Institutional Moderators of the Relationship between College Remediation and Degree Attainment

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INSTITUTIONAL MODERATORS OF THE RELATIONSHIP BETWEEN COLLEGE REMEDIATION AND DEGREE ATTAINMENT

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INSTITUTIONAL MODERATORS OF THE RELATIONSHIP BETWEEN COLLEGE REMEDIATION AND DEGREE ATTAINMENT

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Students who take postsecondary remedial courses graduate from college at lower rates than other students (Adelman, 2006), but the relationship between remedial education and college outcomes is not well understood. This study analyzes the association between remediation and the odds of degree attainment in two- and four-year colleges, after controlling for other student and institutional factors related to persistence. Using generalized multilevel mixed modeling, it examines variation in these relationships across institutional contexts. Data are drawn from the Beginning Postsecondary Students Longitudinal Study (2004/2009), a nationally representative sample that tracked students through interviews and transcript data for six years from their first enrollment. Additional institutional variables are incorporated from the Integrated Postsecondary Education Data System (IPEDS). Comparisons are made among remedial course subjects, higher and lower numbers of remedial courses taken, and different postsecondary credentials.

For students who first enroll at a four-year college, this analysis finds that remediation has a negative association with completing a Bachelor's degree or higher, particularly among students who take remedial Mathematics or three or more remedial classes. While students at two-year institutions who take three or more remedial courses have lower odds of completing a certificate or Bachelor's degree, English as a Second Language emerges as a positive factor for Bachelor's attainment in this population. By contrast, remediation has a positive relationship with Associate's degree attainment for two-year college students. This relationship varies significantly across two-year institutions, but institutional factors are not predictive of the variation. No other significant cross-college variation is found in the relationships between remedial variables and outcomes.

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CHAPTER 1. INTRODUCTION

A postsecondary degree has become a prerequisite for middle-class employment, yet the majority of Americans do not graduate from college. Although most high school students start with college expectations, many exit the track to higher education at various points along the way, from dropping out of secondary school, to graduating but not applying to college, to enrolling but dropping out of college without a degree. Among those who make it as far as enrolling in a postsecondary program, inadequate academic skills land many in remedial education. These basic skills courses, sometimes referred to as developmental or compensatory education, are intended to help students continue in their quest for a higher education credential. For some, they instead present an insurmountable obstacle. Because a high proportion of students enter college through the gate of remediation, educators and policymakers need to understand how it affects students' college paths. This dissertation study explores how outcomes for students taking remedial courses differ across different types of colleges, and how institutional factors interact with participation in remediation in relation to those differences. Further, it analyzes variation in the relationship between participation in remediation and college completion across students who take different remedial course subjects and levels. As a correlational study, it does not attempt to evaluate causal relationships among these factors.

This chapter begins with the larger context of college access and persistence. It discusses why low degree attainment rates are a problem for economic as well as equity reasons; outlines factors related to college completion, and situates remediation among those factors; summarizes findings about the relationship between college remediation and degree attainment; and highlights gaps in the existing research literature. Next, the chapter reviews the research questions and design for this dissertation study, including the methodology and data sources. It concludes with a discussion of the significance of the study.

The Challenge of Low Degree Attainment Rates

Remediation matters because it is one of the many factors implicated in low college graduation rates, particularly among lower-income, first generation, minority, and other nontraditional students. Although about 80% of high school graduates enroll in college within two years, many of them never earn a postsecondary credential (National Center for Education Statistics, 2006). In fact, only 27% of all U.S.-born residents earn a Bachelor's degree by age 25 (M. J. Bailey & Dynarski, 2011). Among those who do enroll, graduation rates have stagnated over the past twenty years. According to Census Bureau cross-sectional data, the four-year degree completion rate has hovered around 50% for adults aged 25-29, while the two-year degree completion rate has stayed near 15% (Mortenson, 2012). A recent national longitudinal study corroborates the Census statistics; only 49% of those who enrolled in college in 2003-2004 succeeded in earning a certificate or degree within six years (Ross et al., 2012). Although these rates are on par with the country's peers in the Organisation for Economic Co-operation and Development (OECD, 2012), they represent a lost opportunity for individuals and the economy. These low completion rates have negative consequences for employers, individuals, and colleges.

Employers: Jobs that require a college degree are projected to grow faster than other occupations from 2010 to 2020 (Lockard & Wolf, 2012). The rising share of college-level occupations reflects growth in white-collar office jobs, as well as the healthcare, education, and technology sectors, and the decline of manufacturing and agriculture (Carnevale, Strohl, & Smith, 2009). Demographic and labor market trends suggest that the human capital available to fill those jobs will decline in the coming decades: As older workers retire, they will be replaced by less-educated, lower-skilled workers (Kirsch, Braun, Yamamoto, & Sum, 2007). In addition to training in hard mathematics, reading, and writing skills, college also tends to foster the all-important soft skills in problem-solving, communication, and collaboration that employers seek for today's jobs (Murnane & Levy, 1996).

Individuals: Among students who attempt college, noncompletion can leave them with burdensome student loan debt. For those who finish college, the labor market benefits are growing. The wage premium for postsecondary education compared to a high school degree nearly doubled from the 1970's to 2007 (Carnevale et al., 2009). Growth in the college premium was driven primarily by decelerating growth in the relative supply of college-educated workers versus high-school level beginning in the 1980s, and exacerbated by technological advances that favored higher-skilled workers, as well as declines in the real value of the minimum wage and in labor union strength (Goldin & Katz, 2007). In 2012, full-time workers with an Associate's degree earned nearly one-third more on average than those with only a high school degree; those with a Bachelor's degree enjoyed roughly double the average earnings of high school graduates (U.S. Census Bureau, 2012). Not only do graduates reap greater lifetime earnings themselves, but they also pass on advantages to the next generation. A study that tracked New York students who took advantage of free education at open-access colleges in the

1970's found that completing a degree was associated with better academic outcomes for their children, a result the authors attributed in part to increased academic resources such as books and computers in the home (Attewell & Lavin, 2009). The authors conclude that college represents a critical means of reversing poverty cycles across generations.

Institutions: Colleges also stand to lose when their students depart without a degree. The costs of recruitment, institutional financial aid, lost tuition, and indirect expenses make poor retention a budgetary problem for colleges (Schuh & Gansemer-Topf, 2012). In public systems, states are moving toward making retention and graduation rates a key accountability measure for colleges (Berger, Ramirez, & Lyons, 2012). While few states have performance-based funding structures for allocating large portions of the higher education budget, such measures were proposed or enacted in at least a dozen states in 2011 (Harnisch, 2011).

For society at large, the costs of noncompletion include Pell grants funded by tax dollars, safety net benefits needed to support unemployed or underemployed adults, and the lost potential contributions of educated workers, parents, and citizens.

Inequalities in Graduation Rates

Not only are U.S. graduation rates low overall, but they are worse among poor and minority students. Data from the National Longitudinal Survey of Youth (1979 and 1997 cohorts) show that persistence rates correlate with income level, with a growing gap between the highest and lowest income quartiles (M. J. Bailey & Dynarski, 2011). More recent data capture the stark gap: The 2004-2009 Beginning Postsecondary Student Longitudinal Study (BPS:04/09) showed that dependent students living in households in the bottom income quartile had a 43% rate of graduation within six years, compared to

66% in the highest quartile[1] (National Center for Education Statistics, 2011). Similar differences emerge between racial/ethnic groups. According to the BPS:04/09 data, 54% of White students complete some credential within six years, compared to 37% of Black and 41% of Hispanic students, and multivariate analyses identify a unique association between completion and race beyond the relationship with socioeconomic status (Ross et al., 2012). These gaps contribute to the vastly different education and employment opportunities available to the nation's minority and low-income families compared to White middle class households (Reardon, 2011). The two-year institutions that serve larger numbers of low-income students likewise have a weaker completion record. Only 36% of students who start at a two-year college complete a certificate or degree in six years, compared to 62% of those who start at a four-year institution[2] (National Center for Education Statistics, 2011). However, there are some signs of improvement in the community college sector. ACT data suggest that the institutional freshman-to-sophomore year persistence rate has improved over the past ten years at public and open-admissions colleges, while falling at private, more selective schools (Mortenson, 2012).

Policy Responses to Low Graduation Rates

Reflecting the importance of the issue to so many stakeholders, government agencies have joined private foundations and industry associations to launch an array of policy initiatives aimed at increasing graduation rates. One of President Obama's administration's earliest policy directives was the American Graduation Initiative, which set a goal of 5 million additional graduates by 2020. The National Commission on Higher Education Attainment, representing several associations of higher education

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[1] Author's calculations using the NCES online PowerStat analysis tool.
[2] Author's calculations using the NCES online PowerStat analysis tool.

institutions, has issued calls to action and commissioned research on improving persistence among first-generation students and adult students. Private funders have also contributed; for example, the Gates Foundation's Completion by Design program funds two-year colleges around the country to implement reforms to improve their graduation rates. Nevertheless, these initiatives face an uphill battle. Veterans in the field raise concerns that the goals for increased production of graduates are unrealistic based on historical trends (T. W. Bailey, 2012), and will require significant investment on the part of colleges (Harris & Goldrick-Rab, 2010).

Theoretical Frameworks for Understanding College Completion

To increase graduation rates, educators and policymakers must understand what factors help or hinder students in ultimately achieving a degree. The education system loses students at a number of points along the route from the secondary school classroom to the college diploma, and various factors and mechanisms have been theorized to explain departure at each point along that path. Because the proposed study focuses on the trajectories of students after they have reached the point of registering for college courses, the literature related to college access is not germane. However, the next section briefly discusses the pre-college portion of the pathway to a degree to provide context.

Dropout before College Enrollment

According to the Education Longitudinal Study (ELS:2002), 5%[3] of students drop out of high school without earning a diploma, precluding the possibility of higher education (Bozick & Lauff, 2007). Although dropouts represent a relatively small percentage of students, they account for approximately one fourth of the substantial gap

[3] Estimates of high school drop-out vary depending on the definition and data source. For example, the status drop-out rate for 16- to 24-year-olds who are not enrolled in high school and do not hold a degree is 7% according to the Current Population Survey (Ross et al., 2012).

in college graduation rates between the lowest and highest income quartiles, by one estimate based on the National Longitudinal Survey of Youth (M. J. Bailey & Dynarski, 2011).

As mentioned previously, among those who do finish high school, 20% do not enroll in college within two years, based on ELS:2002 data (National Center for Education Statistics, 2006). According to Hossler and Gallagher's widely used model of postsecondary access (1987), the process of reaching college starts well before the senior year with the formation of a predisposition toward college, the college search process, and the choice of which institution to attend. Although more than 94% of high school graduates at every level of socioeconomic status say they plan to attend college at some point in the future, the National Education Longitudinal Study (NELS) found a gap between expectations and enrollment among lower-income students, with only 64% in the lowest income quartile actually enrolling within two years, compared to 93% in the highest quartile (Berkner & Chavez, 1997).

Some students who make it as far as applying and gaining admission to college will still choose not to go by the time fall registration arrives, a phenomenon often referred to as the "summer melt" (Hoover & Supiano, 2009). Arnold and colleagues describe this trend as a more serious "summer flood" (2009) among first-generation and other at-risk students. Their research found that many of these students decide that their financial aid is not enough, or rethink the tradeoff between education and immediate employment, during the summer period when they are disconnected from high school support networks but not yet in touch with college counselors. The decision-making process before college may have implications for later persistence decisions as well.

Some economic theorists argue that students' initial perceptions about the cost of college not only constrain the colleges to which they apply, but also affect their sense of their ability to afford staying in school (St. John, Paulsen, & Starkey, 1996). Perna (2006) offers a more comprehensive conceptual framework that integrates the economists' human capital perspective with socio-cultural approaches; she argues that students' cost-benefit choices about going to college should be understood within the contexts of their individual socio-cultural habits, behaviors and ways of understanding (or *habitus*, discussed further in chapter 2); their school and community; the higher education community; and the larger policy environment.

Persistence beyond College Enrollment

Theorists have proposed numerous explanatory frameworks for understanding why some enrolled college students persist to graduation while others depart. Although Tinto's (1975; 1993) interactionalist model predominates, alternatives have been offered from the perspectives of critical theory (Rendón, 1994; Tierney, 1992), economics (Cabrera, Stampen, & Hansen, 1990; St. John, Cabrera, Nora, & Asker, 2000), and organizational behavior (Berger & Milem, 2000), to name only a few. Chapter 2 discusses these frameworks, and the constructs they include, in more detail.

Each of these theoretical approaches incorporates factors related to student entry characteristics, student experiences and interactions on campus, external forces acting upon the student during the college years, and the institutional environment.

Student entry characteristics. College outcomes vary with student demographic characteristics such as race, gender, and age (Reason, 2009; Ross et al., 2012), as well as the academic preparation students bring to their college enrollment (Adelman, 1999; Adelman, 2006; Cabrera, Burkum, La Nasa, & Bibo, 2012).

Student postsecondary experiences. Once they arrive on campus, students' interactions with faculty, staff, and peers create a sense of integration, both academic and social, that affects their commitment to stay in school (Braxton & Lien, 2000; Tinto, 1993). Their ability to pay, both perceived and actual, also affects persistence (Paulsen & St. John, 2002). Attendance patterns, including the increasingly common migration among multiple institutions and periods of part-time attendance, affect the odds of achieving a degree (McCormick, 2003).

Environmental pull factors. So-called "pull factors" or external factors, such as working off campus, raising children, and maintaining ties with family and home community, exert an especially strong influence on nontraditional students (Bean & Metzner, 1985; Pascarella & Terenzini, 2005).

Institutional characteristics. The postsecondary institution's characteristics, including structural elements such as size and selectivity, and organizational choices such as faculty composition and budget allocations, are associated with differences in graduation rates (Astin & Oseguera, 2012; Berger & Milem, 2000; Titus, 2004).

This study focuses on one component of the postsecondary experience that connects student entry characteristics, on-campus experiences, and institutional context: college remedial education. High school students who take rigorous coursework, complete upper level mathematics classes, and earn a relatively high GPA – in other words, students whose high schools prepare them adequately for college-level work – graduate college at higher rates than their classmates (Adelman, 2006). Those who start college unprepared, in contrast, many find themselves in compensatory coursework in order to catch up. This study will focus on this particular persistence factor – remedial coursework – and how it relates to college completion.

Remediation and its Relationship to College Completion

Fifty percent of students take at least one postsecondary remedial (or "developmental") course, and the proportion is higher (65%) at community colleges (NCES, 2011).[4] Although remedial programs aim to raise students' basic reading and mathematics skills to the level required for regular coursework, students enrolled in remedial courses nevertheless finish college at lower rates than their peers (T. W. Bailey, 2009). It is not clear whether this gap is due to students' continued lack of academic skills, attitudinal differences in motivation or self-efficacy, poor quality of remedial classes, or other factors. Quasi-experimental research attempting to estimate the effect of remedial education on degree attainment has provided inconsistent answers (Bettinger & Long, 2009; Calcagno & Long, 2008; Crisp & Delgado, 2013; Martorell & McFarlin, 2011; Melguizo, Bos, & Prather, 2011; Scott-Clayton & Rodriguez, 2012). Students attending two- and four-year institutions experience different rates of remedial placement and different effects on graduation (Attewell, Lavin, Domina, & Levey, 2006). Enrollment in different remedial course subjects and levels also appears to have statistical associations with different persistence trajectories (Bahr, 2012; Boatman & Long, 2010). The wide range of remediation placement policies, curricula, and instructional quality across institutions makes it difficult to isolate a consistent effect at a state or national level (Long, 2012).

[4] Transcript data from the Beginning Postsecondary Students Longitudinal Study (BPS:04/09), accessed using the online PowerStat tool.

Gaps in the Persistence and Remediation Literature

Given the variation in effects by institution, examining the institutional context may provide a more nuanced understanding of the remediation problem. Some studies have analyzed institutional factors associated with persistence in general, but many examine these relationships by aggregating student outcomes and using the college as the unit of analysis (Gansemer-Topf & Schuh, 2006; Webber & Ehrenberg, 2010). Few such studies have employed a multilevel analysis that appropriately estimates student-level academic outcomes while accounting for the clustering of students in colleges, with some notable exceptions (Calcagno, Bailey, Jenkins, Kienzl, & Leinbach, 2008; Herrera, 2012; Oseguera & Byung, 2009; Titus, 2004). While some of these multilevel persistence studies include remediation as one predictor, none of them has attempted to *predict* differences in remediation effects using institution-level variables such as size or faculty characteristics.

In addition, disaggregating the types of remedial courses may facilitate a more useful analysis of their effects. While studies have begun to address these questions using data from a single state or system (Bahr, 2011; Bahr, 2012; Bettinger & Long, 2009; Boatman & Long, 2010; Calcagno & Long, 2008; Martorell & McFarlin, 2011), few national studies of this question exist aside from the work of Attewell and colleagues (Attewell et al., 2006; Attewell, Heil, & Reisel, 2011).

Finally, many of the existing studies that do use national survey data have relied on student self-report of taking remediation. A comparison of transcript data to self-report interview items demonstrates that students underreport participation in remedial coursework by 50% (National Center for Education Statistics, 2011).[5] Course titles and numbers often fail to clearly identify remediation as such, and advisors may compound the confusion in an effort to avoid stigmatization, with the result that many students do not realize they are enrolled in remedial, noncredit courses (Deil-Amen & Rosenbaum, 2002).

In sum, while recent literature has begun to uncover relationships among student- and college-level factors, remediation, and graduation, the existing studies do not bring together a nationally representative sample, multilevel analysis of variation in relationships across institutions, reliable transcript data, and disaggregated remediation variables. This study directly addresses these gaps.

Research Design

This study built on the prior research cited in the previous section related to student and institutional factors associated with college persistence and completion. Specifically, using the most recent available nationally representative U.S. transcript data, this secondary data analysis explored patterns of remedial course-taking; examined how those patterns vary with student demographic characteristics and academic preparation; modeled the relationship between remediation and postsecondary degree attainment; and investigated potential moderating effects of institutional characteristics on that relationship.

Research Questions

The research questions are:

1. What are the patterns of postsecondary remedial course-taking among students?

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[5] Comparison of interview and transcript data from the Beginning Postsecondary Students Longitudinal Study (BPS:04/09), author's calculations.

   a. Specifically, in which subjects do students receive remediation, and how many remedial courses do they take in total?
   b. How do these patterns vary by student demographic characteristics such as race, gender, and income?
   c. How do these patterns vary by institutional level (i.e., two-year or four-year degrees granted)?

2. How is postsecondary remediation related to certificate and degree attainment?
   a. After controlling for students' demographic characteristics, academic preparation, and postsecondary experiences, as well as institutional characteristics, what is the relationship between students' enrollment in *any remediation* and attainment of a postsecondary certificate or degree?
   b. After controlling for students' demographic characteristics, academic preparation, and postsecondary experiences, as well as institutional characteristics, what is the relationship between enrollment in *different remedial subjects and numbers of remedial courses* and attainment of a certificate or degree?

3. Are the relationships between postsecondary remediation and certificate/degree attainment moderated by contextual characteristics of the student's first postsecondary institution?
   a. Do institutional characteristics predict variation in the relationship between enrollment in *any remediation* and attainment of a certificate or degree?

b. Do institutional characteristics predict variation in the relationships between enrollment in *different remedial subjects and numbers of remedial courses* and attainment of a certificate or degree?

Methodology Overview

The study addressed these research questions by combining two national datasets – a longitudinal student dataset and a cross-sectional institutional dataset – and employing both descriptive analyses and multilevel logistic regression.

Data sources and sample. The study drew on student interview and transcript data from the restricted-use Beginning Postsecondary Students Longitudinal Study (BPS:04/09) data file. Conducted under the auspices of the National Center for Education Statistics, BPS:04/09 followed a nationally representative sample of postsecondary students who first enrolled in the 2003-2004 academic year. Students were interviewed in 2004, 2006, and 2009, and their transcripts were collected from all colleges attended in that timeframe. For the first college attended by each student in the sample, institutional information for 2003-2004 was accessed from the Integrated Postsecondary Education Data System (IPEDS). Two-year and four-year institutions were analyzed separately. The samples used in analysis excluded students who attended a for-profit or less-than-two-year institution, were over age 24 at the time of enrollment, or did not plan to seek a certificate or degree. Missing data also dictated some exclusions. For a more thorough discussion of the sample exclusions, see chapter 3.

Conceptual model and variables. The analyses were grounded in a conceptual model of college degree attainment based primarily on widely-used frameworks for studying persistence developed by Tinto (1993) and Berger and Milem (2000). Analyses included measures of constructs related to student demographic characteristics and high school academic preparation, student experiences and interactions on campus, external pull factors, and characteristics of the institutional environment at the first college attended. Chapter 2 presents this model and discusses past research findings for each of its components. Chapter 3 discusses the specific measures used in this study to represent each construct.

Analysis plan. The analytic methods used to address each research question are detailed in this section.

RQ1. What are the patterns of postsecondary remedial course-taking among students? The study began with descriptive analyses of the proportion of students who enrolled in any remedial courses, as well as the percentage by remedial subject and total number of such courses. In addition, the percentages taking any remedial education were compared by gender, race, and income level, as well as enrollment in two-year versus four-year institutions. Finally, the interactions of gender, race, and income level were examined by comparing the proportions of students remediated within these subgroups.

RQ2. How is postsecondary remediation related to certificate and degree attainment? Multilevel logistic regression was performed to model the probability of a student's earning a credential within six years. At the student level, this binary outcome was predicted by student demographic characteristics, academic preparation, postsecondary experiences, and environmental pull factors; and at the institution level, by structural, demographic, and organizational characteristics. The predictor of key interest was participation in remediation. The same analysis was then repeated, but replacing the single remediation variable with a set of variables representing the subjects and number of remedial courses taken. Separate models were fit for students starting at two-year versus four-year institutions.

RQ3. Are the relationships between postsecondary remediation and certificate/degree attainment moderated by contextual characteristics of the student's first postsecondary institution? Building on the models used in Question 2, the Question 3 multilevel models allowed the relationship between remediation and degree attainment to vary randomly across institutions. If significant variation in that relationship was found, institution-level predictors were then added to test whether college characteristics such as size and percentage of full-time faculty could account for the variation.

As previously noted, these are not causal research questions, and the study did not employ an experimental design to establish causality. This study is limited to exploring how the link between remediation and persistence varies based on institutional context; it cannot demonstrate that remediation *causes* changes in graduation rates in a given context. Further research could use propensity score matching or other quasi-experimental methods to produce credible evidence about causality in these relationships.

Significance of the Study

This study aims to inform both the theory and practice of college remediation in support of improving graduation rates. As Kelly and Schneider (2012) lament in their recent book on the challenge of increasing college completion rates, "…our 'playbook' of solutions is pretty empty" (p. 5). Policymakers and educators need more information that they can apply to devising effective solutions to the problem. While this secondary data analysis does not test specific policy interventions, it attempts to provide richer detail about the complex relationships among institutional and individual factors that may combine to support or impede persistence.

By addressing gaps in the extant literature on persistence and remediation, this study contributes to the theoretical perspectives that guide research in this area. As Berger (2000) states in a review of persistence frameworks, research is needed to build "midrange theories" that examine what factors help particular types of students persist in particular institutional environments. Reason (2009) echoes this assessment in his comprehensive review of persistence research; he calls for multilevel studies that can tease out the moderating effects of the institution on persistence factors, particularly those factors that have exhibited conditional effects in single-level analyses.

Given the slow pace of K-12 improvement, under-prepared youth will continue to apply to colleges for many years to come. At its best, remediation can help those students not only to finish college, but also to leave with adequate literacy and numeracy skills that they can use as employees, parents, and citizens. Research on remediation's effectiveness has struggled to discern its relationship to graduation because of the substantial "noise" due to heterogeneity across schools. This study aims to clarify our understanding of how different types of colleges differ on remedial outcomes, how institutional factors interact with remediation to produce those differences, and how these relationships differ for students with varied remediation needs.

A more nuanced picture of the ways remediation relates to the college completion process would guide educators toward potential policy solutions. A better understanding of the dynamics of remediation has the potential to inform policy responses to low college graduation rates. If some categories of institutions by level, control, and size have better remediation outcomes than others, they could serve as models for other colleges to serve lower-skilled students more effectively. Furthermore, understanding college outcomes related to different remediation patterns – distinguishing those who take several compensatory classes in reading and writing from those who need only a brief refresher in math, for example – may help educators tailor programs and policies to students with varying types of skill gaps.

CHAPTER 2. REVIEW OF THE LITERATURE

Remediation is just one of many factors affecting college outcomes. To put the topic in context, this chapter situates the effects of remedial education within a broader conceptualization of individual and institutional drivers of persistence. The review of the literature that follows provides an overview of the most widely-used frameworks for understanding postsecondary persistence. The chapter then looks more specifically at current research on the relationship between remediation and college outcomes. Finally, a conceptual model is proposed for studying this relationship in terms of institutional context, and the research findings for each element of that model are summarized.

Frameworks for Persistence

The theoretical frameworks for understanding postsecondary persistence draw from a range of fields, including psychology, anthropology, sociology, economics, and political science (Braxton & Hirschy, 2005; Pascarella & Terenzini, 2005). This section provides an overview of the theoretical approaches from these fields. This review goes beyond the constructs that were directly investigated in the present dissertation study, with the goal of situating the analysis in the broader context of persistence literature.

Psychological and Sociological Frameworks: Tinto and His Successors

Tinto’s interactionalist model (Tinto, 1975; 1993) is the starting point for most subsequent explanations of persistence and dropout (Braxton & Lien, 2000; Kuh, Kinzie, Buckley, Bridges, & Hayek, 2006). The model draws together psychological models that locate the causes of actions in individual attributes and attitudes, and sociological frameworks that place responsibility on societal factors. To create a longitudinal model of the process of departure from college, Tinto adapts concepts from social anthropology.

Looking at Durkheim's (1951) theory of suicide, he draws parallels to college drop-out as a failure of integration of the individual into the community. The model also has roots in van Gennep's (1960) study of rites of passage that signify movement from one social role and group to a new one. While acknowledging that students arrive at college with educational intentions, goals, and institutional commitments rooted in their prior experiences and characteristics, Tinto places particular importance on the student's academic and social integration into the community of the college. He envisages integration as a developmental process of day-to-day interactions with faculty, staff, and other students that may moderate or change the student's initial level of commitment. From this perspective, the actions of faculty, staff and students are the mechanisms by which the external institutional environment influences the student's internal intentions and commitments.

Subsequent research has tested and revised Tinto's model to fill gaps and extend its applicability. From a psychological perspective, Astin (1984) developed a theory of student involvement, in many ways congruent with Tinto's "integration" construct, that gives a central role to the student's investment of time and energy in learning activities. Based on Astin's longitudinal studies of student departure, factors such as time and quality of studying, and institutional efforts to encourage student engagement, emerge as the most critical to student learning and educational outcomes. Bean and Eaton's psychological model (2000) fleshes out the internal mechanisms, such as self-efficacy and locus of control, by which students develop intentions and commitments leading to persistence or departure.

In one of the most comprehensive empirical tests of the Tinto model, Braxton, Sullivan and Johnson (1997) break the model down into a set of fifteen propositions and examine each one based on existing rigorous studies. They conclude that only half the propositions are well-supported by evidence. These verified components of the model include the association of academic integration and commitment to the goal of graduation, as well as the links between social integration, institutional commitment, and persistence.

Based on these findings, Braxton and Hirschy (2005) revise Tinto's framework to further describe the antecedents of *social integration*, one of the best-supported components of his original model. With this goal in mind, they incorporate ability to pay (a concept from economics discussed in more depth in this chapter under "The Contributions of Economists") as a factor contributing to social integration. Furthermore, they consider institutional actions that affect students' sense of integration, including how consistently the institution lives out its mission ("integrity"), and its "commitment to the welfare of students" (p. 70).

Pascarella (1984; Pascarella & Terenzini, 2005) also questions conceptual gaps in Tinto's model. Criticizing the omission of internal developmental processes of change that students undergo during college, he elaborates a model of student outcomes that spells out the ways in which the structural and organizational features of a college (such as its size and selectivity) indirectly influence students. He highlights the role of "socializing agents" of the college – faculty and other students – who together create the institutional environment. Environmental features include student perceptions of competitiveness and accessibility of faculty. In addition to these organizational factors, Pascarella includes “quality of student effort,” a factor with demonstrated effects on student learning (Kuh & Hu, 2001).

Adapting Tinto for nontraditional populations. As greater access to higher education since the 1970s has led to increasing proportions of students who are older, attending part-time, or enrolled at two-year colleges, as well as increasing numbers of students of color (Snyder & Dillow, 2012), many theorists have sought to test or adapt these approaches for nontraditional populations and minority students. Until the 1990s, the vast majority of studies on college outcomes were based on samples of “traditional” students and settings: full-time, residential, 18 to 22 year old students at four-year colleges (Pascarella & Terenzini, 2005). In this context, the focus on social integration and the middle-class rituals of going away to school made sense. However, many educators and researchers feel that the Tinto-based models do not adequately capture the experiences of students who do not fit the traditional mold. Nontraditional students may be enrolled for different reasons, such as general enrichment or advancement at a current job; they may balance college with greater responsibilities for family and work; and they may lack the social capital, family support, and college knowledge that support persistence among traditional students (Crisp & Mina, 2012; Rowan-Kenyon, 2007; Taniguchi & Kaufman, 2005). The revised models have particular relevance for students placed in remedial education, since they are disproportionately nontraditional.

Bean and Metzner (1985) modified Tinto’s model for nontraditional students, whom they defined as older than 24, enrolled part-time, and/or commuting to college. They argue that such students often have a narrower, more instrumental purpose in coming to college, such as an occupational goal, and are less strongly influenced by the college social environment than their traditional counterparts. Based on a review of existing research and their own empirical analysis at one college (Bean, 1985), they de-emphasize social integration in their framework, positing that external forces outweigh academic integration. Although Tinto himself has expanded later versions of his model to encompass these factors (1993), he positions them as constraints on, rather than primary drivers of, the decision to persist or leave. For nontraditional students, these environmental pull factors are particularly critical.

Several studies have tested the validity of the Tinto model for the community college setting. For example, Crisp and Nora (2010) proposed a model for Hispanic students in two-year colleges; their quantitative analysis of a national sample indicated that background characteristics, high school preparation, and external pull factors such as employment had a significant association with persistence, while integration variables did not. Deil-Amen (2011) and Karp, Hughes and Gara (2008) also studied the integration construct in this setting, noting that integration may look different in this context, but it is still important. The students interviewed in these two qualitative studies did not experience, or necessarily even want, the traditional milieu of social clubs and "school spirit" of a four-year college; but they did value interpersonal ties more closely related to academics, such as helpful faculty members and peers who served as study partners and sources of information about courses. Findings from qualitative research on learning communities, in which cohorts of students enroll in linked courses together, demonstrate that community colleges can help cultivate these academically supportive ties with peers through their curriculum and programming. In one study of community college remedial students, students in a learning community saw the bonds they formed with their peers as a positive support for persistence, while those in traditional remedial courses viewed friendships as an unwanted distraction (Wathington, Pretlow, & Mitchell, 2011).

First-generation students – those whose parents did not attend college – also face particular barriers to integration and persistence. Delving into the psychological backdrop to the integration process using family psychodynamic theory, London (1989) popularized the idea that first-generation students must “break away” from their parents’ orbits before they can successfully pursue their own educational goals as independent adults. Based on case study research, he argues that parental attitudes toward college and expectations about the child’s role can hold first-generation students back.

Some researchers have gone further and mounted a more fundamental critique of Tinto and his successors, arguing that the concepts of “rites of passage” and “breaking away” rely on assimilationist assumptions that do not do justice to the experiences of students of color and first generation college-goers (Rendón, Jalomo, & Nora, 2000). They argue that the model is inappropriate to these populations, and that a new alternative is needed. Among these critics, Tierney (1992) claims that Tinto misuses the anthropological concept of rites of passage, whereby the model assumes that minority students must assimilate to the dominant White middle-class culture on campus, leaving behind their home cultures, in order to persist. He proposes an alternative framing of the problem: that institutions, not students, should change to function more effectively in a multicultural world. In this view, institutions that help students maintain their ties to their home cultures will support their success in college.

Others have constructed alternative frameworks for minority and first-generation persistence from a critical theory perspective, based in qualitative research that challenges Tinto's positivist assumptions. These studies have uncovered previously unexplored factors that are critical for nontraditional students, particularly family support, academic validation from faculty and other college agents, and the pronounced influence of environmental pull factors. For example, Attinasi's (1989) qualitative study of Mexican-American students finds that family members and mentors can help a student develop early expectations about college and model college-going behavior, mediating the negative effects of low socioeconomic status. Rendón (1994) elaborates a theory of validation that puts the onus on institutional agents to reach out to nontraditional students and help them get involved with the campus, rather than expecting all students to know how to do it themselves. She stresses validation by actors on and off campus as a necessary stage of development for nontraditional students, whereby they gain a sense of academic self-efficacy and the ability to engage socially and academically with the institution.

Social Forces Frameworks: Social and Cultural Capital

The social forces theoretical framework, particularly the work of Bourdieu (1977), offers another lens for viewing student persistence and differences between traditional and nontraditional student experiences. Theorists from this perspective look beyond the individual to the accumulated expectations and norms, or *habitus* in Bourdieu's terminology, of the student's family and home community that guide his or her behavior. For students whose parents are not White, middle-class and college-educated, the patterns developed at home may conflict with the norms of the college environment in ways that hinder their academic progress (Kuh et al., 2006).

Empirical studies of the construct include a large-scale survey by Nora (2004) that found associations between measures of social/cultural capital, including parental support for the student's enrollment choice and intent to re-enroll in the second year. Studying this phenomenon quantitatively using a national longitudinal dataset, Wells (2009) found that social and cultural capital was one of the few significant predictors of college persistence, after controlling for student characteristics such as race and family income. However, its effects were not uniform for all students and contexts. Hispanic and Black students had lower values than White students for *resource-dependent* aspects of social and cultural capital, such as using admissions test preparation materials and parental level of education; but they had equivalent levels of *attitudinal* resources, such as student and parental expectations for attending college. Additionally, social and cultural capital had a weaker effect on persistence at two-year colleges compared to four-year colleges (Wells, 2008).

Pulling together elements of social capital and validation theory, Nora (2004) articulates a comprehensive Student Engagement Model that retains some elements of the Tinto framework, such as aspirations and commitments, but goes beyond the integration construct to address involvement in learning communities, campus climates, validating experiences, mentoring, and noncognitive outcomes (Nora & Crisp, 2012).

The Contributions of Economists

Using the lens of cost-benefit analysis, economists posit that students make a rational decision to persist or drop out by weighing the costs against the rewards of a college degree (Cabrera et al., 1990; Murdock, 1987). Unlike the schools of thought discussed thus far, most of which give little treatment to financial factors aside from the student's entering socioeconomic status, economists assess the effects of the ability to pay for college (both perceived and actual) on persistence, and particularly the role of financial aid in that relationship (St. John et al., 2000). Studies have shown that financial variables have some bearing on psychological and social constructs related to persistence. For example, Cabrera, Stampen, and Hansen (1990) find that ability to pay, when added to the Tinto model, moderates the effect of goal commitment on institutional persistence. Paulsen and St. John's Choice-Persistence Nexus model investigates the role of financial variables at each stage of the process, from the formation of college aspirations through persistence to a degree; they report that a student's socioeconomic context colors his/her perception of the affordability of college, a perception that has different effects for low- and high-income students (Paulsen & St. John, 1997; Paulsen & St. John, 2002; St. John et al., 1996).

Narrowing in on financial aid, a number of rigorous studies have found modest but significant positive effects of grant aid on persistence (Bettinger, 2012; Dynarski & Scott-Clayton, 2013; Gross & Ziskin, 2007). This effect appears to be greater for lower-income and minority students (R. Chen & DesJardins, 2010; Paulsen & St. John, 2002). All grants are not equal; performance-based grants that require a certain level of academic achievement have stronger effects than those without strings attached (Dynarski & Scott-Clayton, 2013). Aid in the form of loans, by contrast, may have negative effects, as Dowd and Coury (2006) found among community college students. These studies suggest policy solutions that might support persistence, especially for nontraditional students.

