 9th grader with homework: 1 or 2 days a week	0.108	-0.070	0.253	-0.699
	(0.328)	(0.088)	(0.498)	(0.578)
Parent helped 9th grader with homework: 3 or more days a week	0.400	0.115	0.410	-0.076
	(0.399)	(0.102)	(0.589)	(0.656)
Family talked with counselor/teacher about postsecondary admission requirements	-0.067	-0.042	-0.008	-0.011
	(0.266)	(0.071)	(0.370)	(0.430)
Number of school-level activity types parent engaged in	0.084	0.044**	0.163	0.087
	(0.081)	(0.019)	(0.111)	(0.118)
Number of student-level activity types parent engaged in	-0.000	0.007	-0.055	-0.017
	(0.079)	(0.019)	(0.111)	(0.123)
Academic engagement, preparation, and achievement				
Academic engagement				
School belonging	-0.078	-0.061*	-0.029	0.003
	(0.129)	(0.033)	(0.162)	(0.183)
School engagement	0.151	-0.007	-0.075	0.276
	(0.125)	(0.034)	(0.154)	(0.169)
Academic ability/wellness	0.031	-0.026	-0.182	0.108
	(0.162)	(0.043)	(0.182)	(0.253)
Academic preparation				
Highest math in 8th grade: Algebra I	0.190	-0.117*	0.340	-0.248

VARIABLES	FAFSA completion	Number of college applications	Postsecondary enrollment, immediately after high school	Postsecondary enrollment, 3 years after high school
	(0.259)	(0.066)	(0.348)	(0.382)
Highest math in 8th grade: Higher than Algebra I	-0.424	0.033	-0.083	0.329
	(0.379)	(0.099)	(0.469)	(0.643)
Highest science taken in 8th grade: Gen Science/Gen Science 8 or Science 8	-0.205	0.001	-0.019	-0.183
	(0.230)	(0.061)	(0.310)	(0.396)
Number of credits taken in 9th grade	-0.569**	-0.047	0.003	-0.206
	(0.232)	(0.076)	(0.285)	(0.404)
Number of credits taken in 9th grade: Square term	0.035*	0.002	-0.012	0.002
	(0.018)	(0.005)	(0.024)	(0.032)
Academic achievement				
GPA 9th grade	0.637	0.349	-1.605	-1.342
	(0.976)	(0.321)	(1.055)	(1.275)
GPA 9th grade: Square term	0.137	0.005	0.600***	0.562**
	(0.182)	(0.056)	(0.209)	(0.262)
Mathematics standardized theta score	0.242***	-0.039	-0.066	0.087
	(0.086)	(0.026)	(0.111)	(0.120)
Mathematics standardized theta score: Square term	-0.002***	0.000*	0.001	-0.000
	(0.001)	(0.000)	(0.001)	(0.001)
Educational aspirations				
Orientation towards college				
9th grader plans to take PSAT, SAT, or ACT	0.085	0.057	0.502	0.278
	(0.300)	(0.085)	(0.362)	(0.392)
9th grader plans to take AP or IB test	0.275	0.137**	-0.002	0.742*
	(0.265)	(0.063)	(0.321)	(0.398)
9th grader participated in college prep program	0.410	0.337***	-0.193	-0.378
	(0.335)	(0.085)	(0.350)	(0.472)
Working is more important that attending college	-0.165	-0.025	-0.045	-0.607
	(0.372)	(0.133)	(0.429)	(0.568)
Postsecondary expectations				