Institutional Factors

The frameworks discussed thus far explain persistence primarily in terms of individual student characteristics and experiences. By contrast, institutional factors have received relatively short shrift in the literature (Ziskin, Hossler, & Kim, 2009). The extant research on this topic typically draws on organizational theory for an institution-level perspective on student outcomes. Models from this discipline take into account such factors as institutional structures, resource allocation, aggregate student body characteristics, and (intersecting with psychological models) organizational climate.

In one of the earlier models explicitly dealing with organizational factors, Bean (1983) drew on industrial research on employee turnover to develop a "student attrition" model, incorporating institutional variables such as the college's communication with students and student input into classroom decision-making. While the model lacks explanatory power in empirical studies and, like Bean's other work (1985; 2000), has more to say about student psychological constructs than about specific institutional factors, it offers a way to think about how the college's actions and norms influence student satisfaction and departure decisions.

As discussed previously, some of the individual-focused models do incorporate institutional features. Braxton and Hirschy (2005) include institutional integrity and commitment to student welfare. Pascarella (1984) contributes the idea of socializing agents whose interactions with students constitute the overall environment or climate. Tinto's most recent work (2012) also addresses organizational features, including academic, social, and financial support from the college. Focusing on interactions in the classroom, he emphasizes the importance of high expectations from faculty, active learning, and frequent assessment of and feedback to students. Reason's (2009) comprehensive conceptual framework for student outcomes goes further, calling for models to incorporate institutional *policies* governing human resources and other organizational features.

The most comprehensive model drawing on institutional factors was proposed by Berger and Milem (2000), who draw on organizational behavior theory. They attempt to integrate what they describe as two parallel tracks of research on persistence, one (comprising the theorists described so far) mainly concerned with student outcomes, and the other with the organization of higher education. Their model includes relatively static organizational features such as size, control, and selectivity, as well as the organization's behaviors, such as its degree of reliance on rational bureaucracy, symbolic meaning-making, and political conflict among interest groups, and how those stances translate into day-to-day interactions for the student. They anticipate that these institutional factors affect an individual student both directly and indirectly (by forming the peer group's aggregate characteristics and behaviors).

While this model has the advantage of spelling out mechanisms by which institutional features affect student outcomes, it does not include a detailed schema for the student characteristics and experiences variables. Two later models offer a more comprehensive view. Titus (2004) bridged this gap with a hybrid model combining Berger and Milem's framework with a richer set of psychosocial variables based on Bean's (1985) approach. At the student level, Titus incorporates student experiences such as living on campus and choosing a major, and student attitudes such as commitment to the institution. At the institutional level, he assesses structural features as well as peer climate, represented by the aggregation of student attitudes and behaviors. Terenzini and Reason (2005) use elements from Tinto, Astin, and Pascarella, in addition to Berger and Milem, to build a comprehensive conceptual framework, with the goal of encouraging more holistic research that widens beyond the effects of isolated variables to examine how various components work together. Taken together, these institutional factors create an environment that supports the student to complete college – through financial resources, as well as through integration and engagement– to varying degrees.

Remediation as a Factor in College Persistence

Remediation sits at the intersection of individual and institutional factors affecting college persistence. Tightly connected to academic preparation and correlated with demographic entry characteristics, it also has implications for the student's integration into the academic and social life of the college and persistence decisions. As such, it is a factor worth consideration in the study of degree attainment.

Students take remedial courses for a variety of reasons, including inadequate levels of academic preparation in high school or attrition of skills after a long time away from school among older returning students. The evidence from national and international secondary-level standardized assessments such as the National Assessment of Educational Progress (NAEP) and the Trends in International Mathematics and Science Study (TIMSS), as well as assessments of adults such as the National Assessment of Adult Literacy (NAALS), points to a high proportion of students leaving high school without college-level literacy and numeracy abilities (Kutner et al., 2007; Mullis et al., 2008; Rampey, Dion, & Donahue, 2009). Many of these unprepared high school graduates nevertheless go on to college. The 2003 NAAL found that among adults whose highest educational attainment was an Associate's degree, 7% scored below the basic level on quantitative literacy skills; the proportion rose to 10% for those who attended some college but earned no degree (Kutner et al., 2007). National studies have found that students who leave high school with inferior academic preparation, both in terms of high school courses taken and standardized test scores, enroll in college remediation at higher rates (Adelman, 2006; Attewell et al., 2006). The uneven quality of secondary schools plays a role; evidence suggests that high schools with fewer qualified teachers produce a higher proportion of students needing college remediation (Howell, 2011). In sum, the student entry characteristics that predict remedial placement are also strongly linked to college drop-out.

From the institutional side, college policies and programs establish the context in which students experience remedial coursework. More than three-quarters of all postsecondary institutions – and virtually all community colleges – offer some form of remediation (Merisotis & Phipps, 2000). However, institutions vary in their policies for placement. Even within the public state systems, many states do not have a single policy for remedial testing and placement; some states require students to take remedial courses if they fail to meet certain criteria, while others only recommend it; and some states relegate all remedial course offerings to their two-year colleges (Boswell & Jenkins, 2002; Fields & Parsad, 2012). The result is that the same student might be required to take a basic skills course at one institution but not at another in the next town. Institutions also differ in the formats available for such courses, offering everything from traditional semester-long courses, to college success skills integrated with basic skills content, to self-paced online courses, to shorter, accelerated mini-courses. This variation in placement, format, and quality of remedial courses across institutions suggests that remediation may have different effects on persistence in different colleges.

History and Purpose of Remediation

Remediation, also known as developmental, basic skills, or compensatory education, is generally defined as courses on fundamental skill areas that students need in order to participate in college academic programs (Cohen & Brawer, 2008). Topics may include reading, writing, math, English for Speakers of Other Languages, and more general skills such as time management and computer use. Typically, remedial courses do not earn credits that can be counted toward a degree or transferred to another college.

Although U.S. colleges have offered some form of college preparatory education since the late 19th century, remedial education became more widespread in the 1970s and 1980s, in response to a decline in mathematics and literacy ability among high school students and a simultaneous expansion in the college-going population (Cohen & Brawer, 2008). The past decade has seen a slight decline in remediation rates, with much of the reduction occurring at low-selectivity or open-admissions institutions (Sparks & Malkus, 2013). However, current rates remain high. Among U.S. students who began college in 2003-2004, 50% enrolled in at least one remedial course during their postsecondary years (National Center for Education Statistics, 2011).[6] The rate is higher at two-year colleges (65%) compared to four-year institutions (37%); and higher among Black (60%) and Hispanic students (62%) than among White students (46%).

Controversy surrounds the value and social function of remediation. Some argue that remedial classes serve to replicate inequitable social structures by "cooling out"

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[6] Transcript data from the Beginning Postsecondary Students Longitudinal Study (BPS:04/09), accessed using the online PowerStat tool.

lower-skilled students, re-directing them from academic degrees to occupational certificates, or to drop-out (Clark, 1960). In this vein, Rosenbaum (2001) argues that well-meaning high school counselors and teachers do not give low-achieving students accurate information about the distance between their current performance and the rigor of college work; in his view, this soft approach fills students with false hopes and dooms them to a failed college attempt. Research indicates that high school students have unrealistic beliefs about how easy college will be and a misimpression that they will be able to take any course regardless of their secondary preparation (Kirst & Venezia, 2004). College advisors sometimes perpetuate these mistaken ideas by failing to explain the consequences of spending time in remediation, or by not offering alternatives such as less rigorous occupational certificates. One study found that 39% of students in noncredit remedial courses incorrectly thought that the classes counted toward degree programs; some students did not realize they were enrolled in remediation at all (Deil-Amen & Rosenbaum, 2002).

However, other studies support the argument that remediation offers a second-chance route to a college degree for a substantial proportion of students who start with inadequate skills. Although they may take longer, require more support, and succeed at lower rates, many of these students do eventually complete some credits or earn a degree, and reap the rewards of that attainment (Attewell & Lavin, 2009). National longitudinal survey data shows that community college students are actually more likely to raise their degree aspirations while enrolled rather than lower them (Adelman, 2005). Supporting this conclusion, a smaller study of low-income Black youth found a “warming up” of four-year degree aspirations after community college enrollment (Alexander, Bozick, &

Entwisle, 2008). Some researchers and educators call not for directing lower-skilled students out of “unrealistic” degree programs, but for improving and streamlining remedial education so that it more effectively supports persistence for all students (T. W. Bailey, 2009).

Does Remediation Work?

To fulfill the promise of a second chance, remedial classes must bring lower-skilled students up to par with their peers so that they can succeed in college. Whether remedial coursework as it exists today facilitates or impedes students’ progress toward a college degree is a matter of debate.

Some researchers argue that the remedial course placement process itself – typically based on standardized placement test scores – lacks predictive validity (Armstrong, 2000; Bowen, Chingos, & McPherson, 2009; Hughes & Scott-Clayton, 2011; Marwick, 2002; Medhanie, Dupuis, LeBeau, Harwell, & Post, 2012). Although validity improves with the use of multiple measures (Scott-Clayton, 2012), the majority of institutions rely only on the test score (Fields & Parsad, 2012). As individual colleges experiment with allowing students to place themselves, some have found that students who test at remedial levels can perform as well as their peers when they go directly to college-level coursework (Abou Sayf, 2008).

Once students are assigned to remedial courses, some studies suggest that the time and cost of completing them leads to drop-out. Using data on more than 250,000 students from 57 colleges, Bailey, Jeong and Cho (2009) found that 60%-70% of students assigned to remedial courses did not complete the sequence, in the majority of cases because they simply did not enroll, rather than failing or withdrawing. This association was stronger among students who were older, African-American, or part-time. A study of the public college system in Texas came to a different conclusion; using a regression discontinuity design, Martorell, McFarlin and Xue (2011) demonstrated that students assigned to remedial education were no less likely to enroll, and no more likely to delay enrollment, than other students. Looking specifically at community colleges in one urban system, Scott-Clayton and Rodriguez (2012) corroborated Martorell et al.'s finding, with no evidence of discouragement effects over a three-year period, using a regression discontinuity design.

Empirical studies have yielded inconclusive evidence about remediation's effect on degree attainment. While Pascarella and Terenzini's (2005) review of studies from the 1990s concluded that remedial interventions had positive effects on academic outcomes, more recent studies with stronger research designs have yielded a more complex picture. A 2011 review of the literature on remedial mathematics programs concluded that the evidence was "contradictory and mixed at best" (Melguizo et al., 2011, p. 180). The studies reviewed in the next sections represent different scopes of inquiry, as well as different degrees of methodological rigor. They include studies on statewide and nationwide datasets that use quasi-experimental designs to make causal inferences; correlational analyses of national-level longitudinal data; and single-college analyses.

Remediation findings from quasi-experimental studies. Six recent quasi-experimental, large-scale studies came to conflicting conclusions. Bettinger and Long (2009) studied data on 28,000 students at Ohio two- and four-year public colleges, taking advantage of the tendency of students to attend a school close to home coupled with arbitrary differences in placement policies at neighboring campuses. Because similar students with similar placement test scores would be assigned to remedial education at one campus and college-level courses at another college nearby, the authors were able to use an instrumental variable approach to estimate causal effects. They found that students taking remedial education were more likely to persist in their education, transfer to a four-year college, and complete a Bachelor's degree than were their matched counterparts who did not take remedial classes. In contrast, Calcagno and Long (2008) found no such effects on outcomes in a study using Florida community college data. Employing a regression discontinuity design, they modeled differences in outcomes for students just above and below the statewide placement cut point. Although students in remedial education exhibited slightly greater persistence from the first to second year, they were no more likely than students starting in college-level courses to earn transferable credits or graduate.

Using a similar regression discontinuity design to analyze more than 450,000 students at public two- and four-year colleges in Texas, Martorell and McFarlin (2011) found no differences in education or labor market outcomes between students in remediation and others. Finally, Scott-Clayton and Rodriguez (2012) found no evidence of different academic outcomes, including credit accumulation, semesters enrolled, transfer, or degree attainment, for those just above and below the placement cut score in a large urban community college system. However, they found limited negative effects for two subgroups: students who were apparently mis-assigned to reading remediation had a significantly higher risk of dropping out over three years; and students with few academic risk factors based on their demographic and high school characteristics, but who were assigned to mathematics remediation, were significantly less likely than similar nonremediated peers to take college-level math.

Although regression discontinuity offers a means of estimating a causal effect from observational data, some researchers have cautioned that its focus on the marginal student (i.e., the student scoring near the cut-score for remedial placement) may obscure the effects of remediation on students at different levels (Melguizo, Kim, Bos, & Prather, 2012). An alternative means of strengthening the inferences that can be made from observational data is propensity score matching, which attempts to reduce selection bias by accounting for factors associated with the propensity to be part of the "treatment" group. In one such study using nationally representative NELS:88 data, Attewell, Lavin, Domina and Levey (2006) identified no effect of remediation on the likelihood of graduation in two-year colleges, but a small negative effect in four-year institutions (56.9% of remedial students complete some degree in eight years, versus 63.7% of similar nonremediated students). Crisp and Delgado (2013) applied a similar propensity score matching design to study persistence into the second year and transfer among two-year college students, using the more recent BPS:04/09 survey. They found a negative effect of remediation on transferring to a four-year college within six years.

Remediation findings from large-scale correlational studies. National longitudinal studies such as the BPS:04/09 offer a rich sample and generalizability to a larger population. However, most studies drawing on such datasets are correlational in nature, and therefore cannot draw causal conclusions because of the possibility of systematic differences between remediated and nonremediated students. With that caveat in mind, such studies nevertheless shed light on associations between remediation, student characteristics and experiences, and academic outcomes.

One suggested conclusion from these studies is that the lower graduation rate observed among remediated students derives from underlying student skill deficits rather than barriers related to their course placement. Comparing remediated and non-remediated traditional-age students using transcript data from the NELS:88, Adelman (2006) found no difference in four-year degree completion and other academic outcomes, once he controlled for high school academic preparation using a combination of high school courses completed, high school GPA, and related factors. (However, Attewell et al.'s quasi-experimental analysis of this dataset, discussed in the previous section, did detect negative effects.)

More recent national datasets have yielded mixed results. A regression analysis of students in the 1996 cohort of the BPS identified a significant negative association between self-reported remediation and completing any certificate or degree within five years, after controlling for student characteristics (X. Chen, 2007). However, a similar analysis on the more recent 2004 BPS cohort found no significant relationship, although the degree attainment rate was lower for remediated students at 20% versus 27% (Ross et al., 2012). Crisp and Nora used the same BPS dataset to look more narrowly at one population: Hispanic students at community colleges (2010). Unlike Adelman's and Chen's analyses, their regression analysis found a positive effect of remediation on persistence to the second year. Like Chen and Ross et al., Crisp and Nora relied on self-report for remediation status rather than transcript data.

Examining the time-varying effects of remediation, a study using event history analysis for data from ten community colleges in one state found a negative effect on degree completion after controlling for other factors (Chiang, 2012). However, maintaining full-time enrollment and a higher GPA compensated for some of this effect.

Remediation findings from single-campus studies. Smaller-scale single-campus studies using a variety of methods also come to differing conclusions. For example, using a regression discontinuity design, Horn, McCoy, Campbell and Brock (2009) found a significant negative relationship between participation in remedial courses and grade earned in the first college-level English class in the sequence at one public college, after controlling for gender, race, and year of high school graduation. In contrast, a study of 1,473 students in a Michigan community college found benefits to remediation: students re-took the placement test after completing English remedial courses, and on average, improved their placement test scores to the same level as non-remediated students (Moss & Yeaton, 2006). Using performance in an academic subject area as the outcome variable, Goldstein and Perin (2008) found positive effects of remedial education on grades in a subsequent college-level psychology course offered at a large urban community college among a sample of 1,169; students who participated in remedial English performed on par with students placed directly into college-level courses.

These contradictory conclusions are not surprising, given the variation in students and remedial programs across schools. What follows is a discussion of the evidence for differential remediation effects based on student race, subject and intensity of remedial courses, and institutional characteristics.

Differential effects by race. Just as persistence factors in general appear to play out differently for students of color and their White peers, remediation may have different effects on different racial groups. Attewell et al. found that not only did Black students participate in remediation at higher rates than White students, but this gap persisted even after controlling for academic preparation and other student characteristics (Attewell et al., 2006). In a multilevel analysis of California community college students taking remedial math, Bahr (2010) demonstrated that Black and Hispanic remedial students were less likely to ultimately pass college-level math, largely based on initial skill gaps in that area. Furthermore, while White remedial students who succeeded in passing the college-level course were more likely to go on to attain degrees, this positive effect of successful remediation was weaker among Black and Hispanic students than among Whites.

Differential effects by subject and intensity. Further complicating the attempt to discern the effects of remediation, enrollment in different remedial levels and topics may lead to different outcomes. In general, students who start at a lower point in the remedial sequence tend to graduate at lower rates than those who start higher in the sequence; Bahr (2012) looked in more depth at factors driving this gap, using data on remedial students in the California community college system. He concluded that one of the main sources of this difference was the accelerating rate of attrition at each successive step in the remedial course sequence, meaning that lower-skilled students had more chances to drop out along the way. In addition, he identified the transition to beginning Algebra as a critical loss point for the lower-skilled students. Boatman and Long (2010) found different patterns for different course subjects, using state-wide data from

Tennessee community colleges and comparing similar students who scored just above and below the cut-points between remedial placement levels. Their regression discontinuity analysis found that students in the highest remedial mathematics level fared worse than their peers in college-level courses, but did not see differences in degree attainment between intermediate and lower mathematics placements. For remedial reading, students placed in the lowest level had lower odds of attainment than those in the higher level. In contrast, students who started in lower-level remedial writing experienced positive effects on some intermediate outcomes, although not ultimately on degree attainment. Their study highlights the different outcomes across remedial subjects; the developmental process of building mathematics skills may differ in important ways from building writing or reading skills.

Flow-Delwiche (2012) investigated the effect of taking more semesters of remedial Algebra on students of the same ability level, exploiting a policy change in the intermediate cut score between remedial levels at a large community college. She did not see a significant difference in outcomes for students who took a longer mathematics sequence. Given the questions surrounding the reliability of the placement process, this result is not surprising.

Institutional effects. Few rigorous studies have examined the effects of remediation on graduation in terms of institutional context. The existing literature has found some variation. As described earlier, two-year colleges enroll a higher percentage of students in remedial courses than four-year colleges. However, these raw proportions do not account for the different characteristics of the student populations. In the previously mentioned study using propensity score matching to reduce selection bias related to prior academic preparation, Attewell, Lavin, Domina, and Levy (2006) found a small but significant difference in graduation rates for four-year college students in remedial education compared to their peers with similar academic preparation (56.9% vs. 63.7%). Two-year college students, in contrast, did not have a gap in graduation rates based on remedial status. This study suggests the existence of interesting conditional effects based on institution type.

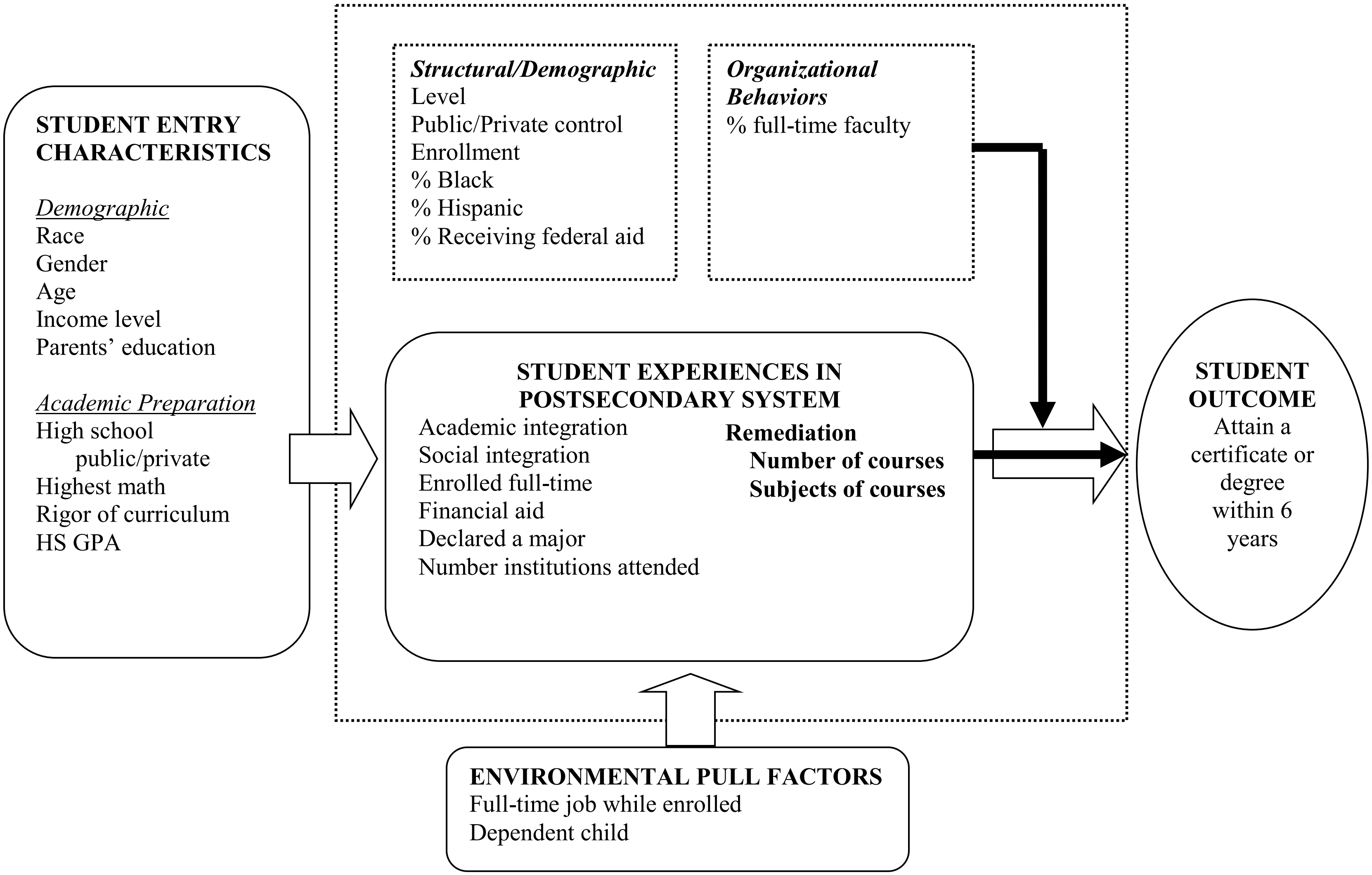
Institutional practices to improve remediation outcomes. To address the college completion gap between basic skills students and their peers, postsecondary institutions have tried a range of new models. Some address the flaws of the placement process by partnering with high schools to administer placement tests to 11th or 12th graders when it is still early enough for them to improve their performance (Tierney & Garcia, 2011), or by supplementing placement tests with multiple measures (Scott-Clayton, 2012). Some reach more deeply into high schools by offering dual enrollment or early college programs in which students can complete basic skills classes before finishing high school. Some offer accelerated and/or self-paced remedial courses that save students from spending a whole semester in noncredit classes if they only need to brush up on a few areas to be ready for college-level coursework. Some go further to undertake a wholesale restructuring of remedial programs, integrating them with academic and/or vocational courses, changing the way credits are awarded, or building well-articulated pathways from remediation through certificate courses to degrees (Tinto, 2012; Washington State Board for Community and Technical Colleges, 2008). Additionally, many colleges attempt to improve the academic and social integration of remedial students through interventions that facilitate richer ties between students, faculty, and their peers while making sure they connect with needed support services. These programs include summer bridge courses, offered to high school graduates the summer before enrollment (Strayhorn, 2011) and learning communities, sets of linked courses attended by a cohort of students (Wathington et al., 2011).

As colleges experiment with new approaches to remediation, the limited evidence base supporting some of these reform practices has grown – e.g., through random assignment studies at community colleges through the Opening Doors Demonstration (Scrivener & Coghlan, 2011). While still limited to a small number of studies, often within a single college, initial findings point to some promising practices. A review of experimental, quasi-experimental, and simpler comparison-group studies found evidence for the effectiveness of accelerated programs and integrated occupational/academic courses (Rutschow & Schneider, 2011). However, it found a lack of high-quality studies that would provide answers about high school initiatives and enhanced support services; the effects of support programs appeared to diminish after the program period. Qualitative research on learning communities has shown promising effects on student integration by encouraging more peer interaction and a more supportive classroom climate (Wathington et al., 2011). However, a relatively large-scale study of summer bridge programs in one state, using an experimental design, found no differences in enrollment and persistence outcomes (Pretlow, 2011). A host of initiatives funded by the Gates Foundation, the Lumina Foundation, and others continue to pilot, test, and scale these new approaches.

Conceptual Model

Building on the research discussed in the previous sections, the present study investigates the moderating effects of institutional factors on the relationship between college remediation and graduation. To represent a set of key individual and institutional factors related to completing college, the study is grounded in a conceptual model based primarily on the work of Berger and Milem (2000) and Titus (2004) discussed previously. Berger and Milem's approach is particularly appropriate because it includes institutional factors. Because Titus adapts Berger and Milem's model to incorporate more detailed student-level variables, it is useful for the research questions addressed in this study. Figure 1 shows the components of the conceptual model.

Figure 1. Conceptual Model



At the student level (shown in solid lines), the model posits that entry characteristics, experiences in the postsecondary system, and environmental pull factors all affect degree attainment. The institutional context (shown in box with dashed border) moderates these relationships. The specific focus of this study is the relationship (shown with black arrows) of one particular student postsecondary experience – remediation – to degree attainment, and how that relationship varies in accordance with institutional factors.

Rationale for Components of the Model

Within the overall framework, the individual elements of this model were chosen based on the body of literature on persistence in general and remediation specifically. The rationale relies on comprehensive literature reviews of these topics (Melguizo et al., 2011; Pascarella & Terenzini, 2005; Reason, 2009), as well as numerous individual quantitative studies cited in this chapter. While measures were not available for all the constructs discussed in the literature review in chapter 2, those discussed in this section are represented in the dataset (see "Limitations" for further discussion).

Student entry characteristics. Across the disciplines, models of student persistence incorporate student demographic characteristics as well as academic preparation.

Demographic characteristics.

Gender and race. Although some studies have found that the influence of some demographic variables fades in the presence of academic preparation and college experiences (Adelman, 2006; Reason, 2009), gender and race are nevertheless included in order to identify any conditional effects. According to the most recent national longitudinal data, Black, and Hispanic undergraduates are less likely to complete a degree than their female and White counterparts (Ross et al., 2012). Furthermore, studies have found differences in remediation patterns based on race, with Black students more likely to enroll in remedial courses than White peers with similar skills (Attewell et al., 2006). Women graduate at higher rates than men; while this gap has grown dramatically among upper-income students, it is much smaller within the lowest income groups (M. J. Bailey & Dynarski, 2011). One study found that remediation had more positive effects on persistence among women than among men (Long & Boatman, 2013).

Age. Student age is also included as a proxy for delayed entry to college, increased family responsibilities that may not be apparent in the available data, and as an indicator of nontraditional status (Bean & Metzner, 1985; L. Horn, Cataldi, & Sikora, 2006). In addition, some research indicates that the effects of remediation on persistence may be stronger for younger students (Calcagno, Crosta, Bailey, & Jenkins, 2007).

Socioeconomic status. This factor emerges as the strongest predictor of graduation in multiple studies, regardless of race, gender, and academic preparation, and will be included as an important control here (Adelman, 2006; Reason, 2009; Ross et al., 2012).

Parental education level. Related to socioeconomic status, parental education level is also a robust predictor of college success, with first-generation students exhibiting lower odds of persistence (Choy, 2001; Hahs Vaughn, 2004; Ross et al., 2012). As an early factor in academic development, the K-12 achievement gap associated with parental education has held steady for the past fifty years, although it has not increased in the way that the income-based gap has done in that period (Reardon, 2011). Parents who lack first-hand knowledge of how to prepare for, apply to, and succeed in college have limited means to help their children navigate the postsecondary landscape, particularly working class parents juggling multiple jobs whose work schedules keep them from attending events at the high school or college (Rowan-Kenyon, Bell, & Perna, 2008).

Academic preparation.

High school curriculum, GPA, and mathematics coursework. The second category of student entry characteristics is academic preparation. Akin to what Adelman describes as "academic resources" (1999; 2006), these factors include the rigor of the high school courses taken, particularly in the mathematics sequence, and high school academic achievement as measured by GPA. Academic preparation is a strong predictor of degree attainment even in the presence of demographic controls (Ross et al., 2012). Furthermore, some studies have identified a compensatory effect of academic preparation for the negative effects of low socioeconomic status, with the influence of this factor magnified for lower-income students (Adelman, 2006; Cabrera et al., 2012; Klepfer & Hull, 2012). The quality of a high school and the level of courses offered there are associated with the socioeconomic status of the student body, as well as with the rate of college remediation among the high school's graduates (Howell, 2011).

Student experiences in the postsecondary system. Tinto's model and most subsequent frameworks include an extensive treatment of student interactions and experiences during their postsecondary career. This study includes several key components of that experience.

Academic and social integration. The student's alignment and fit with the social and academic world of the college exhibits an effect in many studies (Barnett, 2011;

Braxton et al., 1997; Braxton & Lien, 2000; Ross et al., 2012). As discussed previously, these interactions that build a student's sense of belonging at an institution may take different forms in a commuter college setting (Deil-Amen, 2011; Karp et al., 2008), and may have a weaker relationship to persistence in those contexts (Crisp & Nora, 2010).

Financial aid. Drawing from the economic literature, a student's ability to pay exerts an influence on student decisions about college persistence, an effect that may be exacerbated by the need to take additional remedial courses. As discussed earlier, grant aid (as opposed to loans) has been found to associate with persistence, particularly among minority and low-income students (Bettinger, 2012; R. Chen & DesJardins, 2010; Dynarski & Scott-Clayton, 2013; Gross & Ziskin, 2007; Paulsen & St. John, 2002).

Declaring a major. Declaring a major can be viewed as a signal that the student has made a more serious commitment to college, or as a result of stronger advising and support from the college. Students who declare a major are more likely to persist than those who do not (Achieving the Dream, 2011; Titus, 2006b). However, the research record is not monolithic on this topic; one study of community college students found those in remediation were more likely than their counterparts to declare a major in the first year (Chiang, 2012).

Multi-institution enrollment. The varied and sometimes itinerant attendance so common among today's students is also included in this conceptual model. Because this study models system-wide persistence, the path students take through various institutions to a degree is important to consider. As McCormick's research has shown, the majority of students attend more than one college, and many "swirl" or "double dip" back and forth between multiple two- and four-year institutions to accumulate credits for a degree

(2003). Attending more than one institution not only has a negative effect on Bachelor's degree attainment overall, but also complicates the researcher's ability to isolate the effect of any one institution (McCormick, 2003; Pascarella & Terenzini, 2005). However, some students, whom Adelman calls "four year drop-ins," maintain a primary relationship with a single four-year institution while accumulating some credits at a community college; these students tend to have even better odds of graduation than their peers who stayed in one place (Adelman, 2005; McCormick, 2003), as do those who transfer up to a more selective college (Wang & Wickersham, 2013).

Full-time enrollment. Whether or not a student maintains full-time enrollment is also an important factor. Part-time enrollment is associated with lower odds of degree completion (Attewell et al., 2011; Cabrera et al., 2012; Ross et al., 2012), and making lengthy "stop-outs" has a more deleterious effect than dropping to part-time status (Adelman, 2006; Pascarella & Terenzini, 2005).

Remediation. Finally, the on-campus experience of key interest in this study is remediation. As discussed previously, the evidence for the relationship between enrolling in remedial courses and completing a degree is inconclusive (Melguizo et al., 2011). This relationship appears to depend in part on the number and type of remedial courses taken (Boatman & Long, 2010; Flow-Delwiche, 2012).

Environmental pull factors. As Bean and Metzner (1985) and other theorists have argued, external factors are important, particularly for nontraditional students.

Having a dependent child. The demands of parenting are associated with lower odds of graduating (Attewell et al., 2011; St. John et al., 2000; Taniguchi & Kaufman, 2005).

Employment. Working off-campus, particularly for more than half-time, has also demonstrated negative effects on graduation in several studies (Bozick, 2007; Pascarella & Terenzini, 2005; Ross et al., 2012). It should be noted that Bozick (2007) did not find any relationship between lower-intensity work (less than 20 hours per week) and persistence, and a recent study of community college students indicated very small decreases in GPA associated with working 10 hours per week (Dadgar, 2012).

Institutional characteristics. The relationships described thus far – between degree attainment and student entry characteristics, postsecondary experiences, and environmental pull factors – are all formed and enacted within the context of the higher education institution. This conceptual framework allows for an examination of the moderating effects of essential institutional contextual factors on these relationships. While the framework does not include some constructs proposed by Berger and Milem (such as the organization's bureaucratic, symbolic, and political behavior), it focuses on the core organizational features that structure remediation policies and experiences at an institution.

Structural/demographic institutional characteristics. Borrowing Berger and Milem's terminology, the structural/demographic characteristics of an institution are those aspects that cannot be readily changed.

Level. Patterns of persistence and remediation vary according to the level of the college (whether it offers two-year degrees only versus four-year degrees). Students seeking a Bachelor's degree have better odds of success if they begin their studies at a four-year degree-granting institution (Doyle, 2009; Pascarella & Terenzini, 2005; Ross et al., 2012; Velez, 1985). Attewell, Heil, and Reiser (2011) also found that the pattern of racial gaps differed by institutional level, with direct effects of race/ethnicity on college completion rates within two-year institutions, but only indirect effects at four-year institutions. They also found stronger effects of external pull factors and a weaker influence of academic preparation in two-year colleges.

Public/Private institutional control. Students at privately controlled institutions also tend to demonstrate greater persistence and completion rates on average than undergraduates at public colleges (Astin & Oseguera, 2012; Titus, 2006a; Titus, 2006b), although much of the gap can be explained by student entry characteristics and experiences they have at the college (Pascarella & Terenzini, 2005).

Size. Smaller enrollment is associated with better student outcomes as well (Adelman, 2006; Astin & Oseguera, 2012; T. W. Bailey, Calcagno, Jenkins, Leinbach, & Kienzl, 2006).

Peer characteristics (race and income). Aggregate student characteristics may have an effect on individual student persistence through the influence of peers. The racial composition of the student body has been the focus of research on the effects of diversity on student outcomes. Some studies have found increases in learning gains for students of all racial/ethnic groups when the student body is more diverse (Gurin, Dey, Hurtado, & Gurin, 2002). However, others have noted a negative association between persistence and higher proportions of minority students at two-year institutions (T. W. Bailey et al., 2006; Calcagno et al., 2008). The inclusion of this factor in the conceptual framework also allows for a further exploration of student-level racial differences in remediation and persistence, and whether they may be due in part to the concentration of minority students in institutions. The conceptual model also includes the proportion of students receiving federal financial aid, the aggregated counterpart to individual-level financial aid. Ehrenberg and Zhang (2005) saw lower graduation rates at institutions with higher percentages of Pell grant recipients. Titus (2006a; 2006b) also found a positive relationship between degree attainment and average socioeconomic status of the student body in four-year colleges, which may be closely related to financial aid usage. However, Calcagno et al. (2008) found no effect of financial aid per FTE enrollment at the two-year level.