VARIABLES	FAFSA completion	Number of college applications	Postsecondary enrollment, immediately after high school	Postsecondary enrollment, 3 years after high school
Student postsecondary expectations: BA	0.440	0.261**	0.450	0.372
	(0.396)	(0.121)	(0.459)	(0.617)
Student postsecondary expectations: MA or higher	-0.267	0.209*	0.391	0.081
	(0.351)	(0.116)	(0.423)	(0.538)
Student postsecondary expectations: Don't know	0.519	0.181	0.611	0.470
	(0.387)	(0.128)	(0.471)	(0.610)
Social influence				
Discussions about going to college	-0.010	0.029	-0.034	0.158
	(0.094)	(0.024)	(0.113)	(0.135)
9th grader's friend gets good grades	0.436	-0.118	0.684*	0.726
	(0.382)	(0.106)	(0.380)	(0.467)
Extracurriculars				
Number of non-academic extracurricular activities types 9th grader participated	0.168	0.006	-0.177	-0.003
	(0.133)	(0.032)	(0.177)	(0.206)
9th grader participated in academic extracurricular activities	0.504	0.046	1.205**	1.062
	(0.328)	(0.072)	(0.471)	(0.729)
Hours spent on extracurricular activities: 1 to 2	0.516	0.020	-0.081	0.614
	(0.320)	(0.097)	(0.371)	(0.477)
Hours spent on extracurricular activities: 2 to 3	-0.185	0.134	0.436	0.747
	(0.312)	(0.092)	(0.454)	(0.555)
Hours spent on extracurricular activities: 3 to 4	0.709*	0.284***	0.942*	0.192
	(0.393)	(0.094)	(0.507)	(0.612)
Hours spent on extracurricular activities: 4 or more	0.502	0.063	0.375	0.262
	(0.391)	(0.105)	(0.458)	(0.583)
Hours spent working for pay: 1 to 2	0.027	0.036	-0.328	0.099
	(0.384)	(0.092)	(0.454)	(0.540)
Hours spent working for pay: 2 or more	-0.013	-0.161	-0.553	-0.451
	(0.398)	(0.101)	(0.456)	(0.507)

VARIABLES	FAFSA completion	Number of college applications	Postsecondary enrollment, immediately after high school	Postsecondary enrollment, 3 years after high school
SCHOOL COVARIATES				
Demographics				
Size				
Total school enrollment	-0.001**	-0.000	-0.001	-0.000
	(0.001)	(0.000)	(0.001)	(0.001)
Total school enrollment: Square term	0.000**	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Racial composition				
Percent of student body: American Indian	-0.007	0.011***	0.208	-0.037
	(0.017)	(0.003)	(0.165)	(0.027)
Percent of student body: Asian/Pacific Islander/Hawaiian Native	0.051***	0.002	0.075**	-0.001
	(0.018)	(0.004)	(0.029)	(0.024)
Percent of student body: Hispanic	0.009	0.001	0.014	0.002
	(0.010)	(0.002)	(0.013)	(0.015)
Percent of student body: Black	-0.008	0.007***	-0.002	-0.004
	(0.009)	(0.002)	(0.012)	(0.013)
Percent of student body: Unknown race or two or more races	-0.039	-0.026	-0.059	-0.010
	(0.039)	(0.019)	(0.054)	(0.074)
Resources				
Percent of student body receiving free lunch	-0.004	-0.002	-0.017	-0.027*
	(0.010)	(0.002)	(0.012)	(0.015)
Pupil-to-teacher ratio	-0.013	-0.000	0.050	-0.077
	(0.022)	(0.003)	(0.056)	(0.055)
Lack of teacher resources and materials is a problem at school	0.140	-0.010	-0.265	-0.030
	(0.189)	(0.050)	(0.232)	(0.311)
Courses not offered by school available at community college	0.649*	-0.043	0.199	1.181**
	(0.355)	(0.083)	(0.388)	(0.561)
Courses not offered by school available at 4-year college	0.245	0.084	0.060	-0.069
	(0.280)	(0.068)	(0.352)	(0.491)

VARIABLES	FAFSA completion	Number of college applications	Postsecondary enrollment, immediately after high school	Postsecondary enrollment, 3 years after high school
College-going culture				
Help with postsecondary schooling is school counseling program's primary goal	0.545**	0.098*	0.049	-0.239
	(0.254)	(0.054)	(0.276)	(0.334)
School has counselor designated for college readiness/selection/application	-0.082	-0.061	0.010	-0.144
	(0.259)	(0.062)	(0.319)	(0.379)
Percent of 9th graders repeating 9th grade	0.029	0.007*	0.016	0.059*
	(0.022)	(0.004)	(0.025)	(0.035)
Schedule				
Block schedule is less than 90 minutes	-0.044	-0.039	0.148	0.466
	(0.542)	(0.101)	(0.604)	(0.676)
Block schedule is at least 90 minutes	-0.116	-0.000	-0.065	0.571
	(0.281)	(0.076)	(0.351)	(0.441)
School uses semester calendar	0.013	-0.066	-0.095	0.451
	(0.322)	(0.070)	(0.393)	(0.464)
Geography				
School urbanicity: City	0.096	0.095	-0.870**	-0.319
	(0.337)	(0.080)	(0.429)	(0.549)
School urbanicity: Suburb	-0.296	0.151*	-0.356	-0.710
	(0.327)	(0.083)	(0.433)	(0.544)
School urbanicity: Town	-0.324	-0.113	-0.266	-0.418
	(0.401)	(0.089)	(0.483)	(0.616)
Travel time to the closest two-year institution	0.008	-0.002**	-0.014***	0.006
	(0.005)	(0.001)	(0.005)	(0.007)
STATES				
Arizona	0.765	0.067	-0.654	1.110
	(0.860)	(0.250)	(1.251)	(1.374)
Arkansas	-0.403	0.251	-1.116	$-^{a}$
	(1.121)	(0.353)	(1.371)	

VARIABLES	FAFSA completion	Number of college applications	Postsecondary enrollment, immediately after high school	Postsecondary enrollment, 3 years after high school
California	-0.351	0.573**	-0.395	1.430
	(0.887)	(0.250)	(1.308)	(1.398)
Colorado	-0.776	0.262	-0.984	1.296
	(0.849)	(0.282)	(1.258)	(1.552)
Florida	0.801	0.303	1.370	1.205
	(0.858)	(0.235)	(1.080)	(1.322)
Georgia	0.888	0.312	-0.613	0.454
	(0.824)	(0.271)	(1.018)	(1.245)
Illinois	1.274*	0.426*	-0.527	-0.277
	(0.770)	(0.222)	(0.972)	(1.130)
Indiana	1.915**	0.447	0.011	0.963
	(0.941)	(0.295)	(1.100)	(1.455)
Iowa	0.885	-0.305	0.125	0.313
	(1.198)	(0.347)	(1.909)	(1.766)
Kansas	0.328	-0.011	1.414	$-^{a}$
	(1.173)	(0.284)	(2.007)	
Kentucky	1.727*	0.330	-0.155	1.584
	(1.031)	(0.282)	(1.286)	(1.727)
Louisiana	-0.172	-0.684*	-1.838	-0.762
	(1.112)	(0.401)	(1.280)	(1.826)
Maryland	0.526	0.199	1.075	-0.190
	(1.674)	(0.297)	(1.211)	(1.363)
Massachusetts	1.221	0.794**	-1.086	-0.920
	(1.346)	(0.341)	(1.426)	(2.027)
Michigan	0.974	0.196	0.861	2.369*
	(0.812)	(0.236)	(1.042)	(1.337)
Minnesota	0.881	0.076	1.124	0.669
	(0.901)	(0.286)	(1.128)	(1.375)
Missouri	1.032	0.023	-0.055	4.639**