Organizational behaviors. Berger and Milem (2000) place an emphasis on decisions and interactions undertaken by institutional actors; Pascarella (1984) also addresses interactions with faculty as part of his model, and Braxton and Hirschy include institutional commitment, which can be demonstrated by how the institution allocates its resources. More importantly, this category is represented in the framework because information about the effects of manipulable inputs is vital for higher education institutions. While structural characteristics like size and public/private control do not change for the most part, human resource policies can be applied by higher education administrators. This study focuses on one particular resource allocation choice that research has linked to persistence outcomes: faculty hiring.

Proportion of full-time faculty. The quality and organization of faculty is particularly relevant in light of trends toward greater reliance on adjuncts and part-time instructors. Although results are mixed, some studies have found that higher proportions of part-time faculty are associated with lower graduation rates (Chingos, 2012). For example, Ehrenberg and Zhang (2005) found this effect using the institution as the unit of analysis in four-year colleges. Similar results were obtained for two-year colleges

(Jacoby, 2006; Levin, 2005), including one study (Jaeger & Eagan, 2009) employing multilevel analysis to look at the percentage of credits a student earned in courses taught by part-timers.

Outcome: Degree attainment. Unlike Tinto's model (1993), which is designed to predict persistence within a single institution, this conceptual framework looks more broadly at system-wide persistence. The focus of this study is on attainment of a credential with labor market value, regardless of the path taken to earn it. For that reason, the system-wide outcome represents students who transfer, reverse transfer, or accumulate credits simultaneously from multiple institutions. By the same token, the outcomes examined include certificates as well as Associate's and Bachelor's degrees. Although certificates typically take less time to complete and have less stringent requirements than degrees, they are included in this framework because research has demonstrated that they have value in the labor market – in some fields, leading to higher average earnings than an Associate's degree (Jacobson & Mokher, 2009).

Limitations of the Conceptual Framework

While this conceptual model builds on the literature of college persistence frameworks, it does not include some elements highlighted by many researchers. The datasets used for this study lack reliable measures of some constructs that figure in the persistence literature. Where measures are unreliable or incomplete, they are excluded with the goal of ensuring a valid analysis that the data can solidly support. The risk of omitting potentially significant predictors is misspecification of the model and resulting biased estimates; the observed effects could be driven by unmeasured factors. Some omitted constructs are student social capital, college peer climate, and attitudinal/behavioral factors such as student effort and goal commitment. However, these topics are not directly germane to the present research questions. By addressing student-level factors that have demonstrated relatively large and consistent effects on persistence, such as prior academic preparation and socioeconomic status, this study aims to provide adequate controls for variation in persistence that may be confounded with the effects of remediation.

In addition, the framework does not include institutional variables related to organizational behaviors of interest to Berger and Milem (2000), such as the use of symbols and communication, nor the institutional policy information called for by Reason (2009). In fact, such information about higher education institutions is not generally available to researchers because it is not systematically collected on a national basis. Nor does this study investigate what happens inside the classroom; the findings from some qualitative studies have suggested that a predominance of traditional drill-based instruction in remedial courses (Grubb, 2013), as well as the misalignment of expectations between faculty and students (R. D. Cox, 2009), may impede the effectiveness of these classes. To more fully investigate the complex relationships among these variables, remediation, and persistence, studies based on a variety of datasets are needed, including national student survey data and qualitative studies at individual institutions.

However, the current study sets the stage for such future investigations by analyzing basic institutional variation in remediation. Little is known about the association between remedial education in different subjects and college enrollment, public and private control, and level of degree offerings. While not exhaustive, this conceptual framework attempts to survey the terrain of remediation across institutional settings in terms of these fundamental characteristics.

The available institutional measures cover core constructs pertinent to the dynamics of remediation. Identifying any existing differences between public and private institutions is important for accountability purposes; if public institutions, particularly the open-access community colleges, are not fulfilling their mandate to educate less-skilled students, taxpayers and policymakers need to know. Examining remediation in terms of institutional level, control, and size may also point to broad categories of institutions that remediate students more successfully than others, and that may serve as models for other colleges. The demographic profile of institutions by race and income could shed light on differential effects of remediation for different subpopulations; if institutions serving historically disadvantaged students use remediation less effectively, this finding would have implications for equity. In addition, disentangling the individual and aggregate effects of socioeconomic status and racial/ethnic group may offer additional context for student-level remediation outcomes. Finally, instructors play one of the most important roles in students' higher education experiences, particularly for nonresidential students who may not connect as much with advisors or peers; the proportion of full-time faculty is a key part of the organizational context that may interact with student's success in remediation.

Conclusion

Although remediation is just one of many factors in the college experience, it offers a useful point of entry for understanding the dynamics of persistence. The theoretical frameworks for persistence discussed in this chapter all attempt to describe the interactions between student and institution, and the mechanisms by which those interactions lead to different outcomes. Models in Tinto's tradition tend to discuss these processes in terms of integration and engagement, located primarily in the student; the frameworks deriving from organizational behavior theory focus more on institutional actors, organizational communication patterns, and transactions with the student. Remedial education is a space in which the student's academic abilities and psychosocial characteristics come into contact with the college's policies, its representatives, and its norms.

In sketching the landscape of persistence research, this chapter attempted to identify the key factors that have been shown to relate to college completion. The conceptual framework presented here brings together these core components: the student's entry characteristics, both demographic and academic; the student's postsecondary experiences, including enrollment patterns and academic and social integration; and environmental factors that "pull" the student away from school. It situates these components within an institutional context that includes both structural and organizational-behavioral aspects of the college.

Holding constant other measurable key factors in persistence to the extent possible with available measures (student entry characteristics, postsecondary experiences, and environmental forces), this dissertation study focuses on the relationship of participation in remediation to college completion. The study makes use of multilevel modeling techniques that allow for a richer exploration of how the institutional context interacts with this relationship.

By teasing out such interaction effects, this analysis aims to contribute to the growing body of literature on the relationship of remediation to college outcomes. As this chapter discussed, a limited set of rigorous quantitative studies have come to conflicting conclusions about the merits of remedial education. Newer research that differentiates between different levels of intensity and remedial course subjects shows promise for reaching a more nuanced understanding of these relationships. In that vein, the dissertation study examines the conditional effects of remediation in terms of student and institutional characteristics, as well as different numbers and types of remedial courses.

The next chapter describes the dataset and analytical methods used to address the research questions, including a more specific discussion of the measures that represent each factor in the conceptual framework.

CHAPTER 3. METHODS

This study examined the institutional factors related to college remediation and graduation rates. It addressed the following research questions:

1. What are the patterns of postsecondary remedial course-taking among students?
   a. Specifically, in which subjects do students receive remediation, and how many remedial courses do they take in total?
   b. How do these patterns vary by student demographic characteristics such as race, gender and income?
   c. How do these patterns vary by institutional level (i.e., two-year or four-year degrees granted)?
2. How is postsecondary remediation related to certificate and degree attainment?
   a. After controlling for students' demographic characteristics, academic preparation, and postsecondary experiences, as well as institutional characteristics, what is the relationship between students' enrollment in *any remediation* at their first institution and attainment of a postsecondary certificate or degree?
   b. After controlling for students' demographic characteristics, academic preparation, and postsecondary experiences, as well as institutional characteristics, what is the relationship between enrollment in *different subjects and numbers of remedial courses* and attainment of a certificate or degree?

3. Are the relationships between postsecondary remediation and certificate/degree attainment moderated by contextual characteristics of the student's first postsecondary institution?

    a. Do institutional characteristics predict variation in the relationship between enrollment in *any remediation* and attainment of a certificate or degree?

    b. Do institutional characteristics predict variation in the relationships between enrollment in *different remedial subjects and numbers of remedial courses* and attainment of a certificate or degree?

To answer the first question, descriptive statistics and cross-tabulations were generated. To answer the second and third questions, two-level logistic regression models with random intercepts and slopes were estimated separately for two-year and four-year college students. This chapter describes those analyses in detail. It outlines the data sources; the population of interest and the sample drawn from it; the instruments and measures used in the analyses; the analytic methods for addressing each research question, and the rationale for selecting them; and issues that complicated the analysis.

Data Sources

Data for this study were drawn from two national datasets collected and maintained by the National Center for Education Statistics (NCES): the 2004-2009 Beginning Postsecondary Students Longitudinal Study (BPS:04/09)[7] and the Integrated Postsecondary Education Data System (IPEDS).

Beginning Postsecondary Students Longitudinal Study

This study is the third in a series of panel studies following postsecondary students beginning in their first year of college. NCES undertook these studies to answer policy questions about student persistence and completion. The BPS:04/09 base sample drew on first-time undergraduate students from the larger cross-sectional 2003-2004 National Postsecondary Student Aid Study (NPSAS), an NCES study of college students pertaining to their use of financial aid. The BPS dataset includes self-reported data about students' enrollment, coursework, campus activities, employment, high school education, family, and demographics from student interviews conducted in 2004, 2006, and 2009; information about high school coursework and grades that students reported to the College Board or ACT; income, student loan, and financial aid data from college and government records, including the Free Application for Federal Student Aid (FAFSA) and the National Student Loan Data System (NSLDS); and transcripts provided by the colleges for all institutions attended by students in the sample (Wine, Janson, & Wheeless, 2011).

Integrated Postsecondary Education Data System

[7] To protect the confidentiality of survey participants, access to the data is restricted to authorized users. The author and her dissertation committee members have obtained authorization from the Institute of Education Sciences Data Security Office under a restricted data license held by Boston College.

IPEDS is the publically available repository for annual survey data collected from all U.S. postsecondary institutions that participate in federal student financial aid programs. Higher education institutions are legally required to submit certain information as a condition of participating in the aid programs. The institution-level data include enrollments, graduation rates, student body demographics, staffing, and finances (Knapp, Kelly-Reid, & Ginder, 2012). This study used IPEDS data from 2003-2004 for institutions attended by students in the BPS:04/09 sample.[8]

Population and Sample

Target Population

The BPS:04/09 is designed to be generalizable to all first-time undergraduate enrollees in the United States in the 2003-2004 academic year. This dissertation study seeks to make inferences about a subpopulation within this group: students who started their undergraduate studies at a public or not-for-profit institution, and were under the age of 24 at the time of enrollment.

Sample

NPSAS, the source of the BPS sample, used a multi-stage, stratified sampling design. The more than 7,500 institutions reporting to IPEDS served as the sampling frame for the first stage; students were then selected within strata (such as first time undergraduates, graduate students, etc.). Institutions were eligible for NPSAS if they met the criteria for participation in Title IV federal student financial aid programs, and offered certificate or degree programs of a minimum duration of three months or 300 clock

[8] IPEDS data were downloaded from the IPEDS Data Center. For data points not available from this source, the Delta Cost Project dataset was consulted. The longitudinal Delta Cost Project dataset was derived from IPEDS data from the years 1987-2010 under the auspices of the American Institutes for Research, and is maintained by NCES (Lenihan, 2012).

hours. Service academies, purely vocational institutions, and in-house employee education programs were excluded. Students concurrently enrolled in high school or GED programs were not eligible. In the restricted data files, there are records from at least one of the data sources for approximately 18,640 unique students attending 1,550 institutions.

Exclusions. This study excluded some cases from the BPS:04/09 sample. First, students were excluded if data were not available for all three interview rounds as well as the transcript study. In some cases, NCES imputed data or collected data from institutional sources for students who missed a round; these students were eligible for inclusion.

Second, students for whom a unique first institution could not be identified from transcript data (because of simultaneous enrollment in the first semester or discrepancies in the transcripts) were not included, because the institutional effects of the two schools could not be disentangled.

Third, students age 24 or older were left out of analyses because key variables related to high school preparation and academic ability were not collected for older students, making it impossible to properly specify the model and account for these important predictors of postsecondary academic performance and attainment.

Fourth, some students enroll in a course with no plan to earn a certificate or degree, for example, to learn a language or pursue a hobby. The first interview asked students about their reasons for enrollment. If a student responded that he/she did not attend college in order to complete a degree/certificate, nor to transfer, he/she was a candidate for exclusion from the sample. As a cross-check, the case was not excluded unless a second interview variable, which lists the student's first-year degree program, also reports that the student was not enrolled in a program. Students who explicitly did not enroll with the intent to earn a degree do not belong to the target population and should be excluded from the analysis. However, students with trivial enrollment spells (e.g., dropping out after one or two classes) were retained in the sample as long as they did not explicitly state that they had no degree intentions; evidence suggests that assignment to remediation may discourage some students from enrolling or continuing (T. W. Bailey et al., 2009), making the outcomes of such students an important part of the analysis.

Finally, some exclusions were made on the basis of the first institution the student attended. Although all institution records in the BPS dataset have an associated IPEDS identification number, a small number of these institutions (fewer than 10) could not be matched with any valid record in the IPEDS database, or were missing at least one institution-level variable. These colleges and all students associated with them were omitted. Students were excluded if they began their studies at a for-profit institution or at a school that did not offer at least a two-year degree, on the grounds that these categories of schools are qualitatively different from public and not-for-profit degree-granting colleges. Additionally, to support the requirements of the mixed-level modeling analysis, institutions were omitted if they had fewer than five students representing them in the dataset after all the student-level exclusions were applied. Although this last criterion applied only to 1,300 students (7%), it excluded 650 (42%) of institutions represented in the complete sample. (See further discussion under "Small Clusters" in this chapter.)

After applying all the exclusions listed herein, the analytic sample was reduced from 18,640 students to 10,380, and from 1,550 institutions to 660.[9] Table 1 summarizes the exclusions. The variables used to perform the exclusions are detailed in Appendix A.

[9] Per Institute of Education Sciences data confidentiality requirements, all data counts are rounded to the nearest 10.

Table 1.

Exclusion Criteria for Analytic Sample (Unweighted Counts)

Criteria	# (%) Excluded			
	Students (N=18,640)		*Institutions* (N=1,550)	
Student-Level				
Data not available from one or more sources[a]	3,700	(19.8%)	n.a.	
Cannot identify a unique first institution attended	460	(2.5%)	n.a.	
Age ≥ 24	2,670	(14.3%)	n.a.	
Explicitly did not enroll with intent to earn credential	390	(2.1%)	n.a.	
Total students excluded for above criteria[b]	*6,460*	*(34.7%)*	*n.a.*	
Institution-Level				
First institution attended:				
Is for-profit	2,180	(11.7%)	250	(16.2%)
Does not offer ≥ 2-year degrees	1,150	(6.0%)	120	(8.0%)
Associated with <5 students after exclusions applied	1,300	(7.0%)	650	(41.9%)
Total excluded for all criteria[b]	8,260	(44.3%)	890	(57.4%)

[a] Sources: 2004, 2006, and 2009 interview rounds, and transcript study.
[b] Some cases excluded for multiple criteria.

Instruments and Measures

Instruments

BPS:04/09 used a structured interview form, self-administered online or conducted by a trained interviewer by telephone or in person, to collect data from participants in spring 2004, spring 2006, and spring 2009. The interview topics included enrollment, coursework, campus activities, employment, high school education, family, and demographics.

For the transcript study, NCES collected student transcripts directly from all institutions attended by any student in the sample. Institutions were identified from the students' interviews, as well as from records in the National Student Clearinghouse. Trained coders converted the raw transcripts into data files with consistent representations of credit hours, course codes, etc.

Institutions respond to IPEDS each year by submitting a structured data collection form with specified definitions and formulas, e.g., for determining how many faculty are full-time versus part-time.

Measures

This study modeled postsecondary outcomes with remediation variables and other student and institutional predictors. (The modeling process is described in detail later in this chapter under Research Questions 2 and 3.) Drawing on the frameworks for persistence discussed in chapter 2, the study represented the constructs in the conceptual framework with specific measures. All student-level measures came from BPS:04/09 and its associated transcript study. Because BPS aggregated data from multiple sources, there were often discrepancies between variables intended to measure the same construct. In general, when there were multiple variables available for the same information, this study assumed that transcripts were a more reliable source than student self-report and used variables derived from the transcripts when available. The outcome and predictor variables used to address the research questions are described in the sub-sections that follow, and summarized in Table 2. In addition, Appendix A provides more detail about the BPS:04/09 and IPEDS source variables and how they were recoded.

Table 2.

Summary of Measures

OUTCOMES
Highest degree attained within six years of first enrollment:
Two-year college students
Certificate (Reference category = did not attain certificate)
Associate's degree (Reference category = did not attain AD)
Associate's degree or higher (Reference category = did not attain AD or higher)
Bachelor's degree or higher (Reference category = did not attain BA or higher)
Four-year college students
Bachelor's degree or higher (Reference category = did not attain BA or higher)
STUDENT-LEVEL PREDICTORS
Student Entry Characteristics: Demographic
Race:
Asian
Black
Hispanic
Other race
(Reference category = White)
Male (Reference category = Female)
Age
Income as a percentage of the poverty level
Parent(s) attended some college (Reference category = Neither parent attended some college)
Student Entry Characteristics: Academic Preparation
Attended private high school (Reference category = did not attend private high school)
Took Algebra II or higher (Reference category = highest math was less than Algebra II)
Took rigorous high school curriculum (Reference category = did not take rigorous curriculum)
High school GPA
Postsecondary Experiences
Academic integration index
Social integration index
Enrolled full-time during first year (Reference category = enrolled less than full-time)
Had Pell grant any year (Reference category = did not receive a Pell grant any year)
Declared a major in first year (Reference category = did not declare major)
Attendance pattern:
Attended 2 institutions
Attended 3 or more institutions
(Reference category = Attended 1 institution)

Remediation
Took at least 1 remedial course at 1st instit. (Reference category = Took no remedial courses)
Number of remedial courses at 1st institution:
Took 1-2 remedial courses at 1st institution
Took 3 or more remedial courses at 1st institution
(Reference category = Took no remedial courses at 1st institution)
Remedial Subjects at 1st Institution:
Mathematics
English
Reading
English as a Second Language
Other
(Reference category = Took no remedial courses at 1st institution)
Environmental Pull Factors
Worked full-time during first year (Reference category = did not work full-time)
Had a dependent child any year (Reference category = did not have dependent child)
INSTITUTION LEVEL PREDICTORS
Structural
Private control (Reference category = public control)
Enrollment
Student Body Characteristics
% Black
% Hispanic
% Receiving federal grants
Organizational Behavior
% Full-time faculty

Student-level predictors.

Student entry characteristics: Demographic. Race, gender, age, parental education level, and income level are background characteristics that prior research on national datasets has linked with differences in degree attainment (Adelman, 2006; Ross et al., 2012). BPS variables representing these demographic and background characteristics were available from student interviews. In addition, because BPS is based on the NPSAS sample, detailed, reliable income information was available from financial aid application records. The variable selected to represent income level for this study was the student's total 2002 income (accounting for parent and student income, family size, and dependency status) as a percentage of the federal poverty threshold for that year.

For descriptive analyses responding to the first research question, this continuous variable was divided into three levels representing approximately one third of cases each: low income (up to two times the poverty level), middle income (two to four times the poverty level), and high income (more than four times the poverty level). The continuous variable was used for the regression analyses to answer the remaining research questions.

Academic preparation. Students' academic achievement and preparation in high school have been found to be strong predictors of performance in college (Adelman, 2006; Attewell et al., 2011; Ross et al., 2012). This study included indicators of the type of high school attended (whether or not the school was private); the highest level of mathematics taken (whether or not the student took Algebra II or higher); the student's high school GPA; and whether the student took a rigorous set of courses (based on the standards established for federal Academic Competitiveness Grants). This self-reported set of variables, only available for students under age 24, came from information students reported to the College Board or ACT when taking college admissions tests, or from interview data.

Postsecondary experience. Several aspects of the student's experience while in college, including enrollment patterns and attitudinal factors, were used to predict degree attainment.

BPS measured academic integration with a set of four interview questions (administered during the first and second rounds of interviews). These items asked students to indicate how often they participated in study groups, had social contact with faculty, met with an academic advisor, and talked with faculty about academic matters outside of class. The response scale was ordinal, with the options "never," "sometimes," and “often” coded 0, 1, and 2. This study used the NCES-computed index based on the average of these four items.

Social integration was measured similarly with a set of three interview questions. These items asked students how often they had attended fine arts activities, participated in intramural or varsity sports, or participated in school clubs during the 2003-2004 academic year. As with the academic integration index, the average index computed by NCES was used.

Financial pressures also pose a threat to completing college (Attewell et al., 2011). Studies indicate that students who access federal grant funds have a lower risk of drop-out, and this association is stronger among lower-income and minority students compared to their higher-income and White peers (R. Chen & DesJardins, 2010). Although studies focused on financial aid issues use more complex variables, dummy variables representing the receipt of aid have proven robust as predictors (Pascarella & Terenzini, 2005). A dummy variable was included indicating whether the student received a federal Pell grant, awarded to students below a certain income threshold, at any point during the course of their studies. This information was available in the BPS:04/09 dataset from federal student loan records.

Whether or not the student declared a major during the first year was known from student self-report in interviews. Although the student’s major was included in the transcript files, a high percent missing made the transcripts a less reliable source than the interviews in this case.

The student’s pattern of enrollment is also represented. The traditional model of full-time attendance at a single college is no longer the norm; many students move back and forth between four-year institutions and cheaper community colleges, or step out for a semester to work and save money (McCormick, 2003). A dummy variable was computed from student interview data indicating whether or not the student was enrolled full-time during the first year. In addition, transcript data was used to create a set of dummy variables indicating whether the student attended one institution, two institutions, or three or more institutions.

Remediation. Enrollment in remedial classes was the key predictor of interest in this study. Information about remedial enrollment comes from student transcripts. Although colleges were asked to flag courses as “remedial,” this designation missed many courses that did not have “remedial” or “developmental” in the title, but in fact met the definition of providing instruction at a pre-college level, often without awarding credits. BPS undertook a painstaking coding procedure to identify remedial courses as accurately as possible, using not only course titles and descriptions provided by the college, but also looking more deeply into ambiguous course descriptions, and using indicators such as whether or not credit was awarded (Wine et al., 2011). Courses counted as remedial included pre-college math, basic English writing and grammar, reading comprehension, English as a second language (ESL), and study skills. A complete list of remedial course codes from the BPS College Course Map (Bryan & Simone, 2012) is provided in Appendix B.

A dichotomous predictor indicating whether or not a student enrolled in any remedial course at the first institution was employed to answer the research questions about the overall effects of remediation.[10] For the questions about different patterns of remediation, dummy variables were computed indicating whether or not the student took remedial courses in a specific subject area at the first institution; the areas were Mathematics, English, Reading, ESL, and Other (i.e., support skills, developmental skills). In addition, a set of dummy variables representing the intensity of remediation indicated whether the total number of remedial courses taken in any subject at any institution during the years of the BPS:04/09 study was zero, one-to-two, or three or more.

Environmental pull factors. Working full-time while enrolled has been found to be associated with lower graduation rates (Bozick, 2007; Ross et al., 2012). Because some research indicates that part-time or low-intensity employment may not have negative effects (Bozick, 2007; Dadgar, 2012), this study focuses on higher-intensity employment. Students reported on their employment status in interviews. A dummy variable was computed indicating whether or not the student worked full time (defined as 35 hours or more per week) during the 2003-2004 academic year (the first year enrolled).

In addition, students reported whether or not they had any dependent children in each year. A dummy variable indicating whether or not the student had a child in any year of the study was computed.

Institution-level predictors. Several variables representing the institutional context were used to address the research questions, based on prior research on institutional factors associated with differences in persistence and graduation rates.

[10] The summary remediation variables provided by NCES in the BPS:04/09 dataset were adjusted by the author to correct for two course codes inadvertently left out of some calculations (Simone, 2013).

Institutional data for the first institution attended by each student in the analytic sample came from the 2003-2004 IPEDS data files.

Structural. A dummy variable indicated whether or not the institution was privately controlled, with public control as the reference category. For-profit and less-than-two-year institutions were excluded from the analysis as discussed in a previous section.

Several studies have found links between institution size and academic outcomes, although with mixed results (Calcagno et al., 2008; Titus, 2004). Total enrollment was included as a continuous variable.

Student body characteristics. Some studies suggest that the college environment can be more or less supportive of persistence, depending on aggregate characteristics of the students and peer effects (Franke, 2012; Titus, 2004; Titus, 2006b). The percentage of Black students and percentage of Hispanic students were included as continuous variables. Because both of these racial composition variables were highly positively skewed, square root transformations were used (see chapter 4 for more detail). The proportion of students receiving federal financial aid, a proxy for overall socioeconomic status of the student body, was also part of the model.

Organizational behavior. College resource allocations are a critical part of the analysis because administrators can alter them more easily than characteristics like public/private control or size. The percentage of faculty who were full-time was used as an important input related to student instruction. Research has found mixed associations between faculty characteristics and student outcomes (Chingos, 2012).

Outcome variables. This study examined the highest credential attained within six years of initial college enrollment. For students beginning at four-year colleges, the analysis examined whether or not the highest credential attained was a Bachelor's degree or higher. For students beginning at two-year institutions, a sequence of credentials was examined. First, the study analyzed the odds of the highest credential being at least an Associate's degree (including those who went on to earn a Bachelor's or higher). Then, the analysis looked separately at three different levels of attainment: a certificate being the highest credential attained, an Associate's degree being the highest level of attainment, and a Bachelor's degree or higher being the highest degree attained. Certificates and degrees from *any* institution, not just the first attended, were counted because the research questions center on persistence to completion in general, not on persistence within a particular institution; furthermore, this outcome captures students who start at a two-year college and transfer elsewhere to complete a four-year degree. Each category of credential attainment was represented by a dummy variable derived from student transcript records.

Missing Data

As the first step, missing values were assessed. After excluding students who had no data available for one of the three interviews or the transcript study, each student-level variable was available for at least 95% of cases. The outcome measures (whether or not the student attained a certificate, Associate's degree, or Bachelor's degree by 2009) had no missing values. The key predictor of interest (whether or not the student took a remedial course at the first institution) was missing for 40 students. Regression estimates are not sensitive to the choice of treatment of missing data at such minimal levels (Little

& Rubin, 2002), so straightforward methods such as mean substitution or listwise deletion are acceptable. Overall, 890 students were missing at least one student-level variable; excluding them would also cause additional institutions to drop below the five-student minimum, along with their associated students. To avoid losing more clusters, mean substitution was performed, conditional on whether the student first attended a two-year or four-year college. However, because remediation was the key predictor of interest, missing values were not substituted for those variables; the small number of students with missing information about remedial courses were excluded. The resulting sample for analysis contains 10,340 students at 670 institutions (3,520 starting at 230 two-year colleges and 6,820 starting at 440 four-year colleges). None of the institution-level variables were missing for the 670 colleges associated with students in the analysis sample.

Table 3 summarizes the missing data for each variable in the models.

Table 3.
Student-Level Missing Data: Number and Percentage of Students in the Analytical Sample (Unweighted Counts)

Variable	# (%) Students Missing Data N=10,380	Treatment of Missing Data
OUTCOME		
Attained a certificate/degree	0 (0.0%)	
PREDICTORS		
Student Entry Characteristics: Demographic		
Race	0 (0.0%)	
Gender	0 (0.0%)	
Age	0 (0.0%)	
Income % of poverty level	0 (0.0%)	
Parents' education	130 (1.3%)	Conditional Mean Substitution
Student Entry Characteristics: Academic Preparation		
Attended private high school	350 (3.4%)	Conditional Mean Substitution
Took Algebra II or higher	0 (0.0%)	
Rigorous high school curriculum	0 (0.0%)	
High school GPA	530 (5.1%)	Conditional Mean Substitution
Postsecondary Experience		
Academic integration index	40 (0.4%)	Conditional Mean Substitution
Social integration index	40 (0.4%)	Conditional Mean Substitution
Enrolled full-time during first year	0 (0.0%)	
Had Pell grant	0 (0.0%)	
Declared a major in first year	0 (0.0%)	
Attended 2 institutions	0 (0.0%)	
Attended 3 or more institutions	0 (0.0%)	
Remediation at First Institution		
Took at least 1 remedial course	40 (0.4%)	Deletion
Took remedial Mathematics	40 (0.4%)	Deletion
Took remedial English	40 (0.4%)	Deletion
Took remedial Reading	40 (0.4%)	Deletion
Took remedial ESL	40 (0.4%)	Deletion
Took remedial – Other	40 (0.4%)	Deletion
Took 1-2 remedial courses	20 (0.2%)	Deletion
Took 3 or more remedial courses	20 (0.2%)	Deletion
Environmental Pull Factors		
Worked full-time during first year	0 (0.0%)	
Had a dependent child	0 (0.0%)	

Analysis Plan

This section describes the analytic methods used to address each research question. It explains design decisions, how data were prepared before analysis, the application of multilevel modeling for a binary outcome, the statistical models used, the modeling-building process, and technical choices regarding weights, centering, and estimation methods.

Analyses by Research Question

Research Question 1: Descriptive analysis. The first set of research questions were answered with descriptive analyses of student-level data.

RQ1. What are the patterns of postsecondary remedial course-taking among students? (a) Specifically, in which subjects do students receive remediation, and how many remedial courses do they take in total? (b) How do these patterns vary by student demographic characteristics such as gender, race, and income level? (c) How do these patterns vary by institutional level?

To address research question 1(a), the number and percentage of students receiving any remediation in Mathematics, English, Reading, English as a Second Language (ESL), and Other subjects at their first institution was estimated, as well as the percentage taking more than one subject. The results from research question 1(a) were disaggregated by student gender, race, and income category to answer research question 1(b). Combinations of race, gender, and income were also examined. Statistical tests were used to assess differences in proportions between these subgroups. To answer research question 1(c), the analyses for research questions 1(a) and (b) were performed separately for two-year versus four-year institutions.

To estimate correct standard errors that accounted for the clustering of students in institutions, as well as for the complex stratified sampling structure of BPS:04/09, these statistics were generated using the complex sampling feature of SPSS 21.0 (IBM Corp, 2012). Taylor linearization was used to compute estimates, a widely used estimation technique whose accuracy and comparability to other methods such as bootstrapping has been demonstrated in empirical studies (Rust, 1985; Wolter, 1985). The complex samples function takes into account the sampling design using the strata, primary sampling unit, and sampling weight. The NCES-recommended sampling weight (WTB000) for panel analyses that combine interview and transcript data, which incorporates adjustments for nonresponse as well as probability of selection, was used.

Research Questions 2 and 3: Multilevel Modeling. In order to understand relationships between institution-level contextual factors and student-level outcomes, the study used multilevel regression models to answer the remaining research questions.

Two important design decisions were made. First, institution-level variables were drawn from the first college only. Although many students attend multiple colleges, this analysis concentrated on the first institution attended as the context for analysis. More than 90% of remediated students in BPS:04/09 took at least one of their remedial classes at their first institution (National Center for Education Statistics, 2011), bearing out evidence from other data sources that college students typically take such classes as freshmen (Parsad, Lewis, & Greene, 2003). This analysis assumed that the context of the first institution is the most crucial for the remediation experience. Therefore, it has the most relevance to the relationship between remedial enrollment and degree attainment. However, irrespective of remediation, the influence of the first institution on eventual graduation may be weaker than that of later institutions for students who quickly transfer elsewhere. This limitation should be kept in mind when making inferences about such students.

Second, separate models were fit for two-year and four-year degree-granting institutions. This design allowed for examination of different, more specific degree attainment outcomes as appropriate for each level. Because the two populations are fundamentally different, a single common set of parameters would likely fail to accurately represent both groups.

Data Preparation. In preparation for multilevel modeling, the data were first examined according to best practices for assessing fit and assumptions (Fox, 2008; Menard, 1995). These exploratory analyses were performed with a single-level logistic regression in SPSS 21.0 (IBM Corp, 2012) using the complex samples function in order to generate the required fit statistics.

Outliers and influential cases. Residual plots were examined to identify outliers, using Menard's (1995) criteria for adequate fit: less than 5 percent Studentized residuals greater than 2, and no standardized residuals greater than 4. To check for influential cases, statistics were examined for leverage values greater than 2 times the mean and DFBETA statistics indicating substantively large changes in the coefficient estimates if the case were removed.

Variable transformations. Each of the measures used in the analysis was examined for potential violations of linearity in the logit, an assumption of logistic regression. Criteria used were: skewness statistics no greater than 2 times the standard error (Tabachnik & Fidell, 2013); a nonsignificant Box-Tidwell statistic (the regression coefficient of the predictor times its natural log); and no sign of nonlinearity from a visual examination of scatterplots of the fitted logit value against the predictor (Menard, 1995). Where warranted, transformations were performed to guard against this violation. See chapter 4 for further discussion.

Colinearity. Colinearity poses problems for regression analysis; high levels of shared variance among predictor variables can make it difficult to tease out the unique variance in the outcome explained by any single predictor, and may produce large standard errors. Following Menard's (1995) guidelines, diagnostic statistics were obtained by analyzing a single-level ordinary least squares version of the model. The resulting tolerance statistics were examined for values below 0.20 indicting problematic colinearity. Bivariate correlations were also examined.

Multilevel modeling. The models to answer research questions 2 and 3 employed multilevel modeling techniques. The analysis was performed using HLM 6.0 (Raudenbush, Bryk, & Congdon, 2004).

When cases are clustered within groups, as is the case with the BPS:04/09 students grouped within colleges, they share a common context that may influence their outcomes. If a significant portion of the variance in outcomes is among clusters, the individual cases are not independent of each other, violating an assumption of ordinary least squares regression analysis. Cluster-based dependency leads to underestimation of standard errors because each case does not contribute unique information. To obtain more accurate estimates of standard errors, a mixed model takes clustering into account with a complex error term.

Furthermore, estimating a single coefficient to represent the intercept or slope across all clusters may yield misleading results. The magnitude and direction of slopes may vary a great deal from one cluster to another, meaning that an average coefficient may fail to capture existing relationships or misrepresent them. A mixed model allows the coefficients for each cluster to vary randomly. This feature of the model allows for the incorporation of cluster-level variables to predict differences in case-level parameters (Raudenbush & Bryk, 2002).

For this study, mixed-level modeling provided a way not only to estimate error terms correctly, but also to assess whether college factors such as total enrollment and proportion of full-time faculty could account for any differences across schools in the student-level relationship between remediation and degree attainment.

Binary logistic regression. Because the outcome, attainment of a certificate/degree, is binary, the generalized linear mixed model was used. Unlike linear regression, which assumes that the outcome is an interval or ratio measure, logistic regression models the probability that the outcome will fall into one of two categories, coded 0 and 1. The odds of the outcome being equal to 1 (in this case, the odds of the student attaining a degree) undergo a logarithmic transformation into the form η using the link function:

$$\eta_{ij} = \log\left(\frac{\varphi_{ij}}{1-\varphi_{ij}}\right) \tag{1}$$

In Equation 1, φ is the probability that y=1 for the i^{th} member of the j^{th} group. Then a linear model is fit with η as the outcome. The resulting regression coefficients can be expressed both in log-odds form and in the equivalent exponentiated form as odds ratios.

Statistical models. The following models were used to address the second and third sets of research questions.

Research question 2(a). The second research question asked, "How is postsecondary remediation related to degree attainment? After controlling for students' demographic characteristics, academic preparation, and postsecondary experiences, as well as institutional factors, what is the relationship between students' enrollment in any postsecondary remediation at the first institution and attainment of a postsecondary certificate or degree?"

This research question was answered with a series of two-level logistic regression analyses, modeling the probability of students' completing a postsecondary certificate or degree at any institution as a function of student-level predictors, with particular attention to the coefficient for receiving remediation at the first institution.

As shown in Equation Set 2, the main predictor of interest is whether or not the student took any remedial course at the first institution. In addition, the analysis controls for student-level factors that have been shown in prior research to be associated with degree completion (Adelman, 2006; Attewell et al., 2006; Braxton & Hirschy, 2005). These include: student demographic characteristics (race, gender, age, parental education level, and income); student academic preparation (taking a rigorous high school curriculum, attending a private high school, taking at least Algebra II, and high school grade point average); the student's postsecondary experience (academic and social integration, full-time enrollment, number of institutions attended, receiving a Pell grant, and declaring a major); and environmental pull factors (having a dependent child and working full-time).