VARIABLES	FAFSA completion	Number of college applications	Postsecondary enrollment, immediately after high school	Postsecondary enrollment, 3 years after high school
	(0.927)	(0.261)	(1.233)	(2.324)
New Hampshire	0.373	0.514	-0.740	0.961
	(1.218)	(0.347)	(1.390)	(1.848)
New Jersey	0.240	0.332	2.658*	4.007**
	(0.997)	(0.272)	(1.447)	(2.015)
New York	1.143	0.027	-1.240	2.010
	(0.866)	(0.316)	(1.225)	(1.650)
North Carolina	1.444*	0.247	2.028*	-0.690
	(0.813)	(0.251)	(1.141)	(1.312)
Ohio	1.359	0.309	0.681	1.642
	(0.864)	(0.259)	(1.052)	(1.411)
Oklahoma	0.183	0.286	$-^{a}$	2.085
	(1.724)	(0.342)		(1.967)
Oregon	-0.129	0.315	-1.740	0.300
	(1.277)	(0.287)	(1.405)	(1.685)
Pennsylvania	0.815	0.360	0.837	2.382
	(0.859)	(0.250)	(1.130)	(1.479)
South Carolina	2.321*	-0.038	0.193	1.677
	(1.202)	(0.271)	(1.169)	(1.492)
Tennessee	0.784	-0.104	-0.441	-0.578
	(0.840)	(0.268)	(1.068)	(1.569)
Texas	0.396	-0.046	-0.003	0.432
	(0.758)	(0.236)	(1.066)	(1.259)
Virginia	-0.483	0.058	-1.199	-0.299
	(0.935)	(0.268)	(1.214)	(1.341)
Washington	-0.475	-0.132	-1.134	-0.087
	(0.760)	(0.243)	(1.150)	(1.440)
West Virginia	-0.027	-0.141	-1.606	0.060
	(1.216)	(0.404)	(1.398)	(1.963)

VARIABLES	FAFSA completion	Number of college applications	Postsecondary enrollment, immediately after high school	Postsecondary enrollment, 3 years after high school
Constant	-9.352***	-0.541	1.125	-3.123
	(3.208)	(0.914)	(3.884)	(4.258)

Note. DE = dual enrollment. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1
$-^{a}$ designates states excluded from the model due to lack of treatment or outcome variation.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), Second Follow-up Restricted-Use Data File.

Appendix F: Results of the Doubly Robust Estimation Models

Where Treatment Is DE Exclusively on a College Campus

VARIABLES	FAFSA completion	Number of college applications	Postsecondary enrollment, immediately after high school	Postsecondary enrollment, 3 years after high school
TREATMENT				
Took DE exclusively on a college campus	0.091	0.089	0.416	0.561
	(0.271)	(0.058)	(0.352)	(0.397)
STUDENT COVARIATES				
Demographics				
Sex				
Student sex: Female	0.188	0.129*	0.103	-0.487
	(0.271)	(0.070)	(0.342)	(0.450)
Race				
Student race: Asian	-0.383	-0.133	0.621	-0.345
	(0.679)	(0.177)	(1.018)	(1.039)
Student race: Black	1.570***	0.251*	1.144	0.689
	(0.575)	(0.147)	(0.729)	(0.751)
Student race: Hispanic	1.080**	-0.053	0.394	2.139**
	(0.447)	(0.103)	(0.534)	(1.004)
Student race: Other	0.373	0.140	-0.641	0.500
	(0.477)	(0.106)	(0.579)	(0.735)
Family characteristics				
Language				
First language is not English	-1.031	0.074	1.157	-1.187
	(0.720)	(0.140)	(0.841)	(0.803)
Family structure				
Number of household members	0.467	0.021	0.241	-1.345*
	(0.443)	(0.120)	(0.490)	(0.706)

VARIABLES	FAFSA completion	Number of college applications	Postsecondary enrollment, immediately after high school	Postsecondary enrollment, 3 years after high school
Number of household members: Square term	-0.038	0.001	-0.036	0.097
	(0.038)	(0.011)	(0.042)	(0.061)
Single parent household	-0.797*	0.021	-1.303**	-0.784
	(0.431)	(0.105)	(0.533)	(0.787)
SES				
Family income: > $15,000 and <=$35,000	-0.071	-0.228	-0.545	0.152
	(0.796)	(0.159)	(0.684)	(0.851)
Family income: > $35,000 and <=$55,000	-0.228	-0.240	-0.803	1.961**
	(0.765)	(0.155)	(0.720)	(0.852)
Family income: > $55,000 and <=$75,000	-1.372*	-0.483***	-1.679**	-0.575
	(0.814)	(0.174)	(0.806)	(0.978)
Family income: > $75,000 and <=$95,000	-1.950**	-0.295*	-1.824**	0.089
	(0.823)	(0.171)	(0.877)	(1.106)
Family income: > $95,000 and <=$115,000	-1.379	-0.227	-1.256	1.215
	(0.964)	(0.188)	(0.939)	(1.154)
Family income: > $115,001	-2.691***	-0.034	-1.202	-0.483
	(0.860)	(0.190)	(0.929)	(1.144)
Parents' highest level of education: BA	0.641	-0.085	1.609***	-0.276
	(0.396)	(0.097)	(0.535)	(0.681)
Parents' highest level of education: MA or higher	0.264	0.107	0.974	0.281
	(0.469)	(0.112)	(0.676)	(0.941)
Parent occupation prestige	-0.008	0.001	-0.013	0.020
	(0.008)	(0.002)	(0.011)	(0.014)
Parental aspirations and expectations				
Parental aspirations: Bachelor's degree	1.068	0.250	0.842	2.143
	(0.917)	(0.334)	(1.036)	(1.356)
Parental aspirations: Master's degree or higher	0.409	0.203	0.055	1.039
	(0.847)	(0.338)	(0.880)	(1.109)
Parental expectations: Bachelor's degree	0.158	0.173	0.196	0.507

VARIABLES	FAFSA completion	Number of college applications	Postsecondary enrollment, immediately after high school	Postsecondary enrollment, 3 years after high school
	(0.687)	(0.220)	(0.645)	(0.963)
Parental expectations: Master's degree or higher	0.963	0.516**	0.515	0.398
	(0.716)	(0.225)	(0.687)	(0.940)
Parental expectations: Don't know	-0.381	0.401*	-1.351	-0.783
	(0.773)	(0.241)	(0.885)	(1.108)
Parental involvement				
Parent helped 9th grader with homework: Less than once a week	-0.083	-0.004	0.388	-0.168
	(0.413)	(0.095)	(0.575)	(0.695)
Parent helped 9th grader with homework: 1 or 2 days a week	0.062	-0.091	0.127	-0.604
	(0.438)	(0.112)	(0.514)	(0.738)
Parent helped 9th grader with homework: 3 or more days a week	0.359	0.222*	0.116	0.145
	(0.530)	(0.121)	(0.686)	(0.935)
Family talked with counselor/teacher about postsecondary admission requirements	-0.398	-0.050	-0.287	-0.679
	(0.358)	(0.087)	(0.476)	(0.527)
Number of school-level activity types parent engaged in	-0.014	0.062***	0.110	0.129
	(0.109)	(0.023)	(0.135)	(0.173)
Number of student-level activity types parent engaged in	0.087	0.003	-0.107	-0.017
	(0.102)	(0.023)	(0.137)	(0.164)
Academic engagement, preparation, and achievement				
Academic engagement				
School belonging	-0.059	-0.092**	-0.271	-0.059
	(0.167)	(0.040)	(0.210)	(0.282)
School engagement	0.495***	0.028	0.210	0.640***
	(0.158)	(0.040)	(0.204)	(0.244)
Academic ability/wellness	0.080	0.009	-0.251	0.268
	(0.186)	(0.060)	(0.208)	(0.279)
Academic preparation				
Highest math in 8th grade: Algebra I	-0.179	-0.230***	0.264	-0.564