At the institution level, covariates selected based on the research literature (Calcagno et al., 2008; Titus, 2004) were: public/private control; total undergraduate enrollment; student body aggregate characteristics (percent of students who are Black, Hispanic, and receiving federal financial aid); and proportion of full-time faculty. These covariates were entered as predictors of a randomly varying intercept at Level 2.

Level 1:

$\eta_{ij} =$

$\beta_{0j} + \beta_{1j}(\text{Any Remediation})_{ij} + \sum_{m=1}^{a} \beta_{mj}^{a}(\text{Student Char.})_{ij} +$

$\sum_{m=1}^{b} \beta_{mj}^{b}(\text{Acad. Prep.})_{ij} + \sum_{m=1}^{c} \beta_{mj}^{c}(\text{Postsec. Exper.})_{ij} + \sum_{m=1}^{d} \beta_{mj}^{d}(\text{Pull Factors})_{ij}$

Level 2:

$\beta_{0j} = \gamma_{00} + \sum_{r=1}^{w} \gamma_{0r}^{w}(\text{Instit. Factors})_{j} + u_{0j}$

$\beta_{mj}^{a} = \gamma_{m0}^{a} + u_{mj}^{a}$ (m = 1, …, a)

$\beta_{mj}^{b} = \gamma_{m0}^{b} + u_{mj}^{b}$ (m = 1, …, b)

$\beta_{mj}^{c} = \gamma_{m0}^{c} + u_{mj}^{c}$ (m = 1, …, c)

$\beta_{mj}^{d} = \gamma_{m0}^{d} + u_{mj}^{d}$ (m = 1, …, d) (2)

In Equation Sets 2-5, *i* indexes students, *j* indexes colleges, *m* indexes student-level covariates within a given set, and *r* indexes college-level covariates. Note that slopes are shown as randomly varying in Equation Set 2; see the discussion under "Model-building Process" in this chapter for details of the process and criteria that were used to determine whether each slope was fixed or allowed to vary randomly.

Research question 2(b). The second research question then asked, "After controlling for students' demographic characteristics, academic preparation, and postsecondary experiences, as well as institutional factors, what is the relationship between enrollment in different subjects and numbers of remedial courses and attainment of a certificate or degree?"

This statistical model has the same form as the previous one, but a set of predictors related to remediation ("Remed. Sub./Num." in Equation Set 3) is used instead of the single dummy variable for remediation at the first institution. For models analyzing the number of remedial courses, those predictors are taking one-to-two courses and taking three or more courses, with taking no courses as the reference category. For models analyzing the subjects of remedial courses, the set of predictors is five dummy variables indicating whether or not the student took each remedial subject at the first institution (Mathematics, English, Reading, ESL, and Other), with no remediation as the reference category. The subject dummy variables did not represent mutually exclusive categories; some students took multiple remedial subjects.

Level 1:

$$\eta_{ij} = \beta_{0j} + \sum_{m=1}^{\theta} \beta_{mj}^{\theta}(\text{Remed. Subj./Num.})_{ij} + \sum_{m=1}^{a} \beta_{mj}^{a}(\text{Student Char.})_{ij} +$$

$$\sum_{m=1}^{b} \beta_{mj}^{b}(\text{Acad. Prep.})_{ij} + \sum_{m=1}^{c} \beta_{mj}^{c}(\text{Postsec. Exper.})_{ij} + \sum_{m=1}^{d} \beta_{mj}^{d}(\text{Pull Factors})_{ij}$$

Level 2:

$$\beta_{0j} = \gamma_{00} + \sum_{r=1}^{w} \gamma_{0r}^{w}(\text{Instit. Factors})_{j} + u_{0j}$$

$$\beta_{mj}^{\theta} = \gamma_{m0}^{\theta} + u_{mj}^{\theta} \text{ (m = 1, …, θ)}$$

$$\beta_{mj}^{a} = \gamma_{m0}^{a} + u_{mj}^{a} \text{ (m = 1, …, a)}$$

$$\beta_{mj}^{b} = \gamma_{m0}^{b} + u_{mj}^{b} \text{ (m = 1, …, b)}$$

$$\beta_{mj}^{c} = \gamma_{m0}^{c} + u_{mj}^{c} \text{ (m = 1, …, c)}$$

$$\beta_{mj}^{d} = \gamma_{m0}^{d} + u_{mj}^{d} \text{ (m = 1, …, d)} \quad (3)$$

Research question 3(a). The third research question asked, "Are the relationships between postsecondary remediation and degree attainment moderated by contextual characteristics of the student's first postsecondary institution? (a) Do institutional characteristics predict variation in the relationship between enrollment in any remediation and attainment of a certificate or degree?"

To address this question, the relationship between remediation and degree outcome (i.e., the partial regression coefficient for remediation) was allowed to take on different values within each college, to assess whether it varied significantly across institutions (i.e., the remediation slope was allowed to vary randomly) as shown in Equation Set 4. If there was significant variation in the relationship, and if the slope representing that relationship could be reliably estimated, institutional characteristics were introduced into the model to investigate whether they were predictive of the remediation-attainment relationship. The same set of institutional predictors described for research questions 2a and b were tested in this Level 2 slope equation. As in the prior research questions, slopes for all covariates were also allowed to vary randomly one at a time to test whether or not they were heterogeneous, but individual slope parameters were fixed if results indicated unreliable or non-varying slopes across clusters. The model-building process and the criteria for including a random slope are described later in this chapter.

Level 1:

$\eta_{ij} =$

$\beta_{0j} + \beta_{1j}(\text{Any Remediation})_{ij} + \sum_{m=1}^{a} \beta_{mj}^{a}(\text{Student Char.})_{ij} +$

$\sum_{m=1}^{b} \beta_{mj}^{b}(\text{Acad. Prep.})_{ij} + \sum_{m=1}^{c} \beta_{mj}^{c}(\text{Postsec. Exper.})_{ij} + \sum_{m=1}^{d} \beta_{mj}^{d}(\text{Pull Factors})_{ij}$

Level 2:

$\beta_{0j} = \gamma_{00} + \sum_{r=1}^{w} \gamma_{0r}^{w}(\text{Instit. Factors})_{j} + u_{0j}$

$\beta_{1j} = \gamma_{10} + \sum_{r=1}^{w} \gamma_{r1}^{w}(\text{Instit. Factors})_{j} + u_{1j}$

$\beta_{mj}^{a} = \gamma_{m0}^{a} + u_{mj}^{a}$ (m = 1, …, a)

$\beta_{mj}^{b} = \gamma_{m0}^{b} + u_{mj}^{b}$ (m = 1, …, b)

$\beta_{mj}^{c} = \gamma_{m0}^{c} + u_{mj}^{c}$ (m = 1, …, c)

$\beta_{mj}^{d} = \gamma_{m0}^{d} + u_{mj}^{d}$ (m = 1, …, d) (4)

Research question 3(b). Finally, the third research question went on to ask, "Do institutional characteristics predict variation in the relationships between enrollment in different subjects and numbers of remedial courses and attainment of a certificate or degree?"

The statistical model for research question 3b (represented by Equation Set 5) is similar to the prior one, but with the set of remedial variables instead of the single dummy variable. Institution-level predictors were added to the Level 2 equations to predict variation in the intercepts and slope coefficients of each of the remediation variables. Institutional variables were not added to the equations for the random slopes of control variables, since explaining variation in those slopes was not the focus of the research questions.

Level 1:

$\eta_{ij} = \beta_{0j} + \sum_{m=1}^{\theta} \beta_{mj}^{\theta}(\text{Remed. Subj./Num.})_{ij} + \sum_{m=1}^{a} \beta_{mj}^{a}(\text{Student Char.})_{ij} +$

$\sum_{m=1}^{b} \beta_{mj}^{b}(\text{Acad. Prep.})_{ij} + \sum_{m=1}^{c} \beta_{mj}^{c}(\text{Postsec. Exper.})_{ij} + \sum_{m=1}^{d} \beta_{mj}^{d}(\text{Pull Factors})_{ij}$

Level 2:

$\beta_{0j} = \gamma_{00} + \sum_{r=1}^{w} \gamma_{0r}^{w}(\text{Instit. Factors})_{j} + u_{0j}$

$\beta_{mj}^{\theta} = \gamma_{m0}^{\theta} + \sum_{r=1}^{w} \gamma_{0r}^{w}(\text{Instit. Factors})_{j} + u_{mj}^{\theta}$ (m = 1, …, θ)

$\beta_{mj}^{a} = \gamma_{m0}^{a} + u_{mj}^{a}$ (m = 1, …, a)

$\beta_{mj}^{b} = \gamma_{m0}^{b} + u_{mj}^{b}$ (m = 1, …, b)

$\beta_{mj}^{c} = \gamma_{m0}^{c} + u_{mj}^{c}$ (m = 1, …, c)

$\beta_{mj}^{d} = \gamma_{m0}^{d} + u_{mj}^{d}$ (m = 1, …, d) (5)

Centering. Dummy variables were left uncentered so that zero values could be interpreted in terms of reference categories. Continuous variables were grand-mean centered – that is, the overall mean for the sample under analysis was subtracted from each student's score. Although group-mean centering (subtracting the mean for the group or institution) produces more accurate, less biased estimates for research questions concerning slope variation because it disentangles group and individual level effects (Enders & Tofighi, 2007), it was not effective in this analysis. An exploratory set of models fit with group-mean centering produced exceptionally large intercept estimates, indicating instability. Because many colleges in the dataset were represented by a relatively small number of students (discussed later in this chapter), the group-centered version of the model may have included more parameters than the data could support; the aggregate of each group-mean-centered predictor must be entered at the group level to re-introduce between-group differences and properly specify the model, adding to the total number of parameters estimated.

Estimation method. Laplace transformation was used to estimate values for the parameters in each model. This method has been shown to produce accurate results in two-level models with binary outcomes and random slopes (Yosef, 2001). Laplace transformation produces unit-specific estimates, which represent the relationship between predictors and the outcome, conditional on group membership. The coefficients for level-2 predictors W indicate the difference in the log-odds of the outcome for a one-unit change in W, while holding level-2 predictors and group mean on those predictors constant. Thus, unit-specific estimates are more useful for analyzing contextual effects of groups (Raudenbush & Bryk, 2002).

Weights. Some controversy surrounds the appropriate method for scaling weights in multilevel analyses. Simulation studies provide some evidence that unscaled weights used with multilevel complex sample data may introduce additional bias into regression coefficient estimates (Pfeffermann, Skinner, Holmes, Goldstein, & Rabat, 1998; Rabe-Hesketh & Skrondal, 2006). To take into account the probability of selection in the multi-stage stratified sampling design, as well as nonresponse, the NCES-recommended weight (WTB000) was entered at the student level.[11] The HLM 6.0 software scales the weights using the method recommended by Pfeffermann et al.

Power and minimum cluster size. Power, the ability to detect an effect if it exists in the population, depends on the number of units at both level-1 and level-2 in a multilevel analysis, as well as the average number of units per cluster. Raudenbush and Bryk (2002) suggest a rule of thumb of a minimum 20 level-1 units and 30 level-2 units, depending on the distribution of level-1 units across level-2 units. The analytic sample in this study meets these criteria, with 3,520 students and 230 institutions in the two-year sample and 6,820 students and 440 institutions in the four-year sample.

However, for multilevel models with random slopes, this minimum may not be adequate, and average cluster size must also be considered. After applying the exclusions to the sample, preliminary analysis of the data revealed that more than half the institutions were associated with fewer than 10 students each. The high proportion of small clusters could make the estimates vulnerable to bias. The empirical Bayes estimation method used in HLM is robust to sparse data such as that found in this sample because it augments the information from a given cluster with information from all other clusters, weighted by their relative precision. Braun, Jones, Rubin and Thayer (1983) demonstrate that empirical Bayes estimates are less biased than ordinary least squares estimates for sparse data in the continuous-outcome case. Although this issue has been studied less thoroughly for binary outcomes than for continuous (Paccagnella, 2011),

[11] The option of using decomposed weights at levels 1 and 2 was considered. However, the decomposed weights provided by NCES were associated with the institution from which the student was sampled in the NPSAS study. This institution did not correspond to the first institution attended in a small number of cases, meaning that students attending the same first institution might have different decomposed institution weights. Thus, the composite weight was used instead.

some simulation studies of multilevel binary logistic regression have found that variance estimates are biased downward when average cluster sizes are small (Rodriguez & Goldman, 1995; Theall et al., 2011). Moineddin, Matheson and Glazier (2007) recommend that for multilevel models with random slopes, researchers should apply a minimum sample size of 50 clusters of 50 members each to avoid bias – a high bar seldom achieved in social science research. Among the few existing multilevel logistic regression studies of national higher education panel datasets (including BPS and NELS), several make no reference to cluster size, presumably using all clusters regardless of size (Calcagno et al., 2008; Franke, 2012; Herrera, 2012); one such study explicitly excludes clusters that only contain one case (Titus, 2004).

Because reliable estimates of institution-level parameters would be difficult to obtain with such small cluster sizes, and shrinkage toward the mean for small clusters would bias the estimates (Raudenbush & Bryk, 2002), colleges represented by fewer than a certain minimum number of students were excluded from the analysis sample. To inform the selection of this minimum threshold, a preliminary analysis was performed to assess sensitivity to different values. Thirty models were fit that varied over five different minimum cluster sizes (two, five, ten, 15 and 20) and across six different model specifications that varied by the number of predictors, including interaction terms. The resulting parameter estimates were consistent across cluster minimums for all but the most complex model, which contained 22 level-1 predictors, six level-2 predictors, and six level-1 interaction terms. A minimum cluster size of five maintained the most consistency across all models. This floor was chosen in order to balance bias reduction with generalizability by not excluding an even higher number of students from the original sample. The complete results of the cluster size analysis are presented in Appendix C.

Model-building process. Model building proceeded according to best practice guidelines (McCoach, 2010; Raudenbush & Bryk, 2002).

First, an unconditional model was fit to estimate the intra-class correlation coefficient indicating the proportion of variance in the outcome attributed to between-institution differences.[12]

Next, the remediation variable (or set of dummy variables) was entered to estimate its unadjusted effect. Then, student-level control variables were entered in four blocks based on the conceptual framework (described in chapter 2): demographic characteristics, academic preparation, postsecondary experiences, and environmental pull factors. As discussed in the previous section and Appendix C, exploratory analysis found that complex models with large numbers of predictors and interaction terms became unstable and sensitive to the choice of minimum cluster size. Because the small number of students per institution could not support estimation of a large number of parameters in a logistic regression framework, a parsimonious approach to variable selection was taken. With the addition of each block, predictors that were not significant at the .05 level were excluded at the subsequent stage. Remediation variables were retained in the model at all stages regardless of statistical significance because they were central to the research question.

Once a final parsimonious set of predictors was identified, two-way interactions between student-level variables were tested one at a time. In keeping with the

[12] The intra-class correlation coefficient is estimated by: $\tau_{00}/(\tau_{00}+\pi^2/3)$, in which τ_{00} represents the estimated between-group variance and $\pi^2/3$ is an approximation of the within-group variance, as recommended by Snijders and Bosker (2012).

parsimonious approach, only interactions of substantive interest and relevance to the research question were examined (interactions of each control variable with the remediation variable(s), and interactions among gender, race and income). If an interaction term's regression coefficient was statistically significant at the .05 level and the model fit significantly improved as measured by a χ^2 test of the change in the deviance statistic (Fox, 2008; McCoach, 2010), the term was retained in the model.

Next, taking each predictor one at a time, the slope coefficient was allowed to vary randomly to test whether it should be fixed or free. Using Raudenbush and Bryk's criteria (2002), the slope was fixed if the main effect of the predictor was not statistically significant at the .05 level; if the slope variance was not significant at the .05 level; or if the slope reliability was less than .05. Additionally, if the model fit was not improved as measured by a reduction in the deviance statistic, the slope was fixed.

Using this final student-level model, the institution-level predictors were then entered as predictors of the random intercept. As with the student level, predictors significant at the .05 level were retained. Finally, if any remediation variable slopes had been allowed to vary randomly, the institutional predictors were tested as predictors of slope variance.

Interpretation of coefficients. Because logistic regression in a multilevel framework has some differences from standard ordinary least squares regression, the interpretation of the parameter estimates is addressed briefly here.

Fixed effects. Odds ratios provide one useful measure of the magnitude of a predictor's effect. However, a more intuitive formulation often used in education research is the Delta-*p* statistic (Petersen, 1985), representing the difference in the probability of Y=1 associated with a one-unit change in the predictor. For a categorical predictor, Delta-*p* represents the difference between the probability P_1 that the outcome Y=1 for the target population and the probability P_0 that Y=1 for the reference category (Equation 6f). Because it is stated in terms of the probability of the outcome occurring rather than as a ratio of odds, Delta-*p* lends itself to easier interpretation and judgment of practical significance. For categorical predictors, a revision to Petersen's formula is recommended (Cruce, 2009) that uses the rate of the outcome in the reference category as its baseline, and centers both outcome and predictor around their sample means. Cruce's (2009, p. 613) formulas for the adjusted calculation are shown in Equation Set 6 (sequence changed by this author):

$$L_{\overline{y}} = ln[\overline{y} \,/\, (1 - \overline{y})] \quad (6a)$$

$$L_1 = L_{\overline{y}} + B_x(1 - \overline{x}) \quad (6b)$$

$$P_1 = exp(L_1) \,/ [1 + exp(L_1)] \quad (6c)$$

$$L_0 = L_{\overline{y}} + B_x(0 - \overline{x}) \quad (6d)$$

$$P_0 = exp(L_0) \,/ [1 + exp(L_0)] \quad (6e)$$

$$\text{Delta-}p = P_1 - P_0 \quad (6f)$$

In Equation Set 6, $L_{\overline{y}}$ is the rate of the outcome occurring in the total sample $(\overline{y})$ in logit form (6a). L_1 is the logit form of the probability of Y=1 for the target group, calculated from the estimated logistic coefficient for the predictor (B_x) and the value of predictor X (in this case 1 for the target group) centered in terms of the rate of X occurring in the sample $(\overline{x})$ (6b). P_1 uses the exponentiated form of the logit L_1 to express it as the probability of Y=1 for the target population (6c). L_0 and P_0 are likewise calculated for the reference group (6d and 6e). The probabilities P_1 and P_0 are thus centered around the base rate of the outcome in the sample.

Both odds ratios and Delta-*p* statistics were used to interpret the magnitude and practical significance of results. In addition, the Cox index was used as an estimate of effect size. To assess the relative size and importance of logistic regression coefficients in a way that can be compared across studies with both continuous and categorical outcomes, the What Works Clearinghouse (WWC) (2011) also recommends the use of the Cox index (D. R. Cox, 1970). The Cox index is the log odds ratio divided by 1.65, essentially a standard deviation unit related to the variance of the logistic distribution ($\pi^2/3$) that can be interpreted in ways comparable to Hedge's G and other effect sizes used with continuous outcome models. A simulation study found this measure to be one of the least biased estimators for this purpose (Sanchez-Meca, Marin-Martinez, & Chacon-Moscoso, 2003). WWC defines a minimum effect size of 0.25 as "substantively important." (Note that "effect size" in the context of this nonexperimental study refers to the magnitude of the relationship between predictor and outcome, not a causal treatment effect.)

Because so many of the predictors were dummy indicators representing categorical predictors, they were left unstandardized so that coefficients could be interpreted in terms of a reference category. For the small number of continuous covariates, unstandardized results were presented in the tables found in chapter 4. Where standardization on X would aid interpretation (dividing the coefficient by the standard deviation of the predictor), this form was also calculated and discussed.

Random components. Variance component estimates in a multilevel logistic regression model are not interpreted in exactly the same way as those obtained from modeling of a continuous outcome. The within-group variance component σ^2 can be approximated by a fixed value of $\pi^2/3$ (or 3.29) (Snijders & Bosker, 2012). Because this value does not change, the addition of level-1 fixed effects may lead to increases in the estimates of other fixed and random components, including between-group variance τ_{00}. These properties complicate the representation of "variance explained," which cannot be estimated by simply calculating the reduction in variance components after the addition of predictors. Snijders and Bosker recommend an approximation of total variance explained by the fixed portion of the model using the formula σ^2_F /($\sigma^2_F + \tau^2_0 + \sigma^2_R$), in which explained variance (σ^2_F) is the observed variance of the linear predictor, calculated from the estimated coefficients $\hat{\gamma}$ and observed predictor values X across individuals and groups ($\hat{Y}_{ij} = \gamma_0 + \sum_{h=1}^{r} \gamma_h X_{hij}$); τ^2_0 is the observed between-group variance (or τ_{00} in Raudenbush and Bryk's (2002) notation); and within-group variance (σ^2_R) is fixed at $\pi^2/3$. Likewise, the intra-class correlation coefficient (ICC) can be approximated by τ^2_0 /($\tau^2_0 + \pi^2/3$). (Goldstein, Browne and Rasbash (2002) also describe this method of estimating the ICC or variance partition coefficient, with the caveat that it rests on the assumption of a continuous distribution underlying the dichotomous outcome.) The proportion of variance explained was calculated by this method in this study.

Limitations

Exclusions

The exclusion of some categories of students limits the generalizability of inferences based on this analysis. In particular, the necessity of omitting students over the age of 24 means that conclusions should be applied with great caution to the older student population. This study makes trade-offs in favor of internal over external validity. While the findings may not be readily applicable to all subpopulations of undergraduates, the analyses attempt to estimate sound, unbiased relationships for the selected subpopulations.

Small Clusters

As discussed earlier in this chapter, institutions represented by fewer than five students were excluded from analysis. Comparisons of students in the small, excluded clusters with those in larger, included clusters using χ^2 and t-tests[13] revealed that excluded students were significantly less likely to earn a degree (49% vs. 53%), more likely to be Black, more likely to have a Pell grant, and had lower incomes and lower high school GPA on average. Institutions associated with smaller, excluded clusters of students were significantly more likely than larger, included institutions to have lower enrollment; to be a two-year college; to have a higher proportion of Black students and students using federal financial aid; and to have lower graduation and retention rates. Because of these differences, particularly in graduation outcomes, generalization to the full target population of students and institutions is limited. In addition, the small cluster size (even with a minimum of five) means that the possibility of underestimating the

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[13] All other student-level exclusions were applied, and the weight WTB000 was used.

variance components cannot be discounted. In other words, there may exist a larger amount of unexplained variance between and within colleges than that represented by the estimates. Furthermore, the excluded institutions with smaller clusters of students may differ from included institutions in systematic ways.

Focus on the First Institution

As described in this chapter, the analysis looks only at institutional factors at the first school attended. For the many students who attended multiple colleges, the context of the other institutions presumably had some influence on their academic outcomes as well, although these effects are not modeled. The clustering of students in additional institutions may also introduce unmodeled dependencies in the error terms.

Limited Information about Academic Preparation and Ability

Unlike NELS, which collects high school transcripts and administers a standardized achievement test, BPS relies on student self-report for data on student ability and achievement, including high school GPA and coursework. Some students may not accurately recall or report these facts. More detailed, reliable measures of students' ability and high school coursework would likely have led to more accurate estimates.

Time Horizon For Degree Attainment

Long-term studies have found that among minority, lower-income populations at community colleges, as many as 29% of students who ultimately earn a degree take 10 years or more to do so (Attewell & Lavin, 2009). Because this dataset only follows students for six years after their initial enrollment, these longer-term outcomes were not captured.

State-Level Clustering

Public two- and four-year colleges are typically governed by a statewide body, which may set common policies for remediation and curriculum (Cohen & Brawer, 2008). The degree of centralization varies widely across states, but in some states, this common context could be considered a third level of clustering that introduces dependency among institutions. However, state effects are not included in the proposed models. Although all 50 states are represented in the analytic sample, there are only a small number of institutions per state, meaning that the model would not meet minimum requirements to produce unbiased variance estimates.

Observational Data and Unobserved Factors

It should be emphasized that this study cannot draw causal conclusions, and does not seek to do so. The BPS collects observational data, and does not use experimental controls or random assignment. As such, selection bias cannot be ruled out as a source of variation in outcomes. Any observed associations among variables may be due to unmeasured systematic differences between students who enroll in remediation and those who do not. Given this limitation, this dissertation study aims to make inferences about associations among factors, not to establish cause-effect relationships. It seeks to predict the relationship between remediation and graduation relationship using institutional variables. Like any nonexperimental study, it is vulnerable to bias from unobserved characteristics. It is possible that omitted factors may confound the effects of remediation and the observed factors on persistence, resulting in biased estimates.

Conclusion

This chapter has outlined the methodology used to address the research questions in this dissertation study, including the data sources, sample, instruments, measures to represent the constructs in the conceptual framework, analytic approach, and limitations. This methodology was selected as an appropriate and useful means of answering questions about student outcomes in an institutional context.

CHAPTER 4. RESULTS

This chapter addresses the research questions by presenting the results of the analyses described in the preceding chapter. The first research question asks, "What are the patterns of postsecondary remedial course-taking among students?" These patterns were described with univariate statistics and cross-tabulations of remediation with student degree attainment and demographic characteristics. To answer the second research question, "How is postsecondary remediation related to certificate and degree attainment?" a series of two-level models were estimated, with different models representing students in two- and four-year colleges and different levels of degree attainment. The third research question asks, "Are the relationships between postsecondary remediation and certificate/degree attainment moderated by contextual characteristics of the student's first postsecondary institution?" Variation in the relationship between remediation and degree attainment across institutions was tested using mixed models with random slope coefficients.

Research Question 1: Patterns of Remedial Course-Taking

The first research question asks, "What are the patterns of postsecondary remedial course-taking among students? Specifically, in which subjects do students receive remediation, and how many remedial courses do they take in total? How do these patterns vary by student demographic characteristics such as race, gender, and income? How do these patterns vary by institutional level (two-year versus four-year degrees granted)?" To address this question, descriptive statistics were estimated.

Table 4 presents the percentages of students who take remedial courses at their first institution, comparing students who first enrolled at two- and four-year institutions.

Logistic regression was performed to test the significance of relationships between level of institution and remedial course-taking variables.[14]

Table 4

Percentages of Students Taking Remedial Courses at Their First Institution

	Two-Year Institution % (*SE*)		Four-Year Institution % (*SE*)	
Took at least 1 remedial course at 1st institution	67.8%	(1.8%)	31.9%***	(1.7%)
# remedial courses taken at 1st institution				
0	32.2%	(1.8%)	68.1%***	(1.7%)
1-2	36.5%	(1.8%)	25.0%***	(1.2%)
3 or more	31.3%	(1.8%)	6.9%***	(0.8%)
Remedial subjects: Took at least 1 at 1st institution:				
Mathematics	59.0%	(1.7%)	24.6%***	(1.6%)
English	15.8%	(1.5%)	6.5%***	(0.9%)
Reading	19.5%	(1.6%)	4.7%***	(1.0%)
ESL	1.5%	(0.3%)	1.7%	(0.4%)
Other	5.8%	(1.3%)	3.2%	(0.7%)
Took multiple remedial subjects	27.3%	(1.6%)	7.3%***	(1.2%)

*p<.05; **p<.01; ***p<.001 for differences between two-year and four-year

A substantial proportion of students participated in remediation – two-thirds of two-year college students and nearly one-third of four-year college students. Students who first enrolled at two-year institutions were more than twice as likely to take one or more remedial courses than their counterparts starting at four-year institutions (67.8% compared to 31.9%), a difference that was statistically significant. Two-year college students also took more remedial courses on average, with 31.3% taking three or more such courses, compared to 6.9% of four-year students taking three or more. Among those students who did any remedial coursework (not shown in table), nearly half (46.2%) took

[14] Logistic regression was performed using the complex samples function of SPSS 21.0 (IBM, 2012) in order to account for the multilevel, stratified sampling design with students clustered within colleges, and thereby to obtain accurate standard error estimates.

three or more courses in the two-year college setting, while less than a quarter (21.5%) took three or more courses in the four-year college setting.

Mathematics was by far the most common subject of remediation in both groups (taken by 59.0% of two-year and 24.6% of four-year students), followed by Reading and English. English as a Second Language courses were taken by less than 2.0% of students at both levels, with no significant difference between two- and four-year students. Two-year students were also more likely to take multiple subjects (27.3%) than four-year students (7.3%).

Table 5 compares the rates of remedial course-taking among students with different demographic characteristics. Significance tests were performed by regressing a binary variable representing remediation on a set of dummy variables representing the categories of the given demographic characteristic. Gender, race, and income[15] were tested separately with female, White, and low-income as the respective reference categories.

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[15] For the purpose of comparing proportions among groups, the continuous variable used in the regression models (student income as a percentage of the poverty threshold) was transformed into a categorical variable. "Low" is up to two times the poverty level; "middle" is two to four times the poverty level; and "high" is more than four times the poverty level. These categories were selected to correspond roughly to one third of the sample each.

Table 5

Percentages of Students Taking One or More Remedial Courses at Their First Institution by Gender, Race, and Income

Two-Year Institutions	% Taking Remedial Courses (*SE*)			
Gender				
Female	Male			
69.8%	65.3%*			
(2.1%)	(2.2%)			
Race				
White	Asian	Black	Hispanic	Other
61.2%	70.8%	82.2%***	78.7%**	70.5%*
(2.5%)	(6.3%)	(2.7%)	(2.7%)	(3.4%)
Income				
Low	Middle	High		
72.5%	65.1%*	63.8%**		
(2.1%)	(2.8%)	(2.9%)		
Four-Year Institutions	% Taking Remedial Courses (*SE*)			
Gender				
Female	Male			
32.5%	31.1%			
(1.8%)	(1.9%)			
Race				
White	Asian	Black	Hispanic	Other
27.8%	25.9%	52.8%***	51.1%**	22.6%
(1.9%)	(3.4%)	(4.6%)	(3.1%)	(3.0%)
Income				
Low	Middle	High		
44.8%	32.6%***	23.6%***		
(2.3%)	(2.1%)	(1.6%)		

*p<.05; **p<.01; ***p<.001 for differences between columns. Reference category shown in leftmost column.
Note: Low income: < 2 times poverty level; Middle income: 2-4 times; high income: >4 times.

Within both two- and four-year institutions, male and female students took remedial courses at similar rates (although the difference was statistically significant in the two-year institutions). However, remediation differed significantly by racial category at both levels of institutions. Higher percentages of Black and Hispanic students took remedial courses compared to White students. Among two-year college students, 82.2%

of Black and 78.7% of Hispanic students took at least one remedial course, compared to 61.2% of White and 70.8% of Asian students. Students in the Other Race category were also more likely than White students to take such a course (70.5%). Among four-year college students, the differences were more pronounced. The proportion of remediated Black (52.8%) and Hispanic (51.1%) students was nearly twice that of White (27.8%), Asian (25.9%), or Other Race (22.6%) students.

Lower-income students were more likely to take remedial classes than their higher-income peers. For those starting their studies at a two-year institution, 72.5% of students in the lowest income category took remediation, compared to 63.8% of students in the highest income group. In four-year institutions, twice the percentage of low-income students (44.8%) were remediated as high-income (23.6%).

In sum, for race and income, the differences in remediation rates between categories were larger in the four-year setting than in the two-year setting; in two-year colleges, the majority of students in every category took remedial courses, with less variation by demographic characteristics.

Table 6 presents further detail of the interaction between gender and race categories.

Table 6

Percentages of Students Taking One or More Remedial Courses at Their First Institution: Interaction of Gender and Race

	Two-Year Institutions: % Remediated (SE)				*Four-Year Institutions: % Remediated (SE)*			
	Female		Male		Female		Male	
White	63.0%	(2.9%)	59.2%	(3.0%)	28.9%	(2.1%)	26.5%	(2.1%)
Asian	72.5%	(5.6%)	69.8%	(8.5%)	18.0%	(3.2%)	35.3%*	(6.1%)
Black	83.1%	(3.4%)	80.6%	(3.4%)	54.0%	(5.2%)	51.2%	(5.2%)
Hispanic	80.7%	(3.2%)	76.1%	(3.9%)	52.8%	(3.2%)	49.0%	(5.1%)
Other Race	72.3%	(4.1%)	67.7%	(7.9%)	20.3%	(3.7%)	25.1%	(4.4%)

*p<.05; **p<.01; ***p<.001 for differences between gender categories within race and institutional level

For the most part, the patterns were similar for race and gender, with little difference based on gender and with higher rates among Black and Hispanic students than White. However, this cross-tabulation identified a significant difference between male and female remediation rates among Asian four-year college students. In this subgroup, men were almost twice as likely to take a remedial course as women (35.3% versus 18.0%). It should be noted that this estimate was based on a small number of sampled male Asian four-year students, and the standard error for the estimate was somewhat large (6.1 percentage points). Asian women had the lowest remediation rate of any race-gender subgroup among four-year college students, while Black women had the highest rate. In the two-year college cohort, Black women also had the highest rate, while white men had the lowest rate.

Table 7 displays the interaction of gender and income category.

Table 7

Percentages of Students Taking One or More Remedial Courses at Their First Institution: Interaction of Gender and Income

	Low income	Middle income	High income
Two-Year Institutions: % Remediated (SE)			
Female	73.9% (2.5%)	68.0% (3.0%)	63.8%** (3.2%)
Male	70.4% (2.9%)	61.4% (3.9%)	63.8% (3.8%)
Four-Year Institutions: % Remediated (SE)			
Female	47.1% (2.6%)	31.0% (2.1%)***	24.3% (1.9%)***
Male	41.6% (2.9%)	34.5% (2.9%)*	22.8% (2.0%)***

*p<.05; **p<.01; ***p<.001 for differences between income categories within gender and institutional level
Note: Low income: < 2 times poverty level; Middle income: 2-4 times; high income: >4 times.

Remediation rates did not differ significantly by gender within any income category at two- or four-year institutions. Reflecting the pattern shown in Table 5, low-income students were significantly more likely to be remediated than middle- and high-income students within both gender groups at four-year institutions. Among women at two-year institutions, remediation rates were significantly higher for low-income students compared to high- (but not middle-) income students. However, no significant differences in remediation rates were found among male students at two-year colleges.

Table 8 details the interaction between race and income category.

Table 8

Percentages of Students Taking One or More Remedial Courses at Their First Institution: Interaction of Race and Income

	Two-Year Institutions: % Remediated (SE)					
	Low		Middle		High	
White	63.1%	(3.0%)	59.6%	(3.5%)	61.7%	(3.6%)
Asian	78.9%	(5.6%)	65.5%	(10.0%)	61.2%	(14.4%)
Black	79.6%	(3.8%)	89.0%*	(2.8%)	82.2%	(5.3%)
Hispanic	81.6%	(3.2%)	77.2%	(4.4%)	68.0%	(8.1%)
Other Race	71.9%	(5.0%)	64.9%	(9.3%)	74.5%	(8.2%)
	Four-Year Institutions: % Remediated (SE)					
	Low		Middle		High	
White	36.4%	(3.4%)	30.7%*	(2.4%)	22.9%***	(1.8%)
Asian	29.4%	(4.8%)	27.2%	(6.6%)	19.6%	(4.8%)
Black	56.7%	(4.5%)	49.6%	(6.0%)	47.8%	(9.1%)
Hispanic	66.6%	(3.9%)	41.6%**	(6.3%)	26.6%***	(4.3%)
Other Race	28.6%	(6.8%)	24.9%	(5.5%)	17.2%	(4.5%)

*p<.05; **p<.01; ***p<.001 for differences between income categories within race and institutional level
Note: Low income: < 2 times poverty level; Middle income: 2-4 times; high income: >4 times.

Among students at two-year institutions, income-based differences in remediation were no longer significant when disaggregated by race (with the exception of a small difference for middle-income Black students). The same could not be said for four-year institutions. Lower-income White and Hispanic students were more likely to take remedial classes than their middle- and high-income peers. The most dramatic gap was for Hispanic students: 66.6% of low-income Hispanic students took remedial classes at four-year colleges, compared to only 26.6% of high-income Hispanic students. These differences may be related to the diversity of ethnic groups coming under the umbrella of "Hispanic."

Looking at race within each income group[16], Black students were significantly more likely than White students to take remedial courses in the two-year college setting regardless of income category. In fact, even the high-income Black students were remediated at a higher rate (82.2%) than low-income White students (63.1%). Racial differences were more prominent within the lowest income category. At four-year colleges, a similar pattern held true: Black students exhibited higher remediation rates than their White peers within each income category.

Remediation and Degree Attainment

As a precursor to the multivariate analyses that follow, this section presents cross-tabulations of remediation and highest degree attained. Tables 9 and 10 present the rates of degree attainment for students taking remedial courses compared to those who did not.

[16] Table 8 does not show the results of statistical tests of differences by race within income group.

Table 9

Percentages of Two-year College Students Attaining a Credential within Six Years by Remediation Status at First Institution Attended

	Highest Credential Attained: Percent (SE)			
	Certificate	Associate's Degree	Associate's Degree or Higher	Bachelor's Degree or Higher
No remediation	7.0% (2.0%)	15.1% (1.8%)	35.8% (2.6%)	20.7% (2.1%)
At least 1 remedial course	3.6% (0.6%)	17.6% (1.3%)	28.2% (1.7%)	10.7% (1.1%)
Number of remedial courses				
1 or 2	4.4% (0.8%)	17.4% (1.8%)	31.2% (2.6%)	13.8% (1.7%)
3 or more	2.7% (0.9%)	17.7% (1.6%)	24.7% (2.1%)	7.0% (1.2%)
Remedial subjects				
Mathematics	3.1% (0.6%)	18.0% (1.4%)	28.3% (1.7%)	10.3% (1.1%)
English	3.6% (1.3%)	17.3% (1.8%)	23.6% (2.1%)	6.3% (1.2%)
Reading	2.7% (0.8%)	11.4% (1.4%)	19.0% (2.1%)	7.6% (1.4%)
ESL	5.4% (3.7%)	25.5% (9.3%)	52.2% (8.9%)	26.7% (8.5%)
Other subject	5.8% (2.5%)	21.2% (3.6%)	35.3% (5.4%)	14.2% (3.6%)
Multiple subjects	2.9% (0.9%)	14.8% (1.4%)	22.1% (1.9%)	7.3% (1.1%)

Table 10

Percentages of Four-year College Students Attaining a Bachelor's Degree or Higher within Six Years by Remediation Status at First Institution Attended

	Attained Bachelor's Degree or Higher Percent (SE)
No remediation	68.8% (1.1%)
At least 1 remedial course	47.0% (2.1%)
Number of remedial courses	
1 or 2	50.8% (2.3%)
3 or more	32.9% (3.2%)
Remedial subjects	
Mathematics	45.2% (2.4%)
English	37.6% (4.2%)
Reading	38.3% (5.0%)
ESL	36.0% (6.0%)
Other subject	58.5% (4.8%)
Multiple subjects	33.5% (3.2%)

Rates of credential attainment differed by remediation status for Bachelor's degrees, but less so for shorter-term credentials. Among students starting at two-year colleges, students who took one or more remedial courses were less likely to transfer and go on to earn a Bachelor's degree (10.7%) than their peers who took no remediation (20.7%). However, they earned Associate's degrees at about the same rate (17.6% versus 15.1% of unremediated). Remediated students were less likely to earn a certificate (3.6% versus 7.0%), but the percentages were small in both groups. For those who started at a four-year college, 47.0% of students who took remedial courses earned a Bachelor's degree, while 68.8% of their unremediated peers did so.

A similar pattern was evident in the more detailed remedial categories. Those with more severe remedial needs – enrolling in more remedial courses and/or multiple subjects – had lower rates of Bachelor's degree attainment at both levels of institutions. For two-year institutions, the Bachelor's degree attainment rate dropped from 20.7% with no remediation to 13.8% with one or two courses, and still lower to 7.0% with three or more courses. Similarly, two-year students who took multiple remedial subjects had a Bachelor's rate of 7.3%. The rate of attaining a certificate or Associate's degree did not differ as markedly when taking more courses and/or subjects. At four-year institutions, about one-third of those taking three or more remedial courses, and/or taking multiple subjects, completed a Bachelor's degree, compared to more than two-thirds of students taking no remediation.

Comparing degree attainment rates across remedial subjects, remedial Mathematics students had a higher chance of success than English or Reading students at both two- and four-year colleges. While four-year remedial ESL students had the lowest Bachelor's degree attainment rate (36.0%) compared to those taking other subjects, ESL students at two-year colleges had a higher rate than even unremediated students (26.7%).

However, because a small number of students in the analytic sample took ESL (fewer than 50 at two-year colleges), and the standard errors for the attainment estimates shown in Table 9 were relatively large (e.g., more than 8 percentage points), this result should be viewed with caution.

Research Question 2: Relationship of Remediation and Degree Attainment

The second research question asks, "How is postsecondary remediation related to certificate and degree attainment? After controlling for students' demographic characteristics, academic preparation, and postsecondary experiences, as well as institutional characteristics, what is the relationship between students' enrollment in *any remediation* and attainment of a postsecondary certificate or degree? Between enrollment in *different remedial subjects and numbers of remedial courses* and attainment of a certificate or degree?" To address the question, two-level logistic regression models were fit to estimate the association between remedial course-taking and degree attainment after controlling for student and institutional covariates.

Sets of models were fit separately for two-year and four-year institution populations; four different degree attainment outcomes (certificate, Associate's degree, Associate's or higher, and Bachelor's degree or higher); and three sets of remediation predictors (any remediation, number of remedial courses, and remedial subjects).

Different outcomes were also modeled separately. By definition, two- and four-year institutions offer different credentials.[17] In addition, the separate models provide a closer examination of outcomes that require very different levels of time, effort and resources. One outcome was analyzed for students starting at four-year colleges: whether

[17] However, a small number of community colleges, such as Miami-Dade College, do offer four-year degrees.

or not the highest degree attained was at least a Bachelor's degree. For students starting at two-year colleges, the analyzed levels of highest attainment were certificate, Associate's degree, and at least a Bachelor's degree. In addition, a combination of the latter two – Associate's degree or higher – was analyzed for two-year students. It should be noted that the reference category for "highest degree earned is a Certificate" – and likewise for "Associate's" – is problematic. It includes students who earned no credential at all as well as those who went on to earn a higher degree. For this reason, the more clear-cut combined outcome of "Associate's degree or higher" was modeled as well.

Finally, three sets of remediation predictors were separately modeled to explore different facets of the remediation experience at the student's first institution. A binary predictor indicating whether or not the student took any remedial classes was analyzed to understand the overall relationship between credential attainment and remediation. Subsequently, models were fit with a set of dummy variables representing the number of remedial courses taken (one-to-two versus three or more, with zero as the reference category). A third set of models incorporated a set of dummy variables indicating whether the student took at least one remedial course in Mathematics, English, Reading, ESL, or Other subjects, with no remediation as the reference category. These three sets of predictors could not be entered in the same model because of perfect colinearity between some categories.

Table 11 summarizes the 15 sets of models and provides the number of the table in this chapter in which results can be found. (Table 12 summarizes the remediation regression coefficients for these models.)

Table 11

Matrix of Models by Sample, Outcome, and Remedial Predictors

		Remedial Predictors		
Sample	*Outcome: Highest Degree Attained*	Any Remediation	Number of Remedial Courses	Remedial Subjects
Two-Year Institutions	Associate's Degree or higher	Tables 13 & 14	Tables 23 & 24	Tables 33 & 34
	Certificate	Tables 15 & 16	Tables 25 & 26	Tables 35 & 36
	Associate's Degree	Tables 17 & 18	Tables 27 & 28	Tables 37 & 38
	Bachelor's Degree or higher	Tables 19 & 20	Tables 29 & 30	Tables 39 & 40
Four-Year Institutions	Bachelor's Degree or higher	Tables 21 & 22	Tables 31 & 32	Tables 41 & 42

Data Preparation

Before estimating the models, assumptions were tested according to recommended practice for logistic regression (Fox, 2008; Menard, 1995). Selected models from the matrix in Table 11 were assessed for both the two- and four-year samples in a single-level version that provided more diagnostic statistics, using SPSS 21.0 software (IBM Corp, 2012).

Outliers and influential cases. Using Menard's criteria, less than 5 percent of cases had studentized residuals greater than 2 or leverage values greater than 2 times the mean. DFBETA statistics, representing the change in coefficient estimates if a case is removed, were no larger than 0.00005. Thus, influential cases were not deemed a problem per Menard's (1995) guidelines. Residual plots identified only one very large standardized residual (greater than 4), but removal of this case did not change any estimates by more than 0.0001. Given the large sample size, any one individual case exerted little influence.

Variable transformations. Following the procedure described in chapter 3, each continuous variable was examined to determine whether it met the assumption of linearity in the logit. Univariate distributions, as well as bivariate plots of the fitted logit value of y with each predictor, were examined. Skewness values greater than 2 times the standard error (Tabachnik & Fidell, 2013) and significant Box-Tidwell statistics (regression coefficient of the predictor times its natural log, as per Menard, 1995) were also flagged for investigation. Based on these analyses, five variables required transformation: income, number of remedial courses, number of institutions attended, percent Black students, and percent Hispanic students.

Income. The income variable represents the student's total 2002 income (accounting for parent and student income, family size, and dependency status) as a percentage of the federal poverty threshold for that year, with a value of 100 corresponding to the poverty threshold. Values were capped at 10 times the poverty level, so that the highest value was 1,000. The resulting distribution had a very heavy upper tail. To correct this problem and meet the assumption of linearity in the logit, the measure was collapsed into 10 levels in increments of 100 ranging from 100 (at or below the poverty level) to 1,000 (10 times the poverty level or higher). As a result, estimates may not be valid for students with very high income levels.

Number of remedial courses taken at first institution. This integer variable ranged from zero to 15, but was highly positively skewed, with one-third of two-year college students and about two-thirds of four-year college students having values of zero.

The variable was transformed into a categorical set of two dummy variables indicating (1) one-to-two courses, and (2) three or more courses, with zero courses as the reference category. In the two-year college sample, these categories each contained approximately one third of students (the proportion of four-year students was less evenly distributed across these categories). In addition to avoiding the skewness problem, this transformation also avoided outliers with implausibly high numbers of remedial courses that could occur through mistakes in data collection. The categorical version also lends itself to meaningful interpretation: A student can complete one or two courses in a single term, while three or more courses represent a greater burden.

Number of institutions attended. This predictor was transformed into a set of categorical dummy variables for the same reasons discussed for *number of remedial courses*. The categories were "attending one institution" (the reference), "attending two institutions," and "attending three or more institutions." These categories were selected because attending two institutions might represent a straightforward transfer pattern, whereas attending three or more suggests a more complex route to a degree.

Percent Black enrollment* and *percent Hispanic enrollment. These two institution-level variables were skewed to positive values, since 90% of colleges had less than 20% enrollment of either of these racial/ethnic groups. These two predictors had skewness statistics more than 35 times the standard error, as well as significant Box-Tidwell statistics, among four-year colleges. A square root transformation was performed on both variables, improving their linearity with the logit.

Colinearity. Bivariate correlations between each pair of predictors did not indicate any cause for concern. Additionally, following the guidelines of Menard (1995), tolerance statistics obtained from a single-level ordinary least squares version of the model all met the criteria of being above 0.20.

Model-building Process

To build each set of models shown in the matrix in Table 11, a sequence was followed in accordance with best practice guidelines as discussed in chapter 3 (McCoach, 2010; Raudenbush & Bryk, 2002). The parsimonious approach was as follows: (1) An unconditional model was fit and an approximation of the intra-class correlation coefficient obtained; (2) the remediation predictor(s) were added and their unadjusted effects assessed; (3) student-level covariates were added in blocks based on the conceptual framework, with nonsignificant predictors excluded before entering the next block; (4) two-way student-level interaction terms were tested between remediation variables and each covariate remaining in the model, plus all two-way interactions among gender, race, and income if these predictors had significant main effects; (5) each predictor's slope was allowed to vary randomly one at a time, and fixed if it did not meet the criteria to do so; (6) institution-level predictors were added as predictors of the randomly varying intercept, and retained in the model if they were significant; and (7) institution-level predictors were tested for significance as predictors of any randomly varying slopes. The intermediate models for each step of this process are displayed in Appendix D.

The remediation slopes were of particular relevance to Research Question 3, which asks whether the relationship between remediation and degree attainment can be predicted by institutional factors. If the remediation slope was fixed in a model, this relationship was understood to be constant across all institutions, and no slope variance was available to be predicted by institutional variables. If any remediation variable slopes were allowed to vary randomly, the institutional predictors were tested as predictors of slope variance in order to answer Research Question 3. The results of remediation slope testing are discussed fully in the section on Research Question Three later in this chapter.

Interpretation of Coefficients

Fixed components. Because most of the predictors in the model - particularly the remediation variables - are dummy variables representing categories, unstandardized coefficients are presented in the tables and discussed, for clarity of interpretation. However, for those models containing continuous predictors, the X-standardized coefficient (presented in units of the standard deviation of X) is also discussed in the text for the purpose of interpretation. Note that when the term "effect" appears in this chapter, it does not refer to a treatment effect and should not be interpreted as a causal inference.

The magnitude of each predictor's effect is represented by the odds ratio in the fixed effects table for each model. In addition, Table 12 summarizes the fixed effect of each remediation predictor in each model, including the percent change in the probability of degree attainment for students who take remedial classes compared to those who do not (Delta-*p*) and the effect size (Cox index). The Delta-*p* statistic allows a more intuitive interpretation of practical significance, stated in terms of probabilities rather than odds. These measures were discussed in more detail in chapter 3.

Random components. As discussed in chapter 3, the variance components are reported for each model, accompanied by approximations of the proportion of variance explained using the methods recommended by Snijders and Bosker (2012). The formulas are provided in footnotes below each table in this chapter.

Because the intercept reliability was poor in some models, the institutions represented in this sample by larger clusters of students – which would be given greater weight in the empirical Bayes estimation procedure – were examined to check for any notable differences that might make them different from the smaller-cluster institutions in relevant ways (e.g., extreme values, region, religious or military affiliation, unusual student body makeup, etc.). However, no such differences were found.

Results: Relationship of Any Remediation to Degree Attainment

Summary of remediation coefficients and effect sizes. Table 12 summarizes the coefficients for the remediation variables resulting from the multilevel analyses in the 15 final Student- and Institution-level Models. (The coefficients for covariates in each model are not shown in Table 12.) The estimated partial logistic regression coefficient ("Coeff." in the table) represents the change in the log odds of attaining the outcome associated with a one-unit increase in the given remediation measure (e.g., the dummy variable representing "Took one or more remedial courses" = 0 versus 1). Positive values of the logistic coefficient indicate an increase in the log odds, while negative values represent a decrease in the log odds. Table 12 also presents the exponentiated form of that coefficient, the odds ratio (*OR*). The odds ratio represents the odds of attaining the outcome when the remediation dummy equals 1, divided by the odds when the remediation dummy equals 0. Odds ratio values greater than 1 indicate an increase in the odds, whereas odds ratio values less than 1 indicate a decrease in the odds. The table also provides measures of their practical significance in the form of Delta-*p* and Cox index statistics.

Table 12. *Summary of Regression Coefficients and Effect Sizes for Remediation Measures in Each Student- and Institution-level Model*

Source Table	Remediation Predictor	Coeff.[a]	(*SE*)[b]	*OR*[c]	Delta-*p*[d]	Effect Size: Cox Index[e]
Two-Year College Students						
Outcome: Associate's Degree or Higher						
Table 13	Any Remediation	0.02	(0.07)	1.02	<0.01	0.01
Table 23	1-2 courses	0.27	(0.15)	1.32	0.06	0.16
	3+ courses	0.05	(0.10)	1.05	0.01	0.03
Table 33	Mathematics	0.04	(0.10)	1.04	0.01	0.02
	English	-0.09	(0.14)	0.91	-0.02	-0.05
	Reading[f]	-0.25	(0.13)	0.78	-0.05	-0.15
	ESL	1.17**	(0.38)	3.23	0.28	0.71
	Other remedial[f]	0.28	(0.21)	1.32	0.06	0.17
Outcome: Certificate						
Table 15	Any Remediation	-0.28	(0.16)	0.76	-0.01	-0.17
Table 25	1-2 courses	-0.51*	(0.24)	0.60	-0.02	-0.31
	3+ courses	-0.54*	(0.23)	0.58	-0.02	-0.33
Table 35	Mathematics	-0.49**	(0.18)	0.61	-0.02	-0.30
	English	-0.13	(0.28)	0.88	-0.01	-0.08
	Reading	0.07	(0.27)	1.07	<0.01	0.04
	ESL	0.52	(0.68)	1.69	0.03	0.32
	Other remedial	0.46	(0.34)	1.59	0.02	0.28
Outcome: Associate's Degree						
Table 17	Any Remediation	0.68**	(0.21)	1.97	0.09	0.41
Table 27	1-2 courses[†]	0.61**	(0.21)	1.85	0.09	0.37
	3+ courses	0.44**	(0.13)	1.56	0.07	0.27
Table 37	Mathematics	0.26**	(0.09)	1.30	0.04	0.16
	English	0.25	(0.14)	1.28	0.04	0.15
	Reading	-0.41**	(0.15)	0.67	-0.05	-0.25
	ESL	0.82	(0.42)	2.27	0.15	0.50
	Other remedial	0.23	(0.21)	1.26	0.03	0.14
Outcome: Bachelor's Degree or Higher						
Table 19	Any Remediation	-0.17	(0.12)	0.84	-0.02	-0.10
Table 29	1-2 courses	-0.07	(0.13)	0.93	-0.01	-0.04
	3+ courses	-0.40*	(0.17)	0.67	-0.05	-0.24
Table 39	Mathematics	-0.16	(0.12)	0.86	-0.02	-0.10
	English[g]	-0.97**	(0.32)	0.38	-0.09	-0.59
	Reading[g]	-0.19	(0.24)	0.82	-0.02	-0.12
	ESL	1.28*	(0.52)	3.61	0.23	0.78
	Other remedial	0.25	(0.36)	1.28	0.03	0.15

Continued next page

Source Table	Remediation Predictor	Coeff.	(*SE*)	*OR*	Delta-*p*[a]	Effect Size: Cox Index[b]
Four-Year College Students						
Outcome: Bachelor's Degree or Higher						
Table 21	Any Remediation	-0.31**	(0.10)	0.74	-0.07	-0.19
Table 31	1-2 courses	-0.18	(0.10)	0.83	-0.04	-0.11
	3+ courses	-0.41*	(0.17)	0.66	-0.10	-0.25
Table 41	Mathematics	-0.28***	(0.07)	0.75	-0.07	-0.17
	English	-0.08	(0.16)	0.92	-0.02	-0.05
	Reading	-0.02	(0.20)	0.98	<0.01	-0.01
	ESL	-0.20	(0.29)	0.82	-0.05	-0.12
	Other remedial	0.05	(0.21)	1.06	0.01	0.03

* p<.05; ** p<.01; *** p<.001
† Slope allowed to vary randomly; no level-2 variables used to predict slope variance.
[a] Coeff.: Logistic form of the partial regression coefficient for the remediation measure
[b] SE: Standard error of the logistic regression coefficient
[c] OR: Odds ratio: Exponentiated form of the partial regression coefficient for the remediation measure
[d] Delta-*p*: Percentage point difference in the probability of degree attainment for remedial vs. non-remedial students, adjusted for the base rates of attainment and remediation in the sample.
[e] Cox Index: Logged odds ratio ($\hat{\gamma}$) / 1.65
[f] Interaction between Reading and Other was also significant.
[g] Interaction between Reading and English was also significant.

These results from the multilevel analyses that adjusted for covariates were similar in many respects to the simple bivariate statistics shown in Tables 9 and 10. At four-year colleges, the unadjusted descriptive statistics (Table 10) showed an attainment gap between students who took one or more remedial courses and those who took none; this difference was born out by a significant negative association between any remediation and Bachelor's attainment in the regression analysis ($\hat{\gamma}$ = -0.31, *SE* = 0.10, p = .003). The exceptionally high degree attainment rates for ESL students at two-year colleges (Table 9) were also reflected in the regression results, in which ESL had a positive relationship to attaining an Associate's degree or higher, as well as attaining a Bachelor's degree.

However, there were also notable differences from the bivariate statistics. At two-year colleges, the unadjusted percentage of students earning an Associate's degree but no higher was very similar among those who took remedial courses and those who did not (Table 9). By contrast, the regression results indicated a significant, positive relationship between taking any remediation and Associate's degree attainment ($\hat{\gamma}$ = 0.68, *SE* = 0.21, p = .002). Remedial Mathematics students at four-year colleges had somewhat higher rates of attainment than students taking other remedial subjects (Table 10), but Mathematics had a negative relationship with degree completion in the regression models. These findings are discussed in more detail in the sections that follow and in Chapter 5.

In the four-year college sample, effect sizes (represented by the Cox index) were small, ranging from absolute values of 0.17 to 0.25 in the models in which remediation was statistically significant. In those models, the difference in the probability of degree attainment for remediated students compared to non-remediated students (Delta-*p*) was 7 to 10 percentage points. In the two-year college sample, the Cox index effect sizes associated with statistically significant coefficients were mostly small or moderate and ranged from 0.16 to 0.71 in absolute value; the change in the probability of attainment (Delta-*p*) for those models ranged from 2 to 28 percentage points. In the two-year colleges, the significant remedial relationships with certificate attainment had limited practical significance (Delta-*p* = -0.02), but for higher credentials, some relationships with greater practical significance stood out: The probability of earning an Associate's degree was nine percentage points higher for students who took at least one remedial course (Delta-*p* = 0.09), and the probability of attaining at least a Bachelor's degree was 23 percentage points higher for ESL students than for nonremedial students (Delta-*p* = 0.23).

Two-year institutions: Associate's degree or higher. Tables 13 and 14 summarize the parameter estimates for the regressions of attaining an Associate's degree or higher on taking any remediation, among students starting at two-year institutions.

Fixed effects. In the absence of other predictors (the Remediation-Only Model), remediation had a statistically significant negative relationship with the log-odds of earning an Associate's degree or higher; the odds of degree attainment were 29% lower for students who took any remedial courses than the odds for those who took none ($\hat{\gamma}$ = -0.34, *SE* = 0.06, *p* < .001, *OR* = 0.71). However, the magnitude of this fixed effect decreased after controlling for demographic and academic preparation predictors, and became nonsignificant with the addition of postsecondary experience factors. Remediation continued to have a small, nonsignificant coefficient in the final Student- and Institution-level Model ($\hat{\gamma}$ = 0.02, *SE* = 0.07, *p* = .837, *OR* = 1.02). In the final institution-level model, the only significant demographic variables were being Black or Other Race, both of which had negative associations with the odds of graduation: Black students had 40% lower odds of earning a degree than the odds for White students ($\hat{\gamma}$ = -0.52, *SE* = 0.16, *p* = .001, *OR* = 0.60), and students of Other Races had 38% lower odds ($\hat{\gamma}$ = -0.48, *SE* = 0.18, *p* = .007, *OR* = 0.62). High school GPA was positively associated with earning a degree (a 22% increase in the odds of graduation for each half-grade letter increase in GPA: $\hat{\gamma}$ = 0.20, *SE* = 0.04, *p* < .001, *OR* = 1.22), but no other academic preparation factors prevailed. Several of the predictors representing postsecondary experiences did remain in the model: higher scores on the academic integration index had a positive fixed effect (a 0.2% increase in odds for a one unit increase on the index: $\hat{\gamma}$ = 0.002, *SE* = 0.001, *p* = .023, *OR* = 1.002), as did enrolling full-time (more than double the odds of degree attainment: $\hat{\gamma} = 0.71$, $SE = 0.11$, $p < .001$, $OR = 2.04$) and declaring a major in the first year (a 48% increase in odds: $\hat{\gamma} = 0.39$, $SE = 0.09$, $p < .001$, $OR = 1.48$). Attending multiple institutions also had a positive relationship to attaining a degree: the odds increased more than threefold for attending two colleges ($\hat{\gamma} = 1.28$, $SE = 0.09$, $p < .001$, $OR = 3.61$), and more than fivefold for attending three or more colleges ($\hat{\gamma} = 1.69$, $SE = 0.11$, $p < .001$, $OR = 5.40$). The two environmental pull factors – working full-time and having a dependent child – had negative relationships with the outcome: a 26% decrease in odds related to work ($\hat{\gamma} = -0.30$, $SE = 0.12$, $p = .009$, $OR = 0.74$), and a 51% decrease related to having a child ($\hat{\gamma} = -0.71$, $SE = 0.10$, $p < .001$, $OR = 0.49$).

In the final institution-level model, three institutional characteristics had a significant association with the odds of earning an Associate's degree or higher. Students at private institutions (only two percent of students at two-year colleges in this sample) had 71% better odds of graduating than the odds for those at public community colleges ($\hat{\gamma} = 0.54$, $SE = 0.18$, $p = .004$, $OR = 1.71$). In contrast, a 1,000-student increase in enrollment was associated with a two percent decrease in the odds of earning a degree ($\hat{\gamma} = -0.02$, $SE = 0.01$, $p = .006$, $OR = 0.98$). The percentage of Black students also had a negative relationship with the odds of degree attainment. Because this variable was square-root transformed, interpreting the slope coefficient ($\hat{\gamma} = -0.07$, $SE = 0.03$, $p = .032$, $OR = 0.93$) is more complicated. By way of example, if we compare a student for whom all other predictors equal zero (i.e., female, White, average income, average high school GPA) at two institutions, she would have an 11% chance of attaining a degree at a two-year college with 11% Black enrollment, but a 6% probability of this outcome at a two-year college with 16% Black enrollment.

Random effects. As shown in Table 14, remediation on its own explained 0.7% percent of total variation in the outcome, while the full Student- and Institution-level Model explained 27.4%. The estimated intraclass correlation coefficient for obtaining an Associate's degree or higher was 8.6%. In other words, less than a tenth of the variation in the outcome lay between institutions, rather than within. The three institution-level predictors in the Student- and Institution-Level Model accounted for 18% of this between-college variance beyond what was explained by the Student-level Model.

Because the main effect of remediation was not significant, indicating a lack of association between remediation and degree attainment, the remediation slope was fixed at a constant estimated value (statistically equivalent to zero) across all institutions. The implications of this finding for Research Question 3 are discussed further under that section of this chapter.

Table 13

Two-year Institutions: Relationship between Any Remediation and Attaining an Associate's Degree or Higher: Fixed Effects

	Model A *Remediation-Only*			*Model B* *Student-Level*			*Model C* *Student- & Institution-Level*		
	Coeff	*(SE)*	*OR*	Coeff	*(SE)*	*OR*	Coeff	*(SE)*	*OR*
STUDENT-LEVEL									
Intercept	-0.43 ***	(0.07)	0.65	-1.98***	(0.17)	0.14	-2.00***	(0.17)	0.14
Any remediation	-0.34 ***	(0.06)	0.71	0.01	(0.08)	1.01	0.02	(0.07)	1.02
Asian				0.24	(0.19)	1.27	0.34	(0.20)	1.40
Black				-0.64***	(0.14)	0.53	-0.52**	(0.16)	0.60
Hispanic				0.01	(0.12)	1.01	0.05	(0.13)	1.05
Other race				-0.45**	(0.17)	0.64	-0.48**	(0.18)	0.62
Male									
Age									
Income									
Parent education									
Private HS									
Algebra II									
HS curriculum									
HS GPA				0.21***	(0.04)	1.23	0.20***	(0.04)	1.22
Academic integration index				0.00*[a]	(0.00)	1.00	0.00*[b]	(0.00)	1.00
Social integration index									
Full-time enrollment				0.75***	(0.12)	2.13	0.71***	(0.11)	2.04
Pell grant									
Declared a major				0.39***	(0.10)	1.47	0.39***	(0.09)	1.48
Attended 2 colleges				1.26***	(0.09)	3.54	1.28***	(0.09)	3.61
Attended 3+ colleges				1.69***	(0.11)	5.43	1.69***	(0.11)	5.40
Worked full-time				-0.32**	(0.11)	0.73	-0.30**	(0.12)	0.74
Child				-0.69***	(0.10)	0.50	-0.71***	(0.10)	0.49
INSTITUTION-LEVEL									
Private college							0.54**	(0.18)	1.71
College enroll. (1,000s)							-0.02**	(0.01)	0.98
% Black students (sqrt)							-0.07*	(0.03)	0.93
% Hispanic students (sqrt)									
% students w/ federal aid									
% full-time faculty									
Deviance (# parameters)	10,903 (3)			10,272 (15)			10,241 (18)		

* p<.05; ** p<.01; *** p<.001; [a] Actual values 0.0026 (0.0010); [b] Actual values 0.0023 (0.0010)

Table 14

Two-year Institutions: Relationship between Any Remediation and Attaining an Associate's Degree or Higher: Random Effects

	Unconditional Model	*Model A Remediation-Only*	*Model B Student-Level*	*Model C Student- & Institution-Level*
$\hat{\tau}_{00}$ Between-college variance	0.31***	0.30***	0.30***	0.25***
σ^2_F Explained variance[a]	-	0.03	1.26	1.33
σ^2_R Within-college variance (Fixed)	3.29	3.29	3.29	3.29
Intra-class correlation coefficient[b]	8.6%	26.5%	27.5%	24.7%
% residual $\hat{\tau}_{00}$ explained by institutional predictors[c]	-	-	-	18.3%
% total variance explained[d]	-	0.7%	26.0%	27.4%
$\hat{\tau}_{00}$ Reliability	.42	.42	.37	.29

* p<.05; ** p<.01; *** p<.001

[a] Var($\hat{Y}_{ij}$) where $\hat{Y}_{ij} = \gamma_0 + \sum_{h=1}^{r} \gamma_h X_{hij}$

[b] $\hat{\tau}_{00} / (\hat{\tau}_{00} + \pi^2/3)$

[c] $(\hat{\tau}_{00B} - \hat{\tau}_{00C})/\hat{\tau}_{00B}$

[d] $\sigma^2_F / (\sigma^2_F + \tau_{00} + \sigma^2_R)$

The next three sets of models analyzed three specific outcomes and their relationship to any remediation: certificate, Associate's degree, and Bachelors' degree or higher as the highest degree attained.

Two-year institutions: Relationship of any remediation and certificate. Tables 15 and 16 display the parameter estimates for this set of models.

Fixed effects. Most of the variables used in this study were not predictive of earning a certificate. The unadjusted fixed effect of taking any remediation was a 28% decrease in the odds of earning a certificate compared to the odds for those not taking remediation ($\hat{\gamma}$ = -0.33, *SE* = 0.16, *p* = .038, *OR* = 0.72). However, the only significant predictor left in the final Student- and Institution-level Model was attending two institutions, which had a positive association with the outcome. At the institution level, larger enrollment was associated with slightly lower odds of certificate attainment.

Random effects. Table 16 shows the variance components for the certificate models. The Student- and Institution-level Model, with its limited set of predictors, only explained 13.8% of total variance in the outcome. As indicated by the intraclass correlation coefficient, 27.4% of variation in the odds of earning a certificate could be attributed to differences between institutions – a larger proportion than for any of the other outcomes analyzed. Enrollment at the institution level accounted for 13.8% of residual between-school variance after accounting for student factors. The slope for remediation was again fixed because its main effect was not significant; the relationship between remediation and certificate attainment, estimated as statistically equivalent to zero, was not allowed to vary across colleges.

Table 15

Two-year Institutions: Relationship between Any Remediation and Attaining a Certificate: Fixed Effects

	Model A *Remediation-Only*			*Model B* *Student-Level*			*Model C* *Student- & Institution-Level*		
	Coeff	(*SE*)	*OR*	Coeff	(*SE*)	*OR*	Coeff	(*SE*)	*OR*
STUDENT-LEVEL									
Intercept	-3.22***	(0.20)	0.04	-3.51***	(0.24)	0.03	-3.43***	(0.23)	0.03
Any remediation	-0.33*	(0.16)	0.72	-0.28	(0.16)	0.76	-0.28	(0.16)	0.76
Asian									
Black									
Hispanic									
Other race									
Male									
Age									
Income									
Parent education									
Private HS									
Algebra II									
HS curriculum									
HS GPA									
Academic integration index									
Social integration index									
Full-time enrollment									
Pell grant									
Declared a major									
Attended 2 colleges				0.42*	(0.19)	1.52	0.43*	(0.19)	1.53
Attended 3+ colleges				0.44	(0.26)	1.56	0.43	(0.26)	1.54
Worked full-time									
Child									
INSTITUTION-LEVEL									
Private college									
Enrollment (1,000s)							-0.04*	(0.02)	0.96
% Black students (sqrt)									
% Hispanic students (sqrt)									
% students w/ federal aid									
% full-time faculty									
Deviance (# parameters)	7,812 (3)			7,806 (5)			7797 (6)		

* p<.05; ** p<.01; *** p<.001

Table 16

Two-year Institutions: Relationship between Any Remediation and Attaining a Certificate: Random Effects

	Unconditional Model	*Model A Remediation-Only*	*Model B Student-Level*	*Model C Student- & Institution-Level*
$\hat{\tau}_{00}$ Between-college variance	1.24***	1.19***	1.25***	1.08***
σ^2_F Explained variance[a]	-	0.02	0.07	0.22
σ^2_R Within-college variance (Fixed)	3.29	3.29	3.29	3.29
Intra-class correlation coefficient[b]	27.4%	26.5%	27.5%	24.7%
% residual $\hat{\tau}_{00}$ explained by institutional predictors[c]	-	-	-	13.8%
% total variance explained[d]	-	0.5%	1.6%	4.9%
$\hat{\tau}_{00}$ Reliability	.39	.38	.39	.37

* p<.05; ** p<.01; *** p<.001

[a] Var($\hat{Y}_{ij}$) where $\hat{Y}_{ij} = \gamma_0 + \sum_{h=1}^{r} \gamma_h X_{hij}$

[b] $\hat{\tau}_{00} / (\hat{\tau}_{00} + \pi^2/3)$

[c] $(\hat{\tau}_{00B} - \hat{\tau}_{00C})/\hat{\tau}_{00B}$

[d] $\sigma^2_F / (\sigma^2_F + \tau_{00} + \sigma^2_R)$

Two-year institutions: Relationship of any remediation and Associate's degree. Tables 17 and 18 display the results for this set of models.

Fixed effects. In contrast to the other two-year student models, remediation had a significant positive association with the odds of earning an Associate's degree in the unadjusted Remediation-only Model ($\hat{\gamma}$ = 0.19, *SE* = 0.09, *p* = .047, *OR* = 1.20). This positive fixed effect persisted and increased in magnitude with the addition of student-level covariates. In the final institution-level model, taking any remedial courses was associated with 98% higher odds of degree attainment than the odds for unremediated students ($\hat{\gamma}$ = 0.68, *SE* = 0.21, *p* = .002, *OR* = 1.98). The coefficient can also be interpreted as a nine percentage point increase in the probability of earning an Associate's degree associated with taking remedial courses (Delta-p = 0.09). Having race categorized as Other had a negative relationship to completing an Associate's degree, but no other demographic factors were significant predictors. In addition to high school GPA, which had a positive fixed effect, taking a rigorous high school curriculum had a negative coefficient – a surprising result ($\hat{\gamma}$ = -0.22, *SE* = 0.11, p = .042, *OR* = 0.80). Among postsecondary experiences, enrolling full-time and declaring a major had positive relationships to degree attainment, as did receiving a Pell grant. Responsibility for a child was a negative factor. Because of a negative interaction between remediation and declaring a major ($\hat{\gamma}$ = -0.59, *SE* = 0.24, p = .015, *OR* = 0.56), the net fixed effect of these two positive factors was still positive, but not additive. Similar to the model for Associate's degree or higher, this model for Associate's degree showed a significant positive association with the outcome for private institutions and a (weak) negative association with the percentage of Black students.[18] Unlike the findings from that model, however, total enrollment was not a significant factor.