VARIABLES	FAFSA completion	Number of college applications	Postsecondary enrollment, immediately after high school	Postsecondary enrollment, 3 years after high school
	(0.318)	(0.078)	(0.433)	(0.546)
Highest math in 8th grade: Higher than Algebra I	-1.367***	-0.077	-1.160*	-0.743
	(0.453)	(0.121)	(0.608)	(0.881)
Highest science taken in 8th grade: Gen Science/Gen Science 8 or Science 8	-0.532*	-0.051	-0.342	-0.063
	(0.289)	(0.073)	(0.354)	(0.462)
Number of credits taken in 9th grade	-0.434	-0.049	-0.104	-1.466**
	(0.268)	(0.080)	(0.368)	(0.670)
Number of credits taken in 9th grade: Square term	0.017	0.002	-0.008	0.066
	(0.018)	(0.005)	(0.029)	(0.043)
Academic achievement				
GPA 9th grade	1.692	0.347	-1.224	2.970
	(1.277)	(0.401)	(1.533)	(1.808)
GPA 9th grade: Square term	-0.083	0.011	0.513*	-0.165
	(0.240)	(0.071)	(0.301)	(0.341)
Mathematics standardized theta score	0.109	-0.024	-0.191	0.171
	(0.141)	(0.031)	(0.149)	(0.173)
Mathematics standardized theta score: Square term	-0.001	0.000	0.002	-0.002
	(0.001)	(0.000)	(0.001)	(0.002)
Educational aspirations				
Orientation towards college				
9th grader plans to take PSAT, SAT, or ACT	0.457	0.051	0.637	0.391
	(0.424)	(0.095)	(0.497)	(0.589)
9th grader plans to take AP or IB test	0.560*	0.168**	-0.238	0.437
	(0.320)	(0.070)	(0.391)	(0.471)
9th grader participated in college prep program	0.503	0.390***	0.717	-0.709
	(0.538)	(0.114)	(0.851)	(0.652)
Working is more important that attending college	0.273	0.156	-0.100	-0.025
	(0.475)	(0.168)	(0.579)	(0.766)
Postsecondary expectations				

VARIABLES	FAFSA completion	Number of college applications	Postsecondary enrollment, immediately after high school	Postsecondary enrollment, 3 years after high school
Student postsecondary expectations: BA	0.894	0.423***	0.886	1.712**
	(0.553)	(0.157)	(0.643)	(0.778)
Student postsecondary expectations: MA or higher	0.495	0.220	1.072*	1.864**
	(0.476)	(0.151)	(0.566)	(0.734)
Student postsecondary expectations: Don't know	1.309**	0.351**	0.882	1.754**
	(0.531)	(0.164)	(0.619)	(0.811)
Social influence				
Discussions about going to college	-0.080	0.001	0.066	0.125
	(0.118)	(0.029)	(0.132)	(0.173)
9th grader's friend gets good grades	-0.494	-0.412***	0.472	0.349
	(0.696)	(0.140)	(0.701)	(0.832)
Extracurriculars				
Number of non-academic extracurricular activities types 9th grader participated	0.259	-0.017	-0.137	0.469*
	(0.165)	(0.043)	(0.219)	(0.247)
9th grader participated in academic extracurricular activities	-0.115	0.029	0.942	0.117
	(0.397)	(0.097)	(0.601)	(0.695)
Hours spent on extracurricular activities: 1 to 2	0.796**	0.085	-0.106	0.265
	(0.392)	(0.109)	(0.469)	(0.603)
Hours spent on extracurricular activities: 2 to 3	0.667*	0.176*	0.215	-0.050
	(0.373)	(0.099)	(0.499)	(0.735)
Hours spent on extracurricular activities: 3 to 4	1.109**	0.409***	1.005*	-1.178*
	(0.469)	(0.104)	(0.566)	(0.680)
Hours spent on extracurricular activities: 4 or more	1.309**	0.128	-0.027	-0.542
	(0.552)	(0.118)	(0.758)	(0.809)
Hours spent working for pay: 1 to 2	0.246	0.039	-0.878*	-0.391
	(0.466)	(0.110)	(0.508)	(0.738)
Hours spent working for pay: 2 or more	0.271	-0.111	0.268	-0.628
	(0.512)	(0.117)	(0.595)	(0.586)