To place the fixed effect of remediation in context in relation to other categorical predictors in the final model, the logistic coefficient for "any remediation" ($\hat{\gamma}$ = 0.68) was one of the largest, more than one standard deviation above the mean coefficient size in this model. It had a magnitude 42% greater than that of the coefficient for full-time enrollment ($\hat{\gamma}$ = 0.48), and nearly three times the magnitude of the coefficient for having a dependent child ($\hat{\gamma}$ = -0.24).

[18] The cross-level interaction of being Black with institutional percentage of Black enrollment was tested. Although the coefficient for this interaction was statistically significant (γ = 0.19, p =.040), the slope for being Black could not be predicted reliably (reliability = 0.004) and lacked significant variation (χ^2 = 115.78, p >.50). Thus, the slope for being Black was fixed, and the cross-level interaction term was not included in the model.

Random effects. As shown in Table 18, the Student- and Institution-level Model did not have great explanatory power, accounting for only 7.8% of total variance in the odds of attaining an Associate's degree. Nearly 10 percent of variance in this outcome fell between institutions, with private control and percentage of Black students explaining 6.1% of that portion of variance beyond the proportion explained by student-level factors. Although the main effect of remediation was significant, its slope did not meet the criteria for varying at random (the slope did not vary significantly across institutions, and it could not be reliably estimated when varying randomly); therefore, the slope was fixed.

Table 17. *Two-year Institutions: Relationship between Any Remediation and Attaining an Associate's Degree: Fixed Effects*

	Model A Remediation-Only			*Model B Student-Level*			*Model C Student- &Institution-Level*		
	Coeff	(*SE*)	*OR*	Coeff	(*SE*)	*OR*	Coeff	(*SE*)	*OR*
STUDENT-LEVEL									
Intercept	-1.75***	(0.09)	0.17	-2.73***	(0.24)	0.06	-2.79***	(0.24)	0.06
Any remediation	0.19*	(0.09)	1.20	0.68**	(0.21)	1.97	0.68**	(0.21)	1.98
Asian				0.25	(0.22)	1.28	0.25	(0.23)	1.29
Black				-0.43**	(0.16)	0.65	-0.32	(0.18)	0.73
Hispanic				0.05	(0.14)	1.05	0.01	(0.14)	1.01
Other race				-0.56**	(0.20)	0.57	-0.62**	(0.20)	0.54
Male									
Age									
Income									
Parent education									
Private HS									
Algebra II									
HS curriculum				-0.23*	(0.11)	0.79	-0.22*	(0.11)	0.80
HS GPA				0.14**	(0.05)	1.15	0.13**	(0.05)	1.14
Academic integration index									
Social integration index									
Full-time enrollment				0.52***	(0.13)	1.67	0.48**	(0.13)	1.62
Pell grant				0.25*	(0.10)	1.29	0.25*	(0.10)	1.28
Declared a major				0.88***	(0.19)	2.41	0.90***	(0.19)	2.47
Attended 2 colleges									
Attended 3+ colleges									
Worked full-time									
Child				-0.23*	(0.11)	0.79	-0.24*	(0.11)	0.79
Remediation X Major				-0.57*	(0.24)	0.56	-0.59*	(0.24)	0.56
INSTITUTION-LEVEL									
Private college							0.76**	(0.23)	2.13
College enrollment (1,000s)									
% Black students (sqrt)							-0.09*	(0.04)	0.91
% Hispanic students (sqrt)									
% students w/ federal aid									
% full-time faculty									
Deviance (# parameters)	9,740 (3)			9,650 (14)			9,633 (16)		

* p<.05; ** p<.01; *** p<.001

Table 18

Two-year Institutions: Relationship between Any Remediation and Attaining an Associate's Degree: Random Effects

	Unconditional Model	*Model A Remediation-Only*	*Model B Student-Level*	*Model C Student- & Institution-Level*
$\hat{\tau}_{00}$ Between-college variance	0.36***	0.36***	0.44***	0.41***
σ^2_F Explained variance[a]	-	.01	0.25	0.31
σ^2_R Within-college variance (Fixed)	3.29	3.29	3.29	3.29
Intra-class correlation coefficient[b]	9.9%	10.0%	11.8%	11.2%
% residual $\hat{\tau}_{00}$ explained by institutional predictors[c]	-	-	-	6.1%
% total variance explained[d]	-	0.2%	6.2%	7.8%
$\hat{\tau}_{00}$ Reliability	.44	0.43	0.44	0.41

* p<.05; ** p<.01; *** p<.001

[a] Var($\hat{Y}_{ij}$) where $\hat{Y}_{ij} = \gamma_0 + \sum_{h=1}^{r} \gamma_h X_{hij}$

[b] $\hat{\tau}_{00} \,/\, (\hat{\tau}_{00} + \pi^2/3)$

[c] $(\hat{\tau}_{00B} - \hat{\tau}_{00C})/\hat{\tau}_{00B}$

[d] $\sigma^2_F /(\sigma^2_F + \tau_{00}+\sigma^2_R)$

Two-year institutions: Relationship of any remediation and Bachelor's degree. Tables 19 and 20 summarize the results of this set of models.

Fixed effects. As seen in two of the other models for two-year institutions presented thus far, remediation had a significant negative unadjusted association with the outcome (a 52% decrease in the odds of attaining at least a Bachelor's degree: $\hat{\gamma}$ = -0.73, *SE* = 0.08, *p* < .001, *OR* = 0.48) that became nonsignificant in the presence of control variables ($\hat{\gamma}$ = -0.17, *SE* = 0.12, *p* = .150, *OR* = 0.84 in the final Student- and Institution-level Model). The demographic variables predictive of earning a Bachelor's degree were being Black (a negative fixed effect) and having college-educated parents (a positive fixed effect). Better academic preparation - having a higher high school GPA and taking a rigorous high school curriculum - was a positive factor. In the postsecondary realm, higher scores on the academic integration index and enrolling full-time were positively associated with completing a Bachelor's degree. Attending more than one institution was also a positive factor, but this set of dummy variables was problematic; the odds ratio estimates for these predictors were exceptionally high ($\hat{\gamma}$ = 5.57, *SE* = 0.77, $p < .001$, *OR* = 262.04 for attending two colleges and $\hat{\gamma}$ = 5.96, *SE* = 0.77, $p < .001$, *OR* = 387.21). It may not be possible to estimate these coefficients accurately because any student starting at a two-year college and earning a Bachelor's degree would by definition have to transfer to a four-year institution, meaning that the cross-tabulation of outcome and predictor would have an empty cell (virtually no student would attend a single institution and also earn a Bachelor's). Working full-time and having a child were negative factors. None of the institutional variables were significant predictors. Because the model only accounts for associations with characteristics of the first institution attended, it does not capture the institutional characteristics of a later transfer destination on Bachelor's degree attainment; a model allowing cross-classification of students to institutions might be more suitable.

Random effects. Because of the exceptionally large coefficients for the two predictors representing number of institutions attended, the variance of the linear predictor was large, and therefore the estimated total variance explained by the Student- and Institution-level Model was high (75.8%). This figure should be treated with some skepticism because of the large coefficients. As displayed in Table 20, the intra-class correlation coefficient for the odds of attaining a Bachelor's degree or higher was 13.2%.

The institutional variables tested here explained none of this variance and were not included in the model. Further indicating some potential instability in this model, the intercept reliability was poor at 0.10. Because the main effect of remediation was not significant, its slope was fixed; no relationship between remediation and Bachelor's attainment could be detected, and therefore it could not vary across institutions.

Table 19. *Two-year Institutions: Relationship between Any Remediation and Attaining a Bachelor's Degree or Higher: Fixed Effects*

	Model A *Remediation-Only*			*Model B* *Student-Level*			*Model C* *Student- & Institution-Level*		
	Coeff	(*SE*)	*OR*	Coeff	(*SE*)	*OR*	Coeff	(*SE*)	*OR*
STUDENT-LEVEL									
Intercept	-1.32 ***	(0.09)	0.27	-7.31***	(0.81)	<0.01	-7.31***	(0.81)	0.00
Any remediation	-0.73 ***	(0.08)	0.48	-0.17	(0.12)	0.84	-0.17	(0.12)	0.84
Asian				-0.07	(0.28)	0.94	-0.07	(0.28)	0.94
Black				-0.61**	(0.20)	0.54	-0.61 **	(0.20)	0.54
Hispanic				-0.05	(0.19)	0.95	-0.05	(0.19)	0.95
Other race				-0.13	(0.30)	0.88	-0.13	(0.30)	0.88
Male									
Age									
Income									
Parent education				0.47***	(0.12)	1.59	0.47***	(0.12)	1.59
Private HS									
Algebra II									
HS curriculum				0.48***	(0.12)	1.61	0.48***	(0.12)	1.61
HS GPA				0.17**	(0.05)	1.18	0.17 **	(0.05)	1.18
Academic integration index				0.00**[a]	(0.00)	1.00	0.00**[b]	(0.0)	1.00
Social integration index									
Full-time enrollment				0.87***	(0.17)	2.39	0.87***	(0.17)	2.39
Pell grant									
Declared a major									
Attended 2 colleges				5.57***	(0.77)	262.04	5.57***	(0.77)	262.04
Attended 3+ colleges				5.96***	(0.77)	387.21	5.96***	(0.77)	387.21
Worked full-time				-0.49**	(0.17)	0.61	-0.49 **	(0.17)	0.61
Child				-1.35***	(0.20)	0.26	-1.35***	(0.20)	0.26
INSTITUTION-LEVEL									
Private college									
College enrollment (1,000s)									
% Black students (sqrt)									
% Hispanic students (sqrt)									
% students w/ federal aid									
% full-time faculty									
Deviance (# parameters)	9,447 (3)			8,447 (16)			8,447 (16)		

* p<.05; ** p<.01; *** p<.001; [a] Actual values 0.0042 (0.0015); [b] Actual values 0.0042 (0.0015)
Note: None of the institution-level predictors was significant; Models B and C are the same.

Table 20

Two-year Institutions: Relationship between Any Remediation and Attaining a Bachelor's Degree or Higher: Random Effects

	Unconditional Model	*Model A Remediation-Only*	*Model B Student-Level*	*Model C[e] Student- & Institution-Level*
$\hat{\tau}_{00}$ Between-college variance	.50***	0.45***	0.19*	0.19*
σ^2_F Explained variance[a]	-	0.12	10.88	10.88
σ^2_R Within-college variance (Fixed)	3.29	3.29	3.29	3.29
Intra-class correlation coefficient[b]	13.2%	12.0%	5.4%	5.4%
% residual $\hat{\tau}_{00}$ explained by institutional predictors[c]	-	-	-	0.0%
% total variance explained[d]	-	3.1%	75.8%	75.8%
$\hat{\tau}_{00}$ Reliability	.41	.40	.10	.10

* p<.05; ** p<.01; *** p<.001

[a] Var($\hat{Y}_{ij}$) where $\hat{Y}_{ij} = \gamma_0 + \sum_{h=1}^{r} \gamma_h X_{hij}$

[b] $\hat{\tau}_{00} / (\hat{\tau}_{00} + \pi^2/3)$

[c] $(\hat{\tau}_{00B} - \hat{\tau}_{00C})/\hat{\tau}_{00B}$

[d] $\sigma^2_F / (\sigma^2_F + \tau_{00} + \sigma^2_R)$

[e] None of the institution-level predictors was significant; Models B and C are the same.

Four-year institutions: Relationship of any remediation and Bachelor's degree. Tables 21 and 22 summarize the results of this set of models.

Fixed effects. For students starting their college careers at a four-year college, taking any remedial classes had a strong negative unadjusted association with the outcome: a 43% reduction in the odds of earning a degree ($\hat{\gamma}$ = -0.56, *SE* = 0.07, *p* < .001, *OR* = 0.57). After controlling for student- and institution-level predictors, this relationship decreased in magnitude to a 26% decrease in the odds of degree attainment, but remained significant ($\hat{\gamma}$ = -0.31, *SE* = 0.10, *p* = .003, *OR* = 0.74). In other words, taking remedial courses was associated with a seven percentage point reduction in the probability of graduating (Delta-p = -0.07). More demographic factors were significant in the final Student- and Institution-level Model for four-year college students than in the equivalent model for two-year college students earning a Bachelor's degree. In the Student-level Model, being Hispanic had a negative association with the odds of degree attainment, but became nonsignificant with the addition of institutional predictors. In the final Student- and Institution-level Model, male students had 41% lower odds compared to female students ($\hat{\gamma}$ = -0.53, SE = 0.07, p < .001, OR = 0.59). Positive factors included higher income: a 22% increase in the odds of degree attainment was associated with a one standard deviation increase in income[19] (X-standardized coefficients, not shown in table: $\hat{\gamma}$ = 0.20, SE = 0.04, p < .001, OR = 1.22). Having college-educated parents was associated with a 20% increase in odds ($\hat{\gamma}$ = 0.18, SE = 0.08, p = .018, OR = 1.20). Other positive factors were taking Algebra II in high school (associated with a 66% increase in odds: $\hat{\gamma}$ = 0.51, SE = 0.15, p = .001, OR = 1.66), as well as earning a higher high school GPA (a 59% increase in odds associated with every half-letter grade increase: $\hat{\gamma}$ = 0.47, SE = 0.04, p < .001, OR = 1.59). Although academic integration was not a significant factor, higher scores on the social integration index had a positive association with the outcome. Using the X-standardized version of the coefficients, a 24% increase in odds was associated with a one standard deviation increase in the index score (X-standardized coefficients, not shown in table: $\hat{\gamma}$ = 0.21, SE = 0.03, p = .018, OR = 1.24). Enrolling in

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[19] For continuous variables, X-standardized coefficients are discussed where noted in the narrative of this analysis, but the unstandardized coefficients are displayed in the tables. Because most predictors in the models are dummy variables, the unstandardized version lends itself to more straightforward interpretation. Relationships are discussed in terms of standard deviations of X where interpretation is aided. Note that comparisons of magnitude cannot be made between unstandardized coefficients.

college full-time was a positive factor (a 177% increase in odds: $\hat{\gamma}$ = 1.02, *SE* = 0.16, *p* < .001, *OR* = 2.77), while attending more than one institution was a negative factor, associated with a 31% decrease in odds for two colleges, and a 51% decrease for three or more ($\hat{\gamma}$ = -0.37, *SE* = 0.06, *p* < .001, *OR* = 0.69 for the former; and $\hat{\gamma}$ = -0.71, *SE* = 0.10, *p* < .001, *OR* = 0.49 for the latter). Pell grants were a negative factor in the Student-level Model, but became nonsignificant in the presence of institutional variables. Also predicting lower relative odds of completing a four-year degree were working full-time, associated with a 49% decrease in odds ($\hat{\gamma}$ = -0.67, *SE* = 0.15, *p* < .001, *OR* = 0.51) and having a dependent child, associated with a 74% decrease in odds ($\hat{\gamma}$ = -1.36, *SE* = 0.10, *p* < .001, *OR* = 0.26). Although both remediation and attending three or more institutions had negative main effects, a positive interaction between them ($\hat{\gamma}$ = 0.59, *SE* = 0.19, *p* = .002, *OR* = 1.81) led to a weakened (but still negative) net effect when they occurred together.

At the institution level, private colleges were associated with 58% higher odds of earning at least a Bachelor's ($\hat{\gamma}$ = 0.46, *SE* = 0.09, *p* < .001, *OR* = 1.58), and a higher percentage of students receiving federal grant aid (essentially an indicator of the socioeconomic status of the student body) was a negative factor: a one percentage point increase in the proportion of grant recipients was associated with a 2% reduction in the odds of graduating ($\hat{\gamma}$ = -0.02, *SE* < 0.01, *p* < .001, *OR* = 0.98).

Comparing remediation to other categorical predictors in the Student- and Institution-Level model, the logistic coefficient for "any remediation" ($\hat{\gamma}$ = -0.31) was below the average coefficient size in this model; it was smaller than the coefficients for full-time enrollment ($\hat{\gamma}$ = 1.02) and having a child ($\hat{\gamma}$ = -1.36). However, it was 70% larger than the magnitude of the coefficient for parental college education ($\hat{\gamma}$ = 0.18).

Random effects. The Student- and Institution-level Model (Table 22) explained 27.6% of total variance in the odds of attaining a Bachelor's degree. Nearly 26% of the variation in the odds of Bachelor's degree attainment at four-year institutions was attributable to between-college differences, a higher proportion than was found for the two-year colleges' Bachelor's degree outcome. The two institutional predictors explained only 6.2% of this between-school variance beyond that explained by student factors.

The slope of remediation was fixed because a random slope could not be reliably predicted (see the section of this chapter on "Research Question Three" for more discussion). However, the slope for attending two institutions was allowed to vary randomly. This random slope meant that the relationship between a student's attending multiple institutions and attaining a degree varied significantly depending on the student's first college. The random intercept and random slope were highly negatively correlated (r = -0.74). Thus, at a college where the cohort of students who initially enrolled there had higher odds of completing a degree on average, the relationship between one of those student's subsequently attending multiple institutions and eventually attaining a degree was weaker.

Table 21.

Four-year Institutions: Relationship between Any Remediation and Attaining a Bachelor's Degree or Higher: Fixed Effects

	Model A *Remediation-Only*			*Model B* *Student-Level*			*Model C* *Student- & Institution-Level*		
	Coeff	(SE)	OR	Coeff	(SE)	OR	Coeff	(SE)	OR
STUDENT-LEVEL									
Intercept	0.89 ***	(0.06)	2.43	0.07	(0.24)	1.08	-0.27	(0.24)	0.76
Any remediation	-0.56 ***	(0.07)	0.57	-0.42***	(0.10)	0.66	-0.31**	(0.10)	0.74
Asian				0.10	(0.16)	1.10			
Black				-0.24	(0.12)	0.79			
Hispanic				-0.36**	(0.12)	0.70			
Other race				-0.01	(0.15)	0.99			
Male				-0.54***	(0.07)	0.58	-0.53***	(0.07)	0.59
Age									
Income				0.00***[a]	(0.00)	1.00	0.00***[c]	(0.00)	1.00
Parent education				0.17*	(0.08)	1.18	0.18*	(0.08)	1.20
Private HS									
Algebra II				0.50**	(0.15)	1.65	0.51**	(0.15)	1.66
HS curriculum									
HS GPA				0.49***	(0.04)	1.63	0.47***	(0.04)	1.59
Academic integration index									
Social integration index				0.00***[b]	(0.00)	1.00	0.00***[d]	(0.00)	1.00
Full-time enrollment				1.07***	(0.16)	2.91	1.02***	(0.16)	2.77
Pell grant				-0.19*	(0.08)	0.82			
Declared a major									
Attended 2 colleges†				-0.37***	(0.06)	0.69	-0.37***	(0.06)	0.69
Attended. 3+ colleges				-0.72***	(0.10)	0.49	-0.71***	(0.10)	0.49
Worked full-time				-0.71***	(0.16)	0.49	-0.67***	(0.15)	0.51
Child				-1.36***	(0.10)	0.26	-1.36***	(0.10)	0.26
Remediation X 3+ Col.				0.60**	(0.19)	1.83	0.59**	(0.19)	1.81
INSTITUTION-LEVEL									
Private college							0.46***	(0.09)	1.58
College enrollment (1,000s)									
% Black students (sqrt)									
% Hispanic students (sqrt)									
% students w/ federal aid							-0.02***	(0.00)[e]	0.98
% full-time faculty									
Deviance (# parameters)	20,516 (3)			19,622 (22)			19,547 (19)		

* p<.05; ** p<.01; *** p<.001; †Slope allowed to vary randomly in Models B and C; Institution-level variables were not used to predict slope variability. [a] Actual values 0.0007 (0.0002); [b] Actual values 0.0050 (0.0006); [c] Actual values 0.0008 (0.0001); [d] Actual values 0.0041 (0.0006); [e] Actual value (0.0028)

Table 22

Four-year Institutions: Relationship between Any Remediation and Attaining a Bachelor's Degree or Higher: Random Effects

	Unconditional Model	*Model A Remediation-Only*	*Model B Student-Level*	*Model C Student- & Institution-Level*
$\hat{\tau}_{00}$ Between-college variance	1.15***	0.98***	0.64***	0.60***
$\hat{\tau}_{11}$INSTIT2 slope variance	-	-	0.88***	0.93***
$\hat{\tau}_{01}$ as correlation	-	-	-0.67	-0.74
σ^2_F Explained variance[a]	-	0.06	1.28	1.49
σ^2_R Within-college variance (Fixed)	3.29	3.29	3.29	3.29
Intra-class correlation coefficient[b]	25.9%	22.9%	16.4%	15.5%
% residual $\hat{\tau}_{00}$ explained by institutional predictors[c]	-	-	-	6.2%
% total variance explained[d]	-	1.5%	24.6%	27.6%
$\hat{\tau}_{00}$ Reliability $\hat{\tau}_{11}$ Reliability	.72 -	.68 -	.41 .22	.37 .22

* p<.05; ** p<.01; *** p<.001

[a] Var($\hat{Y}_{ij}$) where $\hat{Y}_{ij} = \gamma_0 + \sum_{h=1}^{r} \gamma_h X_{hij}$

[b] $\hat{\tau}_{00}$ / $(\hat{\tau}_{00} + \pi^2/3)$

[c] $(\hat{\tau}_{00B} - \hat{\tau}_{00C})/\hat{\tau}_{00B}$

[d] σ^2_F /(σ^2_F + τ_{00}+σ^2_R)

Relationship of Number of Remedial Courses to Degree Attainment

In this set of models, in place of the single dummy variable for enrollment in one or more remedial courses, a set of two dummy variables was entered representing one-to-two courses and three or more courses, with no remediation as the reference category.

Two-year institutions: Relationship of number of remedial courses and earning an Associate's degree or higher. Tables 23 and 24 summarize the results of this set of models.

Fixed effects. In the absence of other predictors, both remediation dummies had significant negative fixed effects, with more courses having a greater magnitude than fewer courses. Taking one-to-two courses was associated with 24% lower odds of graduating than for taking no courses ($\hat{\gamma}$ = -0.27, *SE* = 0.07, $p < .001$, *OR* = 0.76), while taking three or more courses was linked with 36% lower odds ($\hat{\gamma}$ = -0.45, *SE* = 0.08, $p < .001$, *OR* = 0.64). The coefficients for the two dummy variables were close in magnitude to the single dummy representing "any remediation" in the models shown in Table 13 ($\hat{\gamma}$ = -0.34). As was seen in most of the other two-year college models, including the "any remediation" version of this model, the remediation coefficients became nonsignificant after postsecondary experiences were taken into account ($\hat{\gamma}$ = 0.27, *SE* = 0.15, $p = .064$, *OR* = 1.32 for one-to-two courses, and $\hat{\gamma}$ = 0.05, *SE* = 0.10, $p = .639$, *OR* = 1.05 for three or more courses in the final Student- and Institution-level Model).

The set of statistically significant main effects was the same as in the "any remediation" version of this model, and the covariates' coefficients maintained the same directions and very similar magnitudes. However, there was also a negative interaction between taking one-to-two remedial courses and declaring a major ($\hat{\gamma}$ = -0.40, *SE* = 0.19, $p = .040$, *OR* = 0.67), meaning that taking a small number of remedial courses weakened the positive main effect of declaring a major. At the institution level, the same predictors were statistically significant as in the equivalent "any remediation" model (a positive relationship with private control and negative relationships with enrollment and percentage of Black students).

Random effects. The Student- and Institution-level Model explained 27.5% of total variation in the outcome. The institutional variables accounted for 18.4% of between-college variance after accounting for student-level covariates. Because the main effects of the two remediation variables were nonsignificant, their slopes were fixed; there was no evidence of a statistically significant relationship in which variation could be detected across colleges.

Table 23

Two-year Institutions: Relationship between Number of Remedial Courses and Attaining an Associate's Degree or Higher: Fixed Effects

	Model A Remediation-Only			*Model B Student-Level*			*Model C Student- & Institution-Level*		
	Coeff	(*SE*)	*OR*	Coeff	(*SE*)	*OR*	Coeff	(*SE*)	*OR*
STUDENT-LEVEL									
Intercept	-0.43 ***	(0.07)	0.65	-2.07***	(0.17)	0.13	-2.09***	(0.17)	0.12
1-2 remedial courses	-0.27 ***	(0.07)	0.76	0.25	(0.15)	1.29	0.27	(0.15)	1.32
3+ remedial courses	-0.45 ***	(0.08)	0.64	0.04	(0.10)	1.04	0.05	(0.10)	1.05
Asian				0.22	(0.19)	1.25	0.32	(0.20)	1.38
Black				-0.65***	(0.15)	0.52	-0.53**	(0.16)	0.59
Hispanic				0.00[a]	(0.12)	1.00	0.04	(0.13)	1.04
Other race				-0.46**	(0.17)	0.63	-0.49**	(0.18)	0.62
Male									
Age									
Income									
Parent education									
Private HS									
Algebra II									
HS curriculum									
HS GPA				0.21***	(0.04)	1.23	0.20***	(0.04)	1.22
Academic integration				0.00*[b]	(0.00)	1.00	0.00*[c]	(0.00)	1.00
Social integration index									
Full-time enrollment				0.75***	(0.12)	2.11	0.71***	(0.12)	2.02
Pell grant									
Declared a major				0.52***	(0.12)	1.68	0.54***	(0.11)	1.71
Attended 2 colleges				1.27***	(0.09)	3.56	1.29***	(0.09)	3.64
Attended 3+ colleges				1.69***	(0.11)	5.43	1.69***	(0.11)	5.41
Worked full-time				-0.32**	(0.12)	0.72	-0.31**	(0.12)	0.74
Child				-0.69***	(0.10)	0.50	-0.71***	(0.10)	0.49
1-2 remedial X major				-0.37*	(0.19)	0.69	-0.40*	(0.19)	0.67
INSTITUTION-LEVEL									
Private college							0.54**	(0.19)	1.72
College enr. (1,000s)							-0.02**	(0.01)	0.98
% Black students (sqrt)							-0.08*	(0.03)	0.93
% Hispanic students (sqrt)									
% students w/ federal aid									
% full-time faculty									
Deviance (# parameters)	10,900 (4)			10,267 (17)			10,236 (20)		

* p<.05; ** p<.01; *** p<.001; [a] Actual value -0.0034; [b] Actual values 0.0026 (0.0010); [c] Actual values 0.0027 (0.0010)

Table 24

Two-year Institutions: Relationship between Number of Remedial Courses and Attaining an Associate's Degree or Higher: Random Effects

	Unconditional Model	*Model A Remediation-Only*	*Model B Student-Level*	*Model C Student- & Institution-Level*
$\hat{\tau}_{00}$ Between-college variance	0.31***	0.29***	0.31***	0.25***
σ^2_F Explained variance[a]	-	0.03	1.24	1.34
σ^2_R Within-college variance (Fixed)	3.29	3.29	3.29	3.29
Intra-class correlation coefficient[b]	8.6%	8.0%	8.6%	7.1%
% residual $\hat{\tau}_{00}$ explained by institutional predictors[c]	-	-	-	18.4%
% total variance explained[d]	-	0.9%	25.7%	27.5%
$\hat{\tau}_{00}$ Reliability	.42	.41	.37	.29

* p<.05; ** p<.01; *** p<.001

[a] Var($\hat{Y}_{ij}$) where $\hat{Y}_{ij} = \gamma_0 + \sum_{h=1}^{r} \gamma_h X_{hij}$

[b] $\hat{\tau}_{00} / (\hat{\tau}_{00} + \pi^2/3)$

[c] $(\hat{\tau}_{00B} - \hat{\tau}_{00C})/\hat{\tau}_{00B}$

[d] $\sigma^2_F /(\sigma^2_F + \tau_{00}+\sigma^2_R)$

Two-year institutions: Relationship of number of remedial courses and certificate. Tables 25 and 26 display results for this set of models.

Fixed effects. The Student- and Institution-level Model for certificate attainment and number of remedial courses was similar to the "any-remediation" version (see Table 15), with very few significant factors. However, in contrast to that version, in which "any remediation" was not significantly associated with the outcome, the two remediation dummy variables each had a significant negative association with certificate attainment in this model. Taking one or two remedial courses was associated with a 40% reduction in the odds of earning a certificate compared to the odds for no remediation ($\hat{\gamma}$ = -0.51, *SE* =

0.24, *p* = .032, *OR* = 0.60), and taking three or more courses was associated with a similar reduction in odds ($\hat{\gamma}$ = -0.54, *SE* = 0.23, *p* = .018, *OR* = 0.58). A positive interaction between one-to-two remedial courses and attending two colleges (whose main effect was not significant) was also included ($\hat{\gamma}$ = 0.85, *SE* = 0.36, *p* = .018, *OR* = 2.34), leading to a net positive effect for these two variables together. In other words, for a student who took remedial courses but also attended multiple institutions, the negative association with remediation would be overridden by a positive association with multi-institution attendance.

As compared to other categorical predictors in the Student- and Institution-Level model, the logistic coefficients for taking 1-2 and 3 or more remedial courses ($\hat{\gamma}$ = -0.51 and $\hat{\gamma}$ = -0.54, respectively) were slightly larger than the coefficient for attending two colleges ($\hat{\gamma}$ = 0.40).

Random effects. The Student- and Institution-level Model accounted for 6.3% of total variance in the outcome. Institutional factors explained 13.0% of the residual between-college variance after the introduction of student factors. The slopes of the two remediation variables were fixed because these relationships to certificate attainment did not vary significantly from one college to another, and could not be reliably estimated when varying randomly.

Table 25. *Two-year Institutions: Relationship between Number of Remedial Courses and Attaining a Certificate: Fixed Effects*

	Model A Remediation-Only			*Model B Student-Level*			*Model C Student- & Institution-Level*		
	Coeff	(*SE*)	*OR*	Coeff	(*SE*)	*OR*	Coeff	(*SE*)	*OR*
STUDENT-LEVEL									
Intercept	-3.19 ***	(0.20)	0.04	-3.34***	(0.24)	0.04	-3.27***	(0.23)	0.04
1-2 remedial courses	-0.18	(0.17)	0.84	-0.51*	(0.24)	0.60	-0.51*	(0.24)	0.60
3+ remedial courses	-0.61 **	(0.23)	0.55	-0.55*	(0.23)	0.57	-0.54*	(0.23)	0.58
Asian									
Black									
Hispanic									
Other race									
Male									
Age									
Income									
Parent education									
Private HS									
Algebra II									
HS curriculum									
HS GPA									
Academic integr. index									
Social integration index									
Full-time enrollment									
Pell grant									
Declared a major									
Attended 2 colleges				0.09	(0.21)	1.09	0.09	(0.22)	1.10
Attended 3+ colleges				0.41	(0.26)	1.51	0.40	(0.26)	1.49
Worked full-time									
Child									
1-2 remedial X 2 colleges				0.85*	(0.35)	2.34	0.85*	(0.36)	2.34
INSTITUTION-LEVEL									
Private college									
College enr. (1,000s)							-0.04*	(0.02)	0.96
% Black students (sqrt)									
% Hispanic students (sqrt)									
% students w/ federal aid									
% full-time faculty									
Deviance (# parameters)	7,808 (4)			7,797 (7)			7,788 (8)		

* p<.05; ** p<.01; *** p<.001

Table 26

Two-year Institutions: Relationship between Number of Remedial Courses and Attaining a Certificate: Random Effects

	Unconditional Model	*Model A Remediation-Only*	*Model B Student-Level*	*Model C Student- & Institution-Level*
$\hat{\tau}_{00}$ Between-college variance	1.24***	1.16***	1.22***	1.06***
σ^2_F Explained variance[a]	-	0.06	0.14	0.29
σ^2_R Within-college variance (Fixed)	3.29	3.29	3.29	3.29
Intra-class correlation coefficient[b]	27.4%	26.1%	27.1%	24.4%
% residual $\hat{\tau}_{00}$ explained by institutional predictors[c]	-	-	-	13.0%
% total variance explained[d]	-	1.4%	2.9%	6.3%
$\hat{\tau}_{00}$ Reliability	.39	.37	.38	.36

* p<.05; ** p<.01; *** p<.001

[a] Var($\hat{Y}_{ij}$) where $\hat{Y}_{ij} = \gamma_0 + \sum_{h=1}^{r} \gamma_h X_{hij}$

[b] $\hat{\tau}_{00} / (\hat{\tau}_{00} + \pi^2/3)$

[c] $(\hat{\tau}_{00B} - \hat{\tau}_{00C})/\hat{\tau}_{00B}$

[d] $\sigma^2_F / (\sigma^2_F + \tau_{00} + \sigma^2_R)$

Two-year institutions: Relationship of number of remedial courses and Associate's degree. The results for this set of models are displayed in Tables 27 and 28.

Fixed effects. The Student- and Institution-level Model for Associate's degree attainment was similar to the "any-remediation" version in many respects. Like the single-dummy model ($\hat{\gamma}$ = 0.68 as shown in Table 17), the two remediation dummies both had positive associations with earning an Associate's degree after controlling for covariates: Taking one-to-two remedial courses was related to an 85% increase in the odds of degree attainment compared to non-remediated students ($\hat{\gamma}$ = 0.61, *SE* = 0.21, *p* = .004, *OR* = 1.85), while taking three or more courses was related to a 56% increase in the odds ($\hat{\gamma}$ = 0.44, *SE* = 0.13, *p* = .001, *OR* = 1.56). Stated in terms of the probability of the outcome, one-to-two courses were associated with a nine percentage point increase in the probability of earning an Associate's degree (Delta-*p* = 0.09), and three or more courses were associated with a seven percentage point increase in that probability (Delta-*p* = 0.07). A negative interaction between taking a small number of remedial courses and declaring a major ($\hat{\gamma}$ = -0.60, *SE* = 0.22, *p* = .008, *OR* = 0.55) meant that the net positive effect of the two variables was slightly weakened. The set of statistically significant covariates was similar to the "any-remediation" version of the model. Being categorized as Other race continued to have a negative fixed effect, while being Black now also emerged as a negative factor; having a higher high school GPA was again a positive factor, although taking a rigorous high school curriculum was no longer significant; and full-time enrollment, receiving a Pell grant, and declaring a major were all positively related to attainment again, with coefficients of similar magnitude to those in the "any-remediation" model. There was one significant negative institution-level factor: percentage of Black students. Enrollment was not a significant predictor in this version of the model.

To place remediation in context with other categorical predictors in the Student- and Institution-Level model, the logistic coefficient for taking 1-2 remedial courses ($\hat{\gamma}$ = 0.61) was 20% larger than that of full-time enrollment ($\hat{\gamma}$ = 0.51), while the coefficient for taking 3 or more remedial courses ($\hat{\gamma}$ = 0.44) was only 86% of the magnitude of that coefficient. However, both were above the average coefficient magnitude in this model.

Random effects. The Student- and Institution-level Model explained a small portion of total variance (5.7%). The one institutional factor (percentage of Black students) explained only 1.5% of between-college variance beyond variance explained by student factors.

This model was the only one in which a remediation slope was allowed to vary randomly, because it met the criteria for reliability, significant variation, and significant main effect. The association between taking one or two remedial courses and earning an Associate's degree varied significantly across colleges. However, this slope variance could not be predicted by the institution-level factors, perhaps in part because its reliability was low (0.13). The implications of this finding for Research Question 3 will be discussed further in that section of this chapter. The intercept and slope estimates were moderately negatively correlated ($r = -0.48$), meaning that the lower the odds of attaining an Associate's degree for the mean student at an institution, the stronger the positive relationship between remediation and attainment.

Table 27

Two-year Institutions: Relationship between Number of Remedial Courses and Attaining an Associate's Degree: Fixed Effects

	Model A *Remediation-Only*			*Model B* *Student-Level*			*Model C* *Student- & Institution-Level*		
	Coeff	(*SE*)	*OR*	Coeff	(*SE*)	*OR*	Coeff	(*SE*)	*OR*
STUDENT-LEVEL									
Intercept	-1.76 ***	(0.09)	0.17	-2.79***	(0.21)	0.06	-2.82***	(0.21)	0.06
1-2 remedial courses†	0.09	(0.10)	1.10	0.63**	(0.21)	1.87	0.61**	(0.21)	1.85
3+ remedial courses	0.32 **	(0.11)	1.37	0.43**	(0.13)	1.54	0.44**	(0.13)	1.56
Asian				0.26	(0.23)	1.29	0.28	(0.23)	1.33
Black				-0.52**	(0.15)	0.59	-0.39*	(0.17)	0.68
Hispanic				0.00[a]	(0.14)	1.00	0.00[b]	(0.14)	1.00
Other race				-0.58**	(0.20)	0.56	-0.59**	(0.20)	0.56
Male									
Age									
Income									
Parent education									
Private HS									
Algebra II									
HS curriculum									
HS GPA				0.12*	(0.05)	1.13	0.12*	(0.05)	1.13
Academic integration index									
Social integration index									
Full-time enrollment				0.51***	(0.13)	1.67	0.51***	(0.13)	1.67
Pell grant				0.22*	(0.10)	1.24	0.22*	(0.10)	1.25
Declared a major				0.70***	(0.15)	2.01	0.72***	(0.15)	2.05
Attended 2 colleges									
Attended 3+ college									
Worked full-time									
Child									
1-2 remedial X major				-0.59**	(0.22)	0.55	-0.60**	(0.22)	0.55
INSTITUTION-LEVEL									
Private college									
College enr. (1,000s)									
% Black students (sqrt)							-0.11*	(0.04)	0.90
% Hispanic students (sqrt)									
% students w/ federal aid									
% full-time faculty									
Deviance (# parameters)	9,736 (4)			9,648 (15)			9,641 (16)		

* p<.05; ** p<.01; *** p<.001; †Slope allowed to vary randomly in Models B and C; Institution-level variables were not used to predict slope variability. [a] Actual value -0.0015; [b] Actual value -0.0012

Table 28

Two-year Institutions: Relationship between Number of Remedial Courses and Attaining an Associate's Degree: Random Effects

	Unconditional Model	*Model A Remediation-Only*	*Model B Student-Level*	*Model C Student- & Institution-Level*
$\hat{\tau}_{00}$ Between-college variance	0.36***	0.37***	0.58***	0.57***
$\hat{\tau}_{11}$REM2 slope variance	-	-	0.90*	0.88*
$\hat{\tau}_{01}$ as correlation	-	-	-0.53	-0.48
σ^2_F Explained variance[a]	-	0.02	0.23	0.23
σ^2_R Within-college variance (Fixed)	3.29	3.29	3.29	3.29
Intra-class correlation coefficient[b]	9.9%	10.2%	14.9%	14.7%
% residual $\hat{\tau}_{00}$ explained by institutional predictors[c]	-	-	-	1.5%
% total variance explained[d]	-	0.5%	5.6%	5.7%
$\hat{\tau}_{00}$ Reliability $\hat{\tau}_{11}$ Reliability	.44 -	.43 -	.38 .13	.37 .13

* p<.05; ** p<.01; *** p<.001

[a] Var($\hat{Y}_{ij}$) where $\hat{Y}_{ij} = \gamma_0 + \sum_{h=1}^{r} \gamma_h X_{hij}$

[b] $\hat{\tau}_{00}$ / $(\hat{\tau}_{00} + \pi^2/3)$

[c] $(\hat{\tau}_{00B} - \hat{\tau}_{00C})/\hat{\tau}_{00B}$

[d] $\sigma^2_F / (\sigma^2_F + \tau_{00} + \sigma^2_R)$

Two-year institutions: Relationship of number of remedial courses and Bachelor's degree. Tables 29 and 30 present the results of this set of models.

Fixed effects. Although the same set of student-level predictors had significant fixed effects in this model and the "any-remediation" version (Table 19), with very similar magnitudes, disaggregating remediation into smaller and larger numbers of classes revealed distinct relationships. Whereas "any remediation" was nonsignificant after controlling for other factors, taking three or more courses had a statistically significant negative relationship to Bachelor's attainment in the presence of control variables in the Student- and Institution-level Model ($\hat{\gamma}$ = -0.40, *SE* = 0.17, *p* = .019, *OR* = 0.67). Taking a larger number of remedial courses was associated with a 33% reduction in the odds of earning a Bachelor's degree compared to no remediation, or a 5 percentage point decrease in the probability of degree completion (Delta-*p* = -0.05) associated with taking three or more remedial courses. None of the institutional factors were significant.

In comparison to other categorical predictors, taking three or more remedial courses had a logistic coefficient ($\hat{\gamma}$ = -0.40) nearly half the size of the coefficient for full-time enrollment($\hat{\gamma}$ = 0.88), but close in magnitude to that of parental college education($\hat{\gamma}$ = 0.46); this coefficient was close to the median size for all predictors in the model.

Random effects. The two remediation dummy variables accounted for 5.6% of total variance in the odds of attaining a Bachelor's degree. As noted with the "any remediation" version of this model, the atypically large slope coefficients for number of institutions attended led to a very large estimate of total variance explained (75.8%) in the Student- and Institution-level Model. Institutional factors explained none of the variance between schools and were not included in the final model. The intercept reliability was poor (0.10). The remediation slopes did not meet the criteria for varying at random (lacking significant variation across institutions and not reliably predicted) and were fixed.

Table 29

Two-year Institutions: Relationship between Number of Remedial Courses and Attaining a Bachelor's Degree or Higher: Fixed Effects

	Model A Remediation-Only			*Model B Student-Level*			*Model C Student- & Institution-Level*		
	Coeff	(SE)	OR	Coeff	(SE)	OR	Coeff	(SE)	OR
STUDENT-LEVEL									
Intercept	-1.30 ***	(0.08)	0.27	-7.29***	(0.81)	0.00	-7.29***	(0.81)	0.00
1-2 remedial courses	-0.48 ***	(0.10)	0.62	-0.07	(0.13)	0.93	-0.07	(0.13)	0.93
3+ remedial courses	-1.17 ***	(0.13)	0.31	-0.40*	(0.17)	0.67	-0.40*	(0.17)	0.67
Asian				-0.05	(0.28)	0.95	-0.05	(0.28)	0.95
Black				-0.57**	(0.20)	0.57	-0.57 **	(0.20)	0.57
Hispanic				-0.02	(0.19)	0.98	-0.02	(0.19)	0.98
Other race				-0.10	(0.30)	0.90	-0.10	(0.30)	0.90
Male									
Age									
Income									
Parent education				0.46**	(0.13)	1.58	0.46 **	(0.13)	1.58
Private HS									
Algebra II									
HS curriculum				0.47***	(0.12)	1.60	0.47***	(0.12)	1.60
HS GPA				0.16**	(0.05)	1.18	0.16 **	(0.05)	1.18
Academic integr. index				0.00**[a]	(0.00)	1.00	0.00**[b]	(0.00)	1.00
Social integration index									
Full-time enrollment				0.88***	(0.17)	2.41	0.88***	(0.17)	2.41
Pell grant									
Declared a major									
Attended 2 colleges				5.55***	(0.76)	256.62	5.55***	(0.76)	256.62
Attended 3+ colleges				5.93***	(0.77)	375.92	5.93***	(0.77)	375.92
Worked full-time				-0.48**	(0.17)	0.62	-0.48 **	(0.17)	0.62
Child				-1.34***	(0.20)	0.26	-1.34***	(0.20)	0.26
INSTITUTION-LEVEL									
Private college									
College enrollment (1,000s)									
% Black students (sqrt)									
% Hispanic students (sqrt)									
% students w/ federal aid									
% full-time faculty									
Deviance (# parameters)	9,422 (4)			8,443 (17)			8,443 (17)		

* p<.05; ** p<.01; *** p<.001; [a] Actual values 0.0042 (0.0015); [b] Actual values 0.0042 (0.0015)

Note: None of the institutional factors were significant; Models B and C are the same.

Table 30

Two-year Institutions: Relationship between Number of Remedial Courses and Attaining a Bachelor's Degree or Higher: Random Effects

	Model 0 Unconditional	*Model A Remediation-Only*	*Model B Student-Level*	*Model C[e] Student- & Institution-Level*
$\hat{\tau}_{00}$ Between-college variance	.50***	0.42***	0.18*	0.18*
σ^2_F Explained variance[a]	-	0.22	10.90	10.90
σ^2_R Within-college variance (Fixed)	3.29	3.29	3.29	3.29
Intra-class correlation coefficient[b]	13.2%	11.4%	5.3%	5.3%
% residual $\hat{\tau}_{00}$ explained by institutional predictors[c]	-	-	-	0.0%
% total variance explained[d]	-	5.6%	75.8%	75.8%
$\hat{\tau}_{00}$ Reliability	.41	.38	.10	.10

* p<.05; ** p<.01; *** p<.001

[a] Var($\hat{Y}_{ij}$) where $\hat{Y}_{ij} = \gamma_0 + \sum_{h=1}^{r} \gamma_h X_{hij}$

[b] $\hat{\tau}_{00} / (\hat{\tau}_{00} + \pi^2/3)$

[c] $(\hat{\tau}_{00B} - \hat{\tau}_{00C})/\hat{\tau}_{00B}$

[d] $\sigma^2_F / (\sigma^2_F + \tau_{00} + \sigma^2_R)$

[e] None of the institutional factors were significant; Models B and C are the same.

Four-year institutions: Relationship of number of remedial courses and Bachelor's degree. See Tables 31 and 32 for a summary of results.

Fixed effects. As with the "any remediation" model for four-year college students (in which the remediation coefficient was $\hat{\gamma}$ = -0.31, as shown in Table 21), the two remediation dummies representing number of courses had a negative association with the odds of degree attainment after controlling for covariates. In the Student- and Institution-level Model, taking three or more remedial courses had a stronger negative relationship to the outcome than taking one or two: the larger number of courses was associated with a 34% reduction in odds of Bachelor's attainment compared to the odds with no remediation ($\hat{\gamma}$ = -0.41, *SE* = 0.17, *p* = .014, *OR* = 0.66), and the smaller number was related to a 17% decrease in odds, a relationship that was nonsignificant ($\hat{\gamma}$ = -0.18, *SE* = 0.10, *p* = .070, *OR* = 0.83). Three or more remedial courses were associated with a ten percentage point decrease in the probability of degree completion (Delta-*p* = -0.10). The same main effects were significant as in the "any remediation" version of the model, with coefficients of very similar magnitudes, although there were no interactions in this version. At the institution level, the same two factors were also significant: private control had a positive association with Bachelor's degree attainment, while the percentage of students receiving federal aid had a negative association with this outcome. Once these college factors were added, the coefficients for being Hispanic and for receiving a Pell grant, which had been statistically significant in the Student-level Model, were no longer significant.

To place remediation in context in relation to other categorical predictors, taking three or more remedial courses had a logistic coefficient in the final model ($\hat{\gamma}$ = -0.41) that was just below the average coefficient size: 40% of the magnitude of the coefficient for full-time enrollment ($\hat{\gamma}$ = 1.00) and 30% of the magnitude for having a child ($\hat{\gamma}$ = -1.35), but closer in size to that of taking Algebra II in high school ($\hat{\gamma}$ = 0.50).

Random effects. In the Student- and Institution-level Model, the predictors explained 27.5% of total variance in the odds of Bachelor's degree attainment. The institutional factors accounted for 4.9% of residual between-college variance beyond that accounted for by student factors.

The two remediation slopes did not meet the criteria for varying randomly because they did not exhibit significant variation across colleges and could not be reliably estimated when randomly varying. As with the "any remediation" model for four-year college students, the slope for attending two institutions was allowed to vary randomly, and the intercept and slope coefficients were highly correlated (r = -0.74). Thus, the overall negative relationship between attending two institutions and completing college differed significantly from one college to another, and tended to be more strongly negative at institutions where the average student had higher odds of graduating.

Table 31

Four-year Institutions: Relationship between Number of Remedial Courses and Attaining a Bachelor's Degree or Higher: Fixed Effects

	Model A Remediation-Only			*Model B Student-Level*			*Model C Student- & Institution-Level*		
	Coeff	(SE)	OR	Coeff	(SE)	OR	Coeff	(SE)	OR
STUDENT-LEVE									
Intercept	0.89 ***	(0.06)	2.44	0.07	(0.24)	1.07	-0.28	(0.24)	0.76
1-2 remedial courses	-0.49 ***	(0.07)	0.61	-0.28**	(0.10)	0.76	-0.18	(0.10)	0.83
3+ remedial courses	-0.99 ***	(0.14)	0.37	-0.59**	(0.18)	0.56	-0.41*	(0.17)	0.66
Asian				0.09	(0.16)	1.10			
Black				-0.22	(0.12)	0.80			
Hispanic				-0.35**	(0.12)	0.71			
Other race				-0.01	(0.15)	0.99			
Male				-0.54***	(0.07)	0.59	-0.52***	(0.07)	0.59
Age									
Income				0.00***[a]	(0.00)	1.00	0.00***[c]	(0.00)	1.00
Parent education				0.17*	(0.08)	1.18	0.18*	(0.07)	0.59
Private HS									
Algebra II				0.49**	(0.15)	1.63	0.50**	(0.15)	1.64
HS curriculum									
HS GPA				0.48***	(0.04)	1.62	0.46***	(0.04)	1.59
Academic integr. index									
Social integration index				0.01***	(0.00)[b]	1.01	0.00***[d]	(0.00)	1.00
Full-time enrollment				1.05***	(0.16)	2.86	1.00***	(0.16)	2.72
Pell grant				-0.20*	(0.08)	0.82			
Declared a major									
Attended 2 colleges †				-0.37***	(0.06)	0.69	-0.37***	(0.06)	0.69
Att. 3+ colleges				-0.57***	(0.09)	0.56	-0.57***	(0.08)	0.57
Worked full-time				-0.72***	(0.16)	0.49	-0.68***	(0.16)	0.51
Child				-1.35***	(0.11)	0.26	-1.35***	(0.10)	0.26
INSTITUTION-LEVEL									
Private college							0.46***	(0.09)	1.58
College enr. (1,000s)									
% Black students (sqrt)									
% Hispanic students (sqrt)									
% students w/ federal aid							-0.02***	(0.00)[e]	0.98
% full-time faculty									
Deviance (# parameters)	20,503 (4)			19,628 (22)			19,554 (19)		

* p<.05; ** p<.01; *** p<.001; †Slope allowed to vary randomly in Models B and C; Institution-level variables were not used to predict slope variability. [a] Actual values 0.0007 (0.0002); [b] Actual value (0.0006); [c] Actual values 0.0008 (0.0001); [d] Actual values 0.0042 (0.0006); [e] Actual value (0.0028)

Table 32

Four-year Institutions: Relationship between Number of Remedial Courses and Attaining a Bachelor's Degree or Higher: Random Effects

	Unconditional Model	*Model A Remediation-Only*	*Model B Student-Level*	*Model C Student- & Institution-Level*
$\hat{\tau}_{00}$ Between-college variance	1.15***	0.94***	0.63***	0.59***
$\hat{\tau}_{11}$INSTIT2 slope variance	-	-	0.86***	0.90***
$\hat{\tau}_{01}$ as correlation	-	-	-0.67	-0.74
σ^2_F Explained variance[a]	-	0.08	1.21	1.47
σ^2_R Within-college variance (Fixed)	3.29	3.29	3.29	3.29
Intra-class correlation coefficient[b]	25.9%	22.3%	16.0%	15.3%
% residual $\hat{\tau}_{00}$ explained by institutional predictors[c]	-	-	-	4.9%
% total variance explained[d]	-	1.8%	23.5%	27.5%
$\hat{\tau}_{00}$ Reliability $\hat{\tau}_{11}$ Reliability	.72 -	.67 -	.40 .22	.36 .21

* p<.05; ** p<.01; *** p<.001

[a] Var($\hat{Y}_{ij}$) where $\hat{Y}_{ij} = \gamma_0 + \sum_{h=1}^{r} \gamma_h X_{hij}$

[b] $\hat{\tau}_{00} \,/\, (\hat{\tau}_{00} + \pi^2/3)$

[c] $(\hat{\tau}_{00B} - \hat{\tau}_{00C})/\hat{\tau}_{00B}$

[d] $\sigma^2_F /(\sigma^2_F + \tau_{00}+\sigma^2_R)$

Relationship of Remedial Subjects to Degree Attainment

In this final group of models, a set of five dummy variables represented enrollment in five different remedial subjects, with no remediation as the reference category for each dummy. (Note that the subject categories were not mutually exclusive; a student could be enrolled in multiple subjects.)

Two-year institutions: Relationship of remedial subjects and earning an Associate's degree or higher. Tables 33 and 34 summarize the results of this model.

Fixed effects. In the previously discussed versions of this model that used "any remediation" (Table 13) and "number of courses" (Table 23) as predictors, remediation variables had negative unadjusted fixed effects, but nonsignificant fixed effects after controlling for covariates. The remediation subject model revealed different relationships. The unadjusted fixed effects of taking remedial Mathematics, English, and Reading were significant and negative. ESL and Other Remediation, by contrast, had significant positive fixed effects. After the addition of covariates, ESL was the only statistically significant subject predictor in the Student- and Institution-level Model, and had a relatively large magnitude ($\hat{\gamma}$ = 1.17, *SE* = 0.38, *p* = .003, *OR* = 3.23): taking an ESL course was associated with a 28 percentage point increase in the probability of earning an Associate's degree (Delta-*p* = 0.28). This pattern was foreseeable in the crosstabs presented under research question 1 earlier in this chapter (Table 9), which showed that ESL students had a higher graduation rate than their unremediated peers. In addition, Reading and Other Remediation had a significant positive interaction ($\hat{\gamma}$ = 1.23, *SE* = 0.36, *p* = .001, *OR* = 3.41), which led to a positive net effect. The same set of student-level main effects were significant in the Student- and Institution-level Model as in the equivalent "any remediation" and "number of courses" versions. Private control, total enrollment, and the percentage of Black students were again significant institutional factors.

To compare the significant fixed effect for ESL to other categorical predictors in the final model, its logistic coefficient ($\hat{\gamma}$ = 1.17) was one of the largest - larger than that of full-time enrollment ($\hat{\gamma}$ = 0.73) or having a child ($\hat{\gamma}$ = -0.69).

Random effects. The Student- and Institution-level Model explained 27.5% of total variance. Out of the residual between-school variance left beyond the proportion explained by student factors, the institutional variables accounted for 17.1% of differences in the odds of graduation between institutions. None of the five remediation slopes met the criteria to vary randomly, whether because of nonsignificant main effects, nonsignificant slope variation across institutions, or poor slope reliability (see discussion in this chapter on “Research Question Three”). The slope for attending two institutions did vary randomly, but its reliability was low (0.08). The random intercept and random slope were highly negatively correlated (r = -0.77), indicating that the overall positive relationship between attending two institutions and degree attainment was weaker at institutions with higher odds of graduation for the average student.

Table 33. *Two-year Institutions: Relationship between Remedial Subjects and Attaining an Associate's Degree or Higher: Fixed Effects*

	Model A *Remediation-Only*			*Model B* *Student-Level*			*Model C* *Student- & Institution-Level*		
	Coeff	(*SE*)	*OR*	Coeff	(*SE*)	*OR*	Coeff	(*SE*)	*OR*
STUDENT-LEVEL									
Intercept	-0.46 ***	(0.07)	0.63	-2.03***	(0.19)	0.13	-2.04***	(0.19)	0.13
Remedial Mathematics	-0.20 **	(0.07)	0.82	0.04	(0.10)	1.04	0.04	(0.10)	1.04
Remedial English	-0.23 *	(0.11)	0.79	-0.05	(0.13)	0.95	-0.09	(0.14)	0.91
Remedial Reading	-0.45 ***	(0.11)	0.64	-0.28*	(0.13)	0.75	-0.25	(0.13)	0.78
ESL	0.97 **	(0.35)	2.65	1.16**	(0.38)	3.18	1.17**	(0.38)	3.23
Remedial - Other	0.41 *	(0.17)	1.50	0.27	(0.21)	1.30	0.28	(0.21)	1.32
Reading X Other Remedial				1.20**	(0.37)	3.31	1.23**	(0.36)	3.41
Asian				0.09	(0.20)	1.10	0.20	(0.21)	1.22
Black				-0.61***	(0.14)	0.55	-0.50**	(0.16)	0.61
Hispanic				-0.01	(0.13)	0.99	0.04	(0.13)	1.04
Other race				-0.41*	(0.17)	0.66	-0.43*	(0.18)	0.65
Male									
Age									
Income									
Parent education									
Private HS									
Algebra II									
HS curriculum									
HS GPA				0.21***	(0.04)	1.23	0.20***	(0.04)	1.23
Academic integr. index				0.00*[a]	(0.00)	1.00	0.00*[b]	(0.00)	1.00
Social integration index									
Full-time enrollment				0.77***	(0.12)	2.17	0.73***	(0.13)	2.08
Pell grant									
Declared a major				0.38***	(0.10)	1.47	0.39***	(0.10)	1.48
Attended 2 colleges †				1.29***	(0.09)	3.64	1.31***	(0.10)	3.69
Attended 3+ colleges				1.76***	(0.12)	5.82	1.74***	(0.12)	5.68
Worked full-time				-0.33**	(0.12)	0.72	-0.31*	(0.12)	0.73
Child				-0.68***	(0.11)	0.51	-0.69***	(0.11)	0.50
INSTITUTION-LEVEL									
Private college							0.54**	(0.19)	1.71
College enr. (1,000s)							-0.02**	(0.01)	0.98
% Black students (sqrt)							-0.07*	(0.03)	0.94
% Hispanic students (sqrt)									
% students w/ federal aid									
% full-time faculty									
Deviance (# parameters)	10,869 (7)			10,241 (22)			10,212 (25)		

* p<.05; ** p<.01; *** p<.001; †Slope allowed to vary randomly in Models B and C; Institution-level variables not used to predict slope. [a] Actual values 0.0027 (0.0011); [b] Actual values 0.0024 (0.0011)

Table 34

Two-year Institutions: Relationship between Remedial Subjects and Attaining an Associate's Degree or Higher: Random Effects

	Unconditional Model	*Model A Remediation-Only*	*Model B Student-Level*	*Model C Student- & Institution-Level*
$\hat{\tau}_{00}$ Between-college variance	0.31***	0.31***	0.58***	0.48***
$\hat{\tau}_{11}$INSTIT2 slope variance	-	-	0.56*	0.57*
$\hat{\tau}_{01}$ as correlation	-	-	-0.91	-0.77
σ^2_F Explained variance[a]	-	0.08	1.35	1.43
σ^2_R Within-college variance (Fixed)	3.29	3.29	3.29	3.29
Intra-class correlation coefficient[b]	8.6%	8.6%	14.9%	12.7%
% residual $\hat{\tau}_{00}$ explained by institutional predictors[c]	-	-	-	17.1%
% total variance explained[d]	-	2.3%	25.9%	27.5%
$\hat{\tau}_{00}$ Reliability $\hat{\tau}_{11}$ Reliability	.42 -	.43 -	.36 .07	.29 .08

* p<.05; ** p<.01; *** p<.001

[a] Var($\hat{Y}_{ij}$) where $\hat{Y}_{ij} = \gamma_0 + \sum_{h=1}^{r} \gamma_h X_{hij}$

[b] $\hat{\tau}_{00} \,/\, (\hat{\tau}_{00} + \pi^2/3)$

[c] $(\hat{\tau}_{00B} - \hat{\tau}_{00C})/\hat{\tau}_{00B}$

[d] $\sigma^2_F \,/ (\sigma^2_F + \tau_{00} + \sigma^2_R)$

Two-year institutions: Relationship of remedial subjects and earning a certificate. See Tables 35 and 36 for the results of this model.

Fixed effects. Mathematics was the only subject with a significant unadjusted fixed effect ($\hat{\gamma}$ = -0.53, *SE* = 0.18, *p* = .004, *OR* = 0.59); taking one or more remedial Mathematics courses was associated with a 41% decrease in the odds of earning a certificate, compared to the odds for students with no remediation. This significant relationship persisted at about the same magnitude after the addition of covariates in the

Student- and Institution-level Model ($\hat{\gamma}$ = -0.49, *SE* = 0.18, *p* = .007, OR = 0.61). However, its practical significance was minimal (associated with a 2 percentage point decrease in the probability of earning a certificate: Delta-*p* = -0.02). Parallel to the "any-remediation" certificate model for remedial subjects (Table 15), only two covariates were significant in the final model: attending two institutions (a positive association with certificate attainment) and total enrollment of the institution (a negative association).

The significant fixed effect for Mathematics remediation in the final model ($\hat{\gamma}$ = -0.49) was similar in magnitude to that of attending two colleges ($\hat{\gamma}$ = -0.41).

Random effects. The Student- and Institution-level model explained a small percentage of total variance in certificate attainment (6.2%). Institutional factors accounted for 14.2% of residual between-institution variance after the inclusion of student factors. None of the remediation slopes were allowed to vary at random because none of them exhibited significant variation across institutions.

Table 35. *Two-year Institutions: Relationship between Remedial Subjects and Attaining a Certificate: Fixed Effects*

	Model A Remediation-Only			*Model B Student-Level*			*Model C Student- & Institution-Level*		
	Coeff	(*SE*)	*OR*	Coeff	(*SE*)	*OR*	Coeff	(*SE*)	*OR*
STUDENT-LEVEL									
Intercept	-3.14 ***	(0.19)	0.04	-3.42***	(0.23)	0.03	-3.34***	(0.22)	0.04
Remedial Mathematics	-0.53 **	(0.18)	0.59	-0.50**	(0.18)	0.61	-0.49**	(0.18)	0.61
Remedial English	-0.09	(0.28)	0.91	-0.07	(0.28)	0.94	-0.13	(0.28)	0.88
Remedial Reading	0.00 [a]	(0.26)	1.00	0.05	(0.27)	1.05	0.07	(0.27)	1.07
ESL	0.38	(0.66)	1.46	0.37	(0.66)	1.45	0.52	(0.68)	1.69
Remedial - Other	0.45	(0.35)	1.56	0.44	(0.34)	1.56	0.46	(0.34)	1.59
Asian									
Black									
Hispanic									
Other race									
Male									
Age									
Income									
Parent education									
Private HS									
Algebra II									
HS curriculum									
HS GPA									
Academic integr. index									
Social integration index									
Full-time enrollment									
Pell grant									
Declared a major									
Attended 2 colleges				0.41*	(0.19)	1.50	0.41*	(0.19)	1.51
Attended 3+ colleges				0.42	(0.26)	1.52	0.41	(0.26)	1.50
Worked full-time									
Child									
INSTITUTION-LEVEL									
Private college									
College enr. (1,000s)							-0.04*	(0.02)	0.96
% Black students (sqrt)									
% Hispanic students (sqrt)									
% students w/ federal aid									
% full-time faculty									
Deviance (# parameters)	7,803 (7)			7,798 (9)			7,788 (10)		

* p<.05; ** p<.01; *** p<.001; [a] Actual value -0.0031

Table 36

Two-year Institutions: Relationship between Remedial Subjects and Attaining a Certificate: Random Effects

	Unconditional Model	*Model A Remediation-Only*	*Model B Student-Level*	*Model C Student- & Institution-Level*
$\hat{\tau}_{00}$ Between-college variance	1.24***	1.11***	1.17 ***	1.00***
σ^2_F Explained variance[a]	-	0.08	0.13	0.28
σ^2_R Within-college variance (Fixed)	3.29	3.29	3.29	3.29
Intra-class correlation coefficient[b]	27.4%	25.2%	26.2%	23.3%
% residual $\hat{\tau}_{00}$ explained by institutional predictors[c]	-	-	-	14.2%
% total variance explained[d]	-	1.9%	2.8%	6.2%
$\hat{\tau}_{00}$ Reliability	.39	.36	.38	.35

* p<.05; ** p<.01; *** p<.001

[a] Var($\hat{Y}_{ij}$) where $\hat{Y}_{ij} = \gamma_0 + \sum_{h=1}^{r} \gamma_h X_{hij}$

[b] $\hat{\tau}_{00} / (\hat{\tau}_{00} + \pi^2/3)$

[c] $(\hat{\tau}_{00B} - \hat{\tau}_{00C})/\hat{\tau}_{00B}$

[d] $\sigma^2_F / (\sigma^2_F + \tau_{00} + \sigma^2_R)$

Two-year institutions: Relationship of remedial subjects and earning an Associate's degree. Tables 37 and 38 present the results of this model.

Fixed effects. Mathematics, ESL, and Other Remedial courses had significant positive unadjusted associations with Associate's degree attainment, while Reading had a significant negative association with this outcome. English was the only remedial subject exhibiting no significant unadjusted relationship to the outcome. Covariates included in the model were parallel in direction and magnitude to those in the "number of courses" version of the model (Table 27), with the exception being the absence of an interaction term. In the Student- and Institution-level Model, significant control variables were

Black and Other Race (negative factors); high school GPA (positive factor); and full-time college enrollment, receiving a Pell grant, and declaring a major (positive factors). The institution's percentage of Black students had a negative relationship to degree attainment. In this final model, the two significant remediation main effects remaining were a four percentage point increase in the probability of attainment associated with Mathematics ($\hat{\gamma}$ = 0.26, *SE* = 0.09, *p* = .006, OR = 1.30, Delta-*p* = 0.04) and a five percentage point decrease in the probability of attainment associated with Reading ($\hat{\gamma}$ = -0.41, *SE* = 0.15, *p* = .007, OR = 0.67, Delta-*p* = -0.05). A positive interaction between Reading and Other Remediation mean that the two subjects together had a positive net effect ($\hat{\gamma}$ = 1.54, *SE* = 0.53, *p* = .004, OR = 4.67). The subject results complicated the picture presented by the "any remediation" (Table 17) and "number of courses (Table 27) versions, in which remediation predictors were positive.

The Reading ($\hat{\gamma}$ = -0.41) and ESL ($\hat{\gamma}$ = 0.82) coefficients were larger in absolute value than the average coefficient size in this model, while the other subject coefficients were smaller than the average.

Random effects. As shown in Table 38, the Student- and Institution-level Model explained 7.4% of variance in the odds of earning an Associate's degree. The one institutional factor (percent of Black students) explained very little of the residual between-institution variance beyond student factors (0.5%). None of the remediation slopes were allowed to vary randomly because each one either lacked significant variation across institutions, or had a nonsignificant main effect (see further discussion in this chapter under "Research Question Three").

Table 37. *Two-year Institutions: Relationship between Remedial Subjects and Attaining an Associate's Degree: Fixed Effects*

	Model A Remediation-Only			*Model B Student-Level*			*Model C Student- & Institution-Level*		
	Coeff	(*SE*)	*OR*	Coeff	(*SE*)	*OR*	Coeff	(*SE*)	*OR*
STUDENT-LEVEL									
Intercept	-1.76 ***	(0.09)	0.17	-2.58***	(0.20)	0.08	-2.61***	(0.19)	0.07
Remedial Mathematics	0.21 *	(0.09)	1.24	0.26**	(0.09)	1.30	0.26**	(0.09)	1.30
Remedial English	0.21	(0.13)	1.23	0.22	(0.14)	1.25	0.25	(0.14)	1.28
Remedial Reading	-0.38 **	(0.14)	0.68	-0.40**	(0.15)	0.67	-0.41**	(0.15)	0.67
ESL	0.83 *	(0.40)	2.28	0.83*	(0.42)	2.30	0.82	(0.42)	2.27
Remedial - Other	0.43 *	(0.19)	1.54	0.22	(0.21)	1.25	0.23	(0.21)	1.26
Reading X Other Remedial				1.52**	(0.51)	4.59	1.54**	(0.53)	4.67
Asian				0.22	(0.23)	1.24	0.25	(0.23)	1.28
Black				-0.47**	(0.15)	0.62	-0.34*	(0.17)	0.71
Hispanic				0.00[a]	(0.13)	1.00	0.00[b]	(0.13)	1.00
Other race				-0.54**	(0.20)	0.58	-0.54**	(0.20)	0.58
Male									
Age									
Income									
Parent education									
Private HS									
Algebra II									
HS curriculum									
HS GPA				0.12*	(0.05)	1.13	0.12*	(0.05)	1.12
Academic integr. index									
Social integration index									
Full-time enrollment				0.52***	(0.13)	1.68	0.51***	(0.13)	1.67
Pell grant				0.22*	(0.09)	1.24	0.22*	(0.09)	1.25
Declared a major				0.47***	(0.11)	1.60	0.49***	(0.11)	1.63
Attended 2 colleges									
Attended 3+ colleges									
Worked full-time									
Child									
INSTITUTION-LEVEL									
Private college									
College enr. (1,000s)									
% Black students (sqrt)							-0.11*	(0.04)	0.90
% Hispanic students (sqrt)									
% students w/ federal aid									
% full-time faculty									
Deviance (# parameters)	9,722 (7)			9,642 (16)			9,635 (17)		

* p<.05; ** p<.01; *** p<.001; [a] Actual value 0.0015; [b] Actual value 0.0030

Table 38

Two-year Institutions: Relationship between Remedial Subjects and Attaining an Associate's Degree: Random Effects

	Unconditional Model	*Model A Remediation-Only*	*Model B Student-Level*	*Model C Student- & Institution-Level*
$\hat{\tau}_{00}$ Between-college variance	0.36***	0.36***	0.43 ***	0.43***
σ^2_F Explained variance[a]	-	0.05	0.26	0.30
σ^2_R Within-college variance (Fixed)	3.29	3.29	3.29	3.29
Intra-class correlation coefficient[b]	9.9%	9.9%	11.6%	11.5%
% residual $\hat{\tau}_{00}$ explained by institutional predictors[c]	-	-	-	0.5%
% total variance explained[d]	-	1.3%	6.5%	7.4%
$\hat{\tau}_{00}$ Reliability	.44	.43	.44	.42

* p<.05; ** p<.01; *** p<.001

[a] Var($\hat{Y}_{ij}$) where $\hat{Y}_{ij} = \gamma_0 + \sum_{h=1}^{r} \gamma_h X_{hij}$

[b] $\hat{\tau}_{00} / (\hat{\tau}_{00} + \pi^2/3)$

[c] $(\hat{\tau}_{00B} - \hat{\tau}_{00C})/\hat{\tau}_{00B}$

[d] $\sigma^2_F / (\sigma^2_F + \tau_{00} + \sigma^2_R)$

Two-year institutions: Relationship of remedial subjects and earning a Bachelor's degree. Tables 39 and 40 show the results of this model.

Fixed effects. Mathematics and English exhibited negative unadjusted relationships to Bachelor's degree attainment, while the other remedial subjects were not significant predictors. The same student-level covariates had significant associations with the outcome as in the "any remediation" version of this model (Table 19); and parallel to that model, none of the institutional factors were significant. In the final Student- and Institution-level Model, English remained a significant negative factor, associated with a nine percentage point decrease in the probability of earning a

Bachelor's degree ($\hat{\gamma}$ = -0.97, *SE* = 0.32, *p* = .003, OR = 0.38, Delta-*p* = -0.09) and the relationship with Mathematics decreased to nonsignificance ($\hat{\gamma}$ = -0.16, *SE* = 0.12, *p* = .209, OR = 0.86), while ESL emerged as a strong positive predictor associated with a 23 percentage point increase in the probability of attainment ($\hat{\gamma}$ = 1.28, *SE* = 0.52, *p* = .014, OR = 3.61, Delta-*p* = 0.23). In addition, the subject model included a positive interaction between English and Reading, which resulted in a small net positive effect ($\hat{\gamma}$ = 1.23, *SE* = 0.50, *p* = .014, OR = 3.43).

To place the significant fixed effects of English remediation and ESL in the context of other categorical predictors in the final model, both were well above the median coefficient size. The logistic coefficient for English ($\hat{\gamma}$ = -0.97) was close in absolute value to the coefficient for full-time enrollment ($\hat{\gamma}$ = 0.89), and twice the size of the coefficient for parental college education ($\hat{\gamma}$ = 0.45). The ESL coefficient ($\hat{\gamma}$ = 1.28) was 44% larger than the full-time enrollment coefficient, and approaching three times the magnitude of the parental education coefficient.