VARIABLES	FAFSA completion	Number of college applications	Postsecondary enrollment, immediately after high school	Postsecondary enrollment, 3 years after high school
SCHOOL COVARIATES				
Demographics				
Size				
Total school enrollment	-0.000	-0.000	-0.000	-0.002
	(0.001)	(0.000)	(0.001)	(0.002)
Total school enrollment: Square term	0.000	0.000	0.000	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)
Racial composition				
Percent of student body: American Indian	-0.019	0.010***	0.433	-0.007
	(0.020)	(0.003)	(0.312)	(0.039)
Percent of student body: Asian/Pacific Islander/Hawaiian Native	0.099***	0.005	0.148***	-0.012
	(0.030)	(0.005)	(0.054)	(0.030)
Percent of student body: Hispanic	-0.009	-0.003	0.041*	0.041
	(0.015)	(0.003)	(0.022)	(0.032)
Percent of student body: Black	-0.025**	0.003	-0.022	-0.011
	(0.012)	(0.003)	(0.016)	(0.021)
Percent of student body: Unknown race or two or more races	-0.089	-0.025	-0.140	-0.089
	(0.090)	(0.021)	(0.118)	(0.101)
Resources				
Percent of student body receiving free lunch	0.053***	0.001	0.002	-0.015
	(0.013)	(0.003)	(0.020)	(0.022)
Pupil-to-teacher ratio	0.005	-0.001	0.100	-0.092
	(0.012)	(0.005)	(0.090)	(0.091)
Lack of teacher resources and materials is a problem at school	0.197	0.003	-0.521*	-0.037
	(0.257)	(0.058)	(0.311)	(0.412)
Courses not offered by school available at community college	1.207***	-0.018	0.773	1.398*
	(0.433)	(0.101)	(0.536)	(0.759)
Courses not offered by school available at 4-year college	0.672**	0.198**	-0.552	-0.312

VARIABLES	FAFSA completion	Number of college applications	Postsecondary enrollment, immediately after high school	Postsecondary enrollment, 3 years after high school
	(0.338)	(0.086)	(0.458)	(0.632)
College-going culture				
Help with postsecondary schooling is school counseling program's primary goal	0.646**	0.044	0.271	0.129
	(0.303)	(0.066)	(0.380)	(0.470)
School has counselor designated for college readiness/selection/application	-0.036	-0.036	0.133	-0.177
	(0.337)	(0.078)	(0.379)	(0.525)
Percent of 9th graders repeating 9th grade	-0.007	0.005	-0.002	0.087*
	(0.023)	(0.004)	(0.035)	(0.050)
Schedule				
Block schedule is less than 90 minutes	-0.236	-0.033	0.656	0.563
	(0.660)	(0.113)	(0.872)	(1.061)
Block schedule is at least 90 minutes	-0.461	0.130	-0.770	0.223
	(0.395)	(0.098)	(0.541)	(0.585)
School uses semester calendar	0.037	0.006	-0.059	0.297
	(0.382)	(0.088)	(0.459)	(0.549)
Geography				
School urbanicity: City	-0.789*	0.002	-0.760	-0.054
	(0.448)	(0.099)	(0.596)	(0.799)
School urbanicity: Suburb	-0.712*	0.167*	0.013	-0.560
	(0.410)	(0.095)	(0.578)	(0.789)
School urbanicity: Town	0.078	-0.115	-0.277	-0.022
	(0.490)	(0.102)	(0.574)	(0.766)
Travel time to the closest two-year institution	0.001	-0.001	-0.015**	-0.002
	(0.005)	(0.001)	(0.007)	(0.010)
STATES				
Arizona	0.930	-0.038	-4.363**	-2.785
	(1.084)	(0.259)	(1.784)	(1.970)
Arkansas	-1.661	0.619	-3.602*	–[a]
	(1.288)	(0.575)	(2.064)	