Random effects. As displayed in Table 40, the random components exhibited the same patterns discussed for the other two-year college student Bachelor's degree models: exceptionally large variance explained (76.3%) by the Student- and Institution-level Model, no variance explained by institutional variables, and poor intercept reliability (0.12). None of the remediation variable slopes were allowed to vary randomly; four of the five subject slopes could not be reliably predicted, and the fifth (ESL) did not improve overall model fit based on a χ^2 test of the change in the deviance statistic (see further discussion in this chapter under "Research Question Three").

Table 39. *Two-year Institutions: Relationship between Remedial Subjects and Attaining a Bachelor's Degree or Higher: Fixed Effects*

	Model A Remediation-Only			*Model B Student-Level*			*Model C Student- & Institution-Level*		
	Coeff	(*SE*)	*OR*	Coeff	(*SE*)	*OR*	Coeff	(*SE*)	*OR*
STUDENT-LEVEL									
Intercept	-1.34 ***	(0.08)	0.26	-7.32***	(0.83)	0.00	-7.32***	(0.83)	0.00
Remedial Mathematics	-0.53 ***	(0.09)	0.59	-0.16	(0.12)	0.86	-0.16	(0.12)	0.86
Remedial English	-0.86 ***	(0.19)	0.42	-0.97**	(0.32)	0.38	-0.97 **	(0.32)	0.38
Remedial Reading	-0.33	(0.17)	0.72	-0.19	(0.24)	0.82	-0.19	(0.24)	0.82
ESL	0.64	(0.38)	1.89	1.28*	(0.52)	3.61	1.28*	(0.52)	3.61
Remedial - Other	0.22	(0.25)	1.24	0.25	(0.36)	1.28	0.25	(0.36)	1.28
Reading X English				1.23*	(0.50)	3.43	1.23*	(0.50)	3.43
Asian				-0.27	(0.30)	0.77	-0.27	(0.30)	0.77
Black				-0.57**	(0.21)	0.57	-0.57 **	(0.21)	0.57
Hispanic				-0.01	(0.20)	0.99	-0.01	(0.20)	0.99
Other race				-0.08	(0.31)	0.92	-0.08	(0.31)	0.92
Male									
Age									
Income									
Parent education				0.45**	(0.13)	1.57	0.45 **	(0.13)	1.57
Private HS									
Algebra II									
HS curriculum				0.47***	(0.13)	1.59	0.47***	(0.13)	1.59
HS GPA				0.16**	(0.05)	1.18	0.16 **	(0.05)	1.18
Academic integr. index				0.00**[a]	(0.00)	1.00	0.00**[b]	(0.00)	1.00
Social integration index									
Full-time enrollment				0.89***	(0.18)	2.44	0.89***	(0.18)	2.44
Pell grant									
Declared a major									
Attended 2 colleges				5.60***	(0.79)	269.28	5.60***	(0.79)	269.28
Attended 3+ colleges				5.98***	(0.79)	394.02	5.98***	(0.79)	394.02
Worked full-time				-0.51**	(0.18)	0.60	-0.51 **	(0.18)	0.60
Child				-1.34***	(0.21)	0.26	-1.34***	(0.21)	0.26
INSTITUTION-LEVEL									
Private college									
College enr. (1,000s)									
% Black students (sqrt)									
% Hispanic students (sqrt)									
% students w/ federal aid									
% full-time faculty									
Deviance (# parameters)	9,414 (7)			8,423 (21)			8,423 (21)		

* p<.05; ** p<.01; *** p<.001. Note: No significant institutional predictors; Models B and C are the same. [a] Actual values 0.0043 (0.0016); [b] Actual values 0.0043 (0.0016)

Table 40

Two-year Institutions: Relationship between Remedial Subjects and Attaining a Bachelor's Degree or Higher: Random Effects

	Unconditional Model	*Model A Remediation-Only*	*Model B Student-Level*	*Model C[e] Student- & Institution-Level*
$\hat{\tau}_{00}$ Between-college variance	.50***	0.48***	0.21 ***	0.21 ***
σ^2_F Explained variance[a]	-	0.27	11.24	11.24
σ^2_R Within-college variance (Fixed)	3.29	3.29	3.29	3.29
Intra-class correlation coefficient[b]	13.2%	12.8%	5.9%	5.9%
% residual $\hat{\tau}_{00}$ explained by institutional predictors[c]	-	-	-	0.0%
% total variance explained[d]	-	6.6%	76.3%	76.3%
$\hat{\tau}_{00}$ Reliability	.41	.39	.12	.12

* p<.05; ** p<.01; *** p<.001

[a] Var($\hat{Y}_{ij}$) where $\hat{Y}_{ij} = \gamma_0 + \sum_{h=1}^{r} \gamma_h X_{hij}$

[b] $\hat{\tau}_{00} / (\hat{\tau}_{00} + \pi^2/3)$

[c] $(\hat{\tau}_{00B} - \hat{\tau}_{00C})/\hat{\tau}_{00B}$

[d] $\sigma^2_F / (\sigma^2_F + \tau_{00} + \sigma^2_R)$

[e] No significant institutional predictors; Models C and D are the same.

Four-year institutions: Relationship of remedial subjects and earning a Bachelor's degree. See Tables 41 and 42 for a summary of this model's results.

Fixed effects. Mathematics, English, and ESL had significant negative unadjusted fixed effects, while the other subjects were not significant predictors. Almost the same set of statistically significant covariates were included in the Student-level Model as in the "any-remediation" version (Table 21), but there were no interaction terms. After the introduction of these controls in the Student-level Model, the relationships with Bachelor's attainment persisted for Mathematics and ESL, but not

English. In the final Student- and Institution-level Model, after the addition of institutional characteristics (private control and percent of students receiving federal aid, the same as the “any-remediation” version of this model), Mathematics was the only remaining remedial subject with a significant fixed effect ($\hat{\gamma}$ = -0.28, *SE* = 0.07, $p < .001$, OR = 0.75), associated with a seven percentage point decrease in the probability of degree attainment (Delta-*p* = -0.07). This negative relationship aligned with the overall negative associations found in the “any remediation” and “number of courses” models. Being Hispanic was no longer significant and was eliminated from this final model (although receiving a Pell grant remained in this version).

The significant remedial Mathematics logistic coefficient ($\hat{\gamma}$ = -0.28) in the final model was below the average coefficient size. It was fairly small in comparison to that of full-time enrollment ($\hat{\gamma}$ = 1.01) or having a child ($\hat{\gamma}$ = -1.33), although it was 75% larger than the coefficient for parental college education ($\hat{\gamma}$ = 0.48).

Random effects. The Student- and Institution-level Model accounted for 27.5% of total variance. The two institutional factors accounted for 4.2% of residual between-school variance (see Table 42). While the slopes of the five remediation subject variables did not vary at random, the slope for attending two colleges did; the slope and intercept variance components were highly correlated (*r* = -0.75). The overall negative association between attending two institutions and completing a Bachelor’s degree varied significantly across colleges, and was more strongly negative at institutions with higher average odds of achieving the outcome.

Table 41. *Four-year Institutions: Relationship between Remedial Subjects and Attaining a Bachelor's Degree or Higher: Fixed Effects*

	Model A Remediation-Only			*Model B Student-Level*			*Model C Student- & Institution-Level*		
	Coeff	(*SE*)	*OR*	Coeff	(*SE*)	*OR*	Coeff	(*SE*)	*OR*
STUDENT-LEVEL									
Intercept	0.89 ***	(0.06)	2.44	0.08	(0.24)	1.08	-0.19	(0.24)	0.83
Remedial Mathematics	-0.55 ***	(0.07)	0.58	-0.35***	(0.08)	0.70	-0.28***	(0.07)	0.75
Remedial English	-0.55 ***	(0.15)	0.58	-0.17	(0.16)	0.84	-0.08	(0.16)	0.92
Remedial Reading	-0.24	(0.17)	0.78	-0.12	(0.21)	0.89	-0.02	(0.20)	0.98
ESL	-0.89 **	(0.29)	0.41	-0.74*	(0.31)	0.48	-0.20	(0.29)	0.82
Remedial - Other	0.09	(0.23)	1.09	0.08	(0.23)	1.08	0.05	(0.21)	1.06
Asian				0.10	(0.18)	1.10			
Black				-0.22	(0.13)	0.80			
Hispanic				-0.34*	(0.13)	0.72			
Other race				-0.01	(0.15)	0.99			
Male				-0.54***	(0.07)	0.58	-0.53***	(0.10)	0.59
Age									
Income				0.00***[a]	(0.00)	1.00	0.00**[c]	(0.00)	1.00
Parent education				0.17*	(0.08)	1.19	0.16*	(0.08)	1.18
Private HS									
Algebra II				0.49**	(0.16)	1.63	0.48**	(0.16)	1.61
HS curriculum									
HS GPA				0.48***	(0.04)	1.62	0.46***	(0.04)	1.58
Academic integr. index									
Social integration index				0.00***[b]	(0.00)	1.01	0.00***[d]	(0.00)	1.00
Full-time enrollment				1.05***	(0.16)	2.85	1.01***	(0.16)	2.76
Pell grant				-0.19*	(0.08)	0.82	-0.18*	(0.08)	0.84
Declared a major									
Attended 2 colleges †				-0.37***	(0.06)	0.69	-0.37***	(0.06)	0.69
Attended 3+ colleges				-0.58***	(0.09)	0.56	-0.56***	(0.09)	0.57
Worked full-time				-0.72***	(0.16)	0.49	-0.69***	(0.16)	0.50
Child				-1.35***	(0.10)	0.26	-1.33***	(0.11)	0.26
INSTITUTION-LEVEL									
Private college							0.45***	(0.09)	1.57
College enr. (1,000s)									
% Black students (sqrt)									
% Hispanic students (sqrt)									
% students w/ federal aid							-0.02***	(0.00)[e]	0.98
% full-time faculty									
Deviance (# parameters)	20,492 (7)			19,621 (25)			19,546 (23)		

* p<.05; ** p<.01; *** p<.001; †Slope allowed to vary randomly in Models B and C; Institution-level variables were not used to predict slope variability; [a] Actual values 0.0007 (0.0002); [b] Actual values 0.0050 (0.0006); [c] Actual values 0.0006 (0.0002); [d] Actual values 0.0042 (0.0006); [e] Actual value (0.0027)

Table 42

Four-year Institutions: Relationship between Remedial Subjects and Attaining a Bachelor's Degree or Higher: Random Effects

	Unconditional Model	*Model A Remediation-Only*	*Model B Student-Level*	*Model C Student- & Institution-Level*
$\hat{\tau}_{00}$ Between-college variance	1.15***	0.93***	0.63***	0.60***
$\hat{\tau}_{11}$INSTIT2 slope variance	-	-	0.85***	0.90***
$\hat{\tau}_{01}$ as correlation	-	-	-0.68	-0.75
σ^2_F Explained variance[a]	-	0.10	1.22	1.48
σ^2_R Within-college variance (Fixed)	3.29	3.29	3.29	3.29
Intra-class correlation coefficient[b]	25.9%	22.0%	16.0%	15.4%
% residual $\hat{\tau}_{00}$ explained by institutional predictors[c]	-	-	-	4.2%
% total variance explained[d]	-	2.2%	23.7%	27.5%
$\hat{\tau}_{00}$ Reliability $\hat{\tau}_{11}$ Reliability	.72 -	.67 -	.40 .22	.36 .22

* p<.05; ** p<.01; *** p<.001

[a] Var($\hat{Y}_{ij}$) where $\hat{Y}_{ij} = \gamma_0 + \sum_{h=1}^{r} \gamma_h X_{hij}$

[b] $\hat{\tau}_{00} \,/\, (\hat{\tau}_{00} + \pi^2/3)$

[c] $(\hat{\tau}_{00B} - \hat{\tau}_{00C})/\hat{\tau}_{00B}$

[d] $\sigma^2_F / (\sigma^2_F + \tau_{00} + \sigma^2_R)$

Summary of Results

This section briefly summarizes the main findings for research question 2 regarding the relationship between remediation and degree attainment. Chapter 5 synthesizes these results in more depth.

Summary of "any remediation" findings. While the dichotomous variable representing taking one or more remedial classes had a significant negative association with college completion among four-year college students, it had no relationship with three of the four outcomes tested for two-year college students. Remediation was not a significant factor predicting certificate attainment (although the certificate models had very poor explanatory power in general), Associate's degree or higher attainment, nor Bachelor's attainment, for students starting in two-year colleges. However, it emerged as a positive factor related to earning an Associate's degree and no higher. The probability of obtaining this credential was 9 percentage points higher for students taking any remedial courses compared to those who took none. This relationship should be interpreted with caution, since the reference category included earning a higher degree as well as failing to earn an Associate's.

Table 43 presents the final Student- and Institution-Level models for the two and four-year populations with any remediation as a predictor (Associate's degree or higher as the outcome for the two-year model, and Bachelor's degree for the four-year model).

Table 43. *Comparison of Fixed Effects for Two- and Four-year College Students: Relationship between Any Remediation and Degree Attainment (Student- and Institution-Level Models)*

	Two-year: Associate's Degree or Higher			Four-year: Bachelor's Degree or Higher		
	Coeff	(*SE*)	*OR*	Coeff	(*SE*)	*OR*
STUDENT-LEVEL						
Intercept	-2.00***	(0.17)	0.14	-0.27	(0.24)	0.76
Any remediation	0.02	(0.07)	1.02	-0.31 **	(0.10)	0.74
Asian (ref=White)	0.34	(0.20)	1.40			
Black (ref=White)	-0.52**	(0.16)	0.60			
Hispanic (ref=White)	0.05	(0.13)	1.05			
Other race (ref=White)	-0.48**	(0.18)	0.62			
Male				-0.53 ***	(0.07)	0.59
Age						
Income (unit=poverty level)				0.00 ***[b]	(0.00)	1.00
Parent education				0.18 *	(0.08)	1.20
Private HS						
Algebra II				0.51 **	(0.15)	1.66
HS curriculum						
HS GPA	0.20***	(0.04)	1.22	0.47 ***	(0.04)	1.59
Academic integration index	0.00*[a]	(0.00)	1.00			
Social integration index				0.00 ***[c]	(0.00)	1.00
Full-time enrollment	0.71***	(0.11)	2.04	1.02 ***	(0.16)	2.77
Pell grant						
Declared a major	0.39***	(0.09)	1.48			
Attended 2 colleges (ref=1)	1.28***	(0.09)	3.61	-0.37† ***	(0.06)	0.69
Attended 3+ colleges (ref=1)	1.69***	(0.11)	5.40	-0.71 ***	(0.10)	0.49
Worked full-time	-0.30**	(0.12)	0.74	-0.67 ***	(0.15)	0.51
Child	-0.71***	(0.10)	0.49	-1.36 ***	(0.10)	0.26
Remediation X 3+ colleges				0.59 **	(0.19)	1.81
INSTITUTION LEVEL	Coeff	(*SE*)	OR	Coeff	(*SE*)	OR
Private college	0.54**	(0.18)	1.71	0.46 ***	(0.09)	1.58
College enrollment (1,000s)	-0.02**	(0.01)	0.98			
% Black students (sqrt)	-0.07*	(0.03)	0.93			
% Hispanic students (sqrt)						
% students w/ federal grant aid				-0.02 ***	(0.00)[d]	0.98
% full-time faculty						

* p<.05; ** p<.01; *** p<.001; † Slope allowed to vary randomly; no level-2 predictors; [a] Actual values 0.0023 (0.0010); [b] Actual values 0.0008 (0.0001); [c] Actual values 0.0041 (0.0006); [d] Actual values (0.0028)

Summary of results for relationship between number of remedial courses taken and degree attainment. In the four-year colleges, taking three or more remedial courses had a significant negative association with the outcome (10 percentage points lower probability of completing a Bachelors' degree compared to taking no remediation), while only taking one or two had no significant association with the outcome. In the two-year colleges, whereas the dichotomous remediation predictor had no significant fixed effect in the certificate model, disaggregating remediation into two levels produced a small but statistically significant negative fixed effect for both more and fewer courses. Taking one or two courses was related to a 2 percentage point decrease in the probability of certificate attainment compared to taking no remedial courses; the same decrease in probability was obtained for taking three or more courses. In addition, a positive interaction with the number of institutions attended signified that a student who enrolled in two institutions and also took a small number of remedial courses would experience a net positive increase in the odds of earning a certificate.

The positive relationship with Associate's degree attainment held true, with a slightly weaker magnitude associated with taking a larger number of remedial courses (a 9 percentage point increase in the probability of graduating associated with three or more remedial courses, and a 7 percentage point increase associated with one or two classes). The slope for one-to-two courses was allowed to vary randomly across institutions, but could not be predicted well by institutional covariates. For the Bachelor's degree outcome, the results aligned with the findings among four-year students: three or more courses had a significant negative fixed effect (5 percentage point decrease in the probability of attainment), but one or two courses had none.

Table 44 summarizes the coefficients for number of remedial courses from the final Student- and Institution-Level models.

Table 44

Conditional Fixed Effects of Number of Remedial Courses on Degree Attainment Outcomes

	Two-Year								Four-Year	
# Remedial Courses	*Certificate*		*Associate's Degree*		*Associate's Degree or Higher*		*Bachelor's Degree or Higher*		*Bachelor's Degree or Higher*	
	$\hat{\gamma}$	(SE)	$\hat{\gamma}$	(SE)	$\hat{\gamma}$	(SE)	$\hat{\gamma}$	(SE)	$\hat{\gamma}$	(SE)
One or two	-0.51*	(0.24)	0.61† **	(0.21)	0.27	(0.15)	-0.07	(0.13)	-0.18	(0.10)
Three & up	-0.54*	(0.23)	0.44**	(0.13)	0.05	(0.10)	-0.40*	(0.17)	-0.41*	(0.17)
1-2 X Major			-0.60**	(0.22)	-0.40*	(0.19)				
1-2 X 2 Inst.	0.85*	(0.36)								

* p<.05; ** p<.01; *** p<.001; † Slope allowed to vary randomly; no level-2 predictors.
Note: From Student- and Institution-Level Models; covariates not shown.

Summary of results for association between specific remedial course subjects and degree attainment. Among students with initial enrollment at a four-year institution, Mathematics appeared to be the source of the negative remediation fixed effect. It was the only subject with a statistically significant relationship to Bachelor's degree completion in the final model. Although the unadjusted fixed effects were negative for English, Reading and ESL, and positive for Other courses, these subjects were no longer significant factors in the presence of control variables.

Different subject patterns emerged for the three outcomes among two-year college students. The relationship between earning a certificate and Mathematics remediation was negative, but nonsignificant for the other four subjects, a pattern similar to the four-year student model. For the Associate's degree outcome, Mathematics was a positive factor, while Reading was a negative factor, and the previously discussed positive interaction between Reading and Other subjects was present. The overall positive fixed effect of any remediation observed for earning an Associate's degree appeared to depend on Mathematics and the Other subject interaction with Reading. For Bachelor's degree attainment among two-year starters, by contrast, taking remedial Mathematics or Reading had no significant association with the outcome. The relationship with reaching this highest degree level was negative for English but positive for ESL, and there was a net-positive interaction between English and Reading.

Table 45 summarizes the remedial subject coefficients from the final Student- and Institution-level models.

Table 45

Conditional Fixed Effects of Remedial Subjects on Degree Attainment Outcomes

	Two-Year								Four-Year	
Remedial Subject	*Certificate*		*Associate's Degree*		*Associate's Degree or Higher*		*Bachelor's Degree or Higher*		*Bachelor's Degree or Higher*	
	$\hat{\gamma}$	(SE)	$\hat{\gamma}$	(SE)	$\hat{\gamma}$	(SE)	$\hat{\gamma}$	(SE)	$\hat{\gamma}$	(SE)
Mathematics	-0.49**	(0.18)	0.26**	(0.09)	0.04	(0.10)	-0.16	(0.12)	-0.28***	(0.07)
English	-0.13	(0.28)	0.25	(0.14)	-0.09	(0.14)	-0.97**	(0.32)	-0.08	(0.16)
Reading	0.07	(0.27)	-0.41**	(0.15)	-0.25	(0.13)	-0.19	(0.24)	-0.02	(0.20)
ESL	0.52	(0.68)	0.82	(0.42)	1.17**	(0.38)	1.28*	(0.52)	-0.20	(0.29)
Other	0.46	(0.34)	0.23	(0.21)	0.28	(0.21)	0.25	(0.36)	0.05	(0.21)
Read X Oth.			1.54**	(0.53)	1.23**	(0.36)				
Read X Eng.							1.23*	(0.50)		

* p<.05; ** p<.01; *** p<.001
Note: From Student- and Institution-level models; covariates not shown.

Limitations of results for research question 2. The results should be interpreted with caution in light of the models' modest degrees of explanatory power. The effect sizes for remedial enrollment variables were generally small to moderate: only three of the statistically significant relationships had Cox index statistics greater than 0.50 in absolute value. The proportion of total variance explained was also low for many of the models. Those with Bachelor's degree attainment included in the outcome accounted for larger proportions of variance (27% or more) compared to those predicting Associate's Degree (7%-8%) or certificate attainment (5%-6%). Other factors not included in the models may play a greater role. Finally, some of the coefficients for the number and subjects of remedial courses had large standard error estimates relative to the size of the coefficient (e.g., for three or more remedial courses in the certificate attainment model, $\hat{\gamma}$ = -0.54 and *SE* = 0.23), a possible sign of instability or uncertainty in the model.

Research Question 3: Institutional Variation in the Relationship between Remediation and Degree Attainment

The third research question asks, "Are the relationships between postsecondary remediation and certificate/degree attainment moderated by contextual characteristics of the student's first postsecondary institution? Do institutional characteristics predict variation in the relationship between enrollment in *any remediation* and attainment of a certificate or degree? In *different remedial subjects and numbers of remedial courses* and attainment of a certificate or degree?" Answering this question required two steps: (1) determining whether there was significant variation in the slope of the remediation predictor across institutions that could be reliably estimated, and (2) if so, attempting to predict that variation with institution-level variables. This analysis was performed for each set of models discussed in the previous section, and the results have been mentioned briefly. This section presents more detailed results for the random remediation slopes and discusses the implications of these findings for the research question.

For each set of models, once the final set of student-level predictors and interaction terms had been selected, the slopes of the remediation variables were allowed to vary randomly one at a time. As previously discussed, Raudenbush and Bryk's (2002) criteria were used to assess whether a slope should be fixed. If the main effect was significant at the .05 level, the slope variance estimate was also significant at .05, and the slope reliability was at least .05, then the slope was allowed to vary randomly. In addition, a χ^2 test of the change in deviance was used to assess how much a model with a random slope parameter improved fit over the model with a fixed slope (McCoach, 2010).

Table 46 presents the statistics for the remediation slopes. For each remediation predictor within each model, the table presents the variance of the random slope across colleges ($\hat{\tau}_{11}$), the reliability of that slope ($\hat{\tau}_{11}$ Rel.), and the log-odds coefficient for the slope (Coeff.), along with its standard error (*SE*).

Table 46. *Summary of Variance Components from Each Student-level Model with Randomly Varying Remediation Slope*

	Two-Year				*Four-Year*
	Certificate	Associate's	Bachelor's & Up	Assoc. & Up	Bachelor's & Up
Any Rem.	[a]				
$\hat{\tau}_{11}$	1.08	0.46	0.70***	0.88**	0.43
$\hat{\tau}_{11}$ Rel.	0.10	0.04	0.02	0.17	0.03
Coeff. (*SE*)	-0.24 (0.13)	0.72** (0.23)	-0.18 (0.13)	0.03 (0.11)	-0.42*** (0.08)
1-2 Courses					
$\hat{\tau}_{11}$	0.66	0.90*	1.02***	1.14***	0.39
$\hat{\tau}_{11}$ Rel.	0.07	0.13	0.04	0.18	0.03
Coeff. (*SE*)	-0.60*** (0.16)	0.63** (0.21)	-0.07 (0.15)	0.28 (0.18)	-0.28** (0.08)
3+ Courses	[a]				
$\hat{\tau}_{11}$	1.42	0.86**	0.58	1.32***	0.13
$\hat{\tau}_{11}$ Rel.	0.09	0.05	0.02	0.18	0.01
Coeff. (*SE*)	-0.43** (0.15)	0.39** (0.12)	-0.42* (0.17)	0.01 (0.10)	-0.61*** (0.16)
Mathematics					
$\hat{\tau}_{11}$	1.36	0.64	0.70***	0.73**	0.40*
$\hat{\tau}_{11}$ Rel.	0.21	0.07	0.03	0.13	0.09
Coeff. (*SE*)	-0.24 (0.40)	0.25 (0.12)	-0.16 (0.14)	0.02 (0.11)	-0.39*** (0.07)
English	[a]				
$\hat{\tau}_{11}$	1.31	0.01	0.27	0.01	0.34
$\hat{\tau}_{11}$ Rel.	0.09	<0.01	0.01	0.01	0.01
Coeff. (*SE*)	0.03 (0.18)	0.18 (0.15)	-0.92* (0.31)	-0.05 (0.14)	-0.18 (0.16)
Reading					
$\hat{\tau}_{11}$	0.64	0.57	0.19	0.94*	0.13
$\hat{\tau}_{11}$ Rel.	0.12	<0.01	0.01	0.02	<0.01
Coeff. (*SE*)	0.19 (0.27)	-0.39** (0.15)	-0.20 (0.24)	-0.31* (0.13)	-0.12 (0.20)
ESL	[a]				
$\hat{\tau}_{11}$	8.03	1.03	1.29*	0.09	0.88*
$\hat{\tau}_{11}$ Rel.	0.28	0.01	0.17	0.01	0.07
Coeff. (*SE*)	0.33 (0.33)	0.82 (0.42)	1.49** (0.52)	1.14** (0.39)	-0.75* (0.29)
Other	[a]				
$\hat{\tau}_{11}$	0.26	1.87*	0.38	1.25*	0.18
$\hat{\tau}_{11}$ Rel.	0.02	0.22	0.01	0.16	0.01
Coeff. (*SE*)	0.19 (0.22)	0.08 (0.21)	0.24 (0.35)	0.18 (0.20)	0.10 (0.23)

* p<.05; ** p<.01; *** p<.001; Models shown are based on the Student-level models, with the given remediation slope allowed to vary randomly, not predicted by level-2 covariates, and all other slopes fixed. $\hat{\tau}_{11}$ = variance of the random slope for the remediation predictor; $\hat{\tau}_{11}$ Rel. = the slope's reliability; Coeff. (*SE*) = log-odds coefficient for the remediation predictor, and its standard error.
[a] Model did not fully converge, Laplace estimates not computed; Coeff. estimated by population averaging.

Only one of the 15 models tested had a remediation slope that met the criteria to vary randomly. In the Student-level Model for two-year college students with the outcome Associate's degree attainment, when the slope for taking one-to-two remedial courses was allowed to vary randomly, it met the criteria. The estimate of slope variance $\hat{\tau}_{11}$ was 0.90 (χ^2 = 255.04, *df*[20] = 210, *p* = .020), and slope reliability was poor but above the threshold at 0.13. The regression coefficient for the main effect of this predictor was 0.63 (*SE* = 0.21) and statistically significant (*t* = 2.96, *p* = .004). In addition, the model made a slight improvement in fit over the version with the slope parameter fixed, although only significant at a relaxed alpha level of .10 (χ^2 = 5.68, *df* = 2, *p* =.057).

Again in the Student-level Model of Associate's degree attainment, the slope for the other remediation dummy – taking three or more remedial courses – also met the criteria when allowed to vary randomly ($\hat{\tau}_{11}$= 0.86, χ^2 = 233.49, *df* = 190, *p* =.009, reliability = 0.05). However, it did not improve model fit over the fixed-slope version (χ^2 = 1.74, *df* = 2, *p* > .500). Furthermore, when both slopes representing number of remedial courses were allowed to vary randomly in the same model, the resulting variance components for the intercept and each of the two slopes had nonsignificant p-values ($\hat{\tau}_{00}$ = 0.42, χ^2 = 152.68, *df* = 160, *p* > .500 for the intercept; $\hat{\tau}_{11}$ = 0.78, χ^2 = 146.88, *df* = 160, *p* > .500 for one-to-two courses; and $\hat{\tau}_{11}$ = 0.68, χ^2 = 132.67, *df* = 160, *p* > .500 for three or more courses). The reliability for three-or-more courses also dropped below 0.01. Thus, only the one-to-two courses slope was allowed to vary randomly.

[20] Degrees of freedom referring to counts of students or colleges have been rounded to the nearest 10 per IES data nondisclosure guidelines.

To assess whether institutional factors could explain variation across colleges in the relationship between Associate's degree attainment and one-to-two remedial courses, the six institution-level predictors were tested as predictors in the slope equation. However, none of them accounted for significant variation in the slope. This null finding could result in part from the low reliability of the slope.

Two other models resulted in remediation slopes that initially met the criteria to vary randomly. In the two-year/Bachelor's Student-level Model for remedial subjects, the slope for ESL had significant between-school variance ($\hat{\tau}_{11}$ = 1.29, χ^2 = 49.40, *df* = 30, *p* =.033) and reliability of 0.17, but the variance estimate was only based on 34 of the institutions, and the χ^2 test of improvement in fit was not significant (χ^2 = 2.06, *df* = 2, *p* = .358). In the four-year/Bachelor's Student-level Model for remedial subjects, the slopes for Mathematics and ESL each exhibited significant variance and adequate reliability when allowed to vary randomly one at a time ($\hat{\tau}_{11}$ = 0.40, χ^2 = 307.97, *df* = 260, *p* =.032, reliability = 0.09 for Mathematics; $\hat{\tau}_{11}$ = 0.88, χ^2 = 41.91, *df* = 30, *p* =.033, reliability = 0.07 for ESL). However, there was strong evidence for a random slope for attending two colleges ($\hat{\tau}_{11}$ = 0.85, χ^2 = 590.03, *df* = 420, *p* < .001, reliability = 0.22), which significantly improved the model fit based on the change in the deviance statistic (χ^2 = 33.97, *df* = 2, *p* < .001). After adding this random parameter, neither the Mathematics nor the ESL slope met the criteria when allowed to vary randomly one at a time ($\hat{\tau}_{11}$= 0.35, χ^2 = 266.19, *df* = 250, *p* =.244, reliability = 0.05 for Mathematics; $\hat{\tau}_{11}$ = 0.81, χ^2 = 29.61, *df* = 30, *p* =.331, reliability = 0.12 for ESL), and they were both fixed.

Finally, crosslevel interactions were tested in the model regressing two-year student certificate attainment on number of remedial courses. Although the slopes for the two remediation dummy variables each had a nonsignificant variance component, they were reliably estimated and had significant main effects. Snijders and Bosker (2012) recommend that substantively relevant cross-level interactions be tested in such cases, because the statistical test of the interaction has greater power than the test of slope variance. Although each cross-level interaction was tested, none of the institutional predictors were significantly associated with either of the remediation slopes. In the absence of a significant cross-level interaction, those slopes were fixed.

In sum, these findings suggest that all but one of the 15 significant relationships between remediation and degree attainment identified in this study hold constant across institutions. It should be cautioned that this null finding could also be the result of low power for reliably estimating slopes, particularly with the subset of colleges that had a small sample size.

CHAPTER 5. DISCUSSION

With five out of ten college students enrolling in remedial courses, and only two of those five graduating,[21] remedial education is bound up in the problem of low graduation rates. To craft solutions, administrators and policymakers need to understand the dimensions of the problem. Despite a number of well-designed quantitative and qualitative studies of remediation's effects at district, state, and national levels, and a bevy of reform initiatives experimenting with new remediation practices, researchers still lack clear, comprehensive answers about the complex relationships between remedial education and educational outcomes. There is a need for conditional analyses that identify where remediation is and is not effective, for which types of students, in what settings, and in what forms; and for findings that can be generalized beyond a single campus or state system. This study contributes to understanding this complex puzzle by charting the landscape of remediation across institutional settings and for different subjects and numbers of remedial courses taken. It clarifies the relationship of remediation to degree attainment conditional on student and college factors, and the extent to which that relationship varies with institutional context. It does so using a nationally representative sample that includes reliable transcript data.

This chapter synthesizes the findings across the sets of models reported in chapter 4, situates them in the context of the research literature summarized in chapter 2, discusses their implications for higher education policy, reviews methodological limitations, and suggests areas for further research.

[21] Transcript data from the BPS:04/09, accessed using the online PowerStat tool.

Prevalence of Remediation

This study reaffirmed the serious and widespread nature of the remediation problem. Based on a nationally representative sample of college students who first enrolled in 2003-2004, it updated and confirmed figures from prior national surveys and other sources that indicated a substantial minority of students were taking remedial classes (Adelman, 2006; Sparks & Malkus, 2013). Using transcript data, it identified a much higher percentage of remediated students than a previously published NCES report on this dataset (Ross et al., 2012) that used the self-report item from student interviews: 32% at four-year colleges compared to the previously reported 27%, and a dramatically higher 68% of two-year college students compared to 40% self-reported.[22] As discussed in chapter 2, students may not know whether or not a course is classified as remedial, a reality that underscores the importance of using transcript data when it is available.

Not only did the bivariate analyses confirm the negative raw association between remediation and degree attainment that has been documented in the literature (Adelman, 2006; Attewell et al., 2006) but they also highlighted the greater prevalence of remediation among historically disadvantaged groups of students. As shown in other studies (Adelman, 2004; Martorell & McFarlin, 2011; Ross et al., 2012; Sparks & Malkus, 2013) disproportionately higher proportions of students who were Black, Hispanic, or lower-income took remedial classes. Even high-income Black students were more likely to enroll in remediation than low-income White students. These figures reinforce the concern that remediation may serve as one more mechanism by which the ill

[22] Ross et al.'s (2012) figures are based on remediation during the student's first year of college; this study's figures are for remediation at the first institution attended, regardless of year. Ross et al.'s figures for all six years of the study are similar to the first year numbers (29% at four-year institutions, 41% at two-year institutions).

effects of poverty, as well as race-based disadvantages, accrue over a student's academic career.

Relationship of Remediation and Degree Attainment:

Contrasts by Institutional Level

This study found stark differences between the two- and four-year college settings in the relationship of remediation to degree attainment. Among students who first enrolled at a two-year college, taking at least one remedial course had no statistically significant association with earning an Associate's degree or higher, and the direction of the relationship varied with credential and course subject (discussed further in the sections that follow). Among those starting at a four-year college, however, remediation was negatively associated with Bachelor's degree attainment in every version of the model. While the effect sizes for statistically significant remediation predictors in the four-year college setting were small (Cox index values of -0.17 to -0.25) and only one met the What Works Clearinghouse threshold of 0.25 for "substantively important" effects (2011), they represented a difference of 7 to 10 percentage points in the probability of graduating.

These divergent findings by college level may be related to how much the four- and two-year college populations differ: Students who first enroll in a two-year institution are more likely to have the markers of socioeconomic disadvantage (e.g., being Hispanic, lower income, and first-generation); less likely to be academically college-ready (e.g., taking Algebra II and other rigorous high school courses);[23] and less likely to have expectations of earning a Bachelor's degree (Adelman, 2005). They also enter higher education settings that have very different missions and resources: open-access,

[23] BPS:04/09: Author's calculations.

publically funded institutions with high student-faculty ratios in the two-year sector, versus a wide range of selectivity, private funding, and staffing in the four-year sector. It is therefore not surprising that remediation would play out differently for these two groups.

Negative Results for Four-year College Students

The negative result among four-year college students contributes to the mixed but limited literature on remediation in this population. A correlational multivariate analysis of the same national BPS:04/09 dataset used in this dissertation (Ross et al., 2012) analyzed a combined sample of two- and four-year students and found no association between remediation and college completion. However, the findings of this dissertation, as well as other studies, suggest that combining the two- and four-year populations may mask divergent effects in the two institutional settings. In five state- or nationwide studies that modeled four-year colleges separately, one found a positive relationship, two found negative relationships, and