VARIABLES	FAFSA completion	Number of college applications	Postsecondary enrollment, immediately after high school	Postsecondary enrollment, 3 years after high school
California	-1.093	0.723***	-3.595**	-0.347
	(0.965)	(0.255)	(1.664)	(1.984)
Colorado	-0.757	-0.292	-2.955	-0.163
	(1.017)	(0.391)	(2.188)	(2.205)
Florida	2.141**	0.166	-0.441	0.769
	(0.995)	(0.252)	(1.527)	(1.660)
Georgia	0.944	0.161	-1.015	0.422
	(0.917)	(0.282)	(1.451)	(1.663)
Illinois	0.988	0.382	-1.723	-0.061
	(0.827)	(0.239)	(1.420)	(1.440)
Indiana	0.976	0.425	-1.241	-0.561
	(1.435)	(0.329)	(1.434)	(1.935)
Louisiana	1.035	-0.446	-0.731	–[a]
	(1.448)	(0.328)	(1.921)	
Maryland	1.371	0.310	-1.786	-2.462
	(1.464)	(0.359)	(1.939)	(1.775)
Massachusetts	1.068	0.856**	-3.270*	-1.985
	(1.375)	(0.348)	(1.766)	(2.180)
Michigan	-0.654	0.091	-1.499	0.685
	(0.892)	(0.263)	(1.524)	(1.657)
Minnesota	0.162	0.197	-0.761	-1.018
	(0.989)	(0.289)	(1.623)	(1.587)
Missouri	0.973	-0.072	0.506	–[a]
	(1.128)	(0.294)	(1.835)	
New Jersey	0.031	0.599**	1.626	2.010
	(1.189)	(0.284)	(2.044)	(2.394)
New York	1.518	-0.482	-2.343	–[a]
	(1.101)	(0.430)	(1.768)	
North Carolina	1.741*	0.478	0.675	-1.105

VARIABLES	FAFSA completion	Number of college applications	Postsecondary enrollment, immediately after high school	Postsecondary enrollment, 3 years after high school
	(1.017)	(0.310)	(1.561)	(1.849)
Ohio	0.928	0.363	-0.629	1.071
	(1.045)	(0.302)	(1.511)	(2.242)
Oklahoma	3.760*	0.897**	$-^{a}$	1.380
	(2.175)	(0.421)		(2.676)
Oregon	-1.377	0.437	-4.602***	-1.122
	(1.197)	(0.284)	(1.694)	(2.006)
Pennsylvania	0.964	0.461*	-1.062	1.565
	(0.995)	(0.272)	(1.513)	(1.578)
South Carolina	1.529	-0.115	0.571	2.215
	(1.121)	(0.299)	(1.622)	(1.981)
Tennessee	-0.205	-0.300	-2.500*	-2.301
	(0.948)	(0.313)	(1.388)	(1.484)
Texas	0.667	0.216	-3.071*	-1.222
	(0.911)	(0.271)	(1.600)	(1.786)
Virginia	0.579	0.031	-3.931**	-1.880
	(1.144)	(0.278)	(1.543)	(1.619)
Washington	-0.921	-0.152	-4.114**	-1.836
	(0.862)	(0.247)	(1.623)	(1.818)
West Virginia	0.016	0.072	-3.151*	-2.375
	(1.367)	(0.385)	(1.691)	(1.931)
Constant	-9.730**	-1.056	6.896	-2.016
	(4.470)	(1.088)	(5.224)	(6.125)

Note. DE = dual enrollment. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

$-^{a}$ designates states excluded from the model due to lack of treatment or outcome variation.

SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), Second Follow-up Restricted-Use Data File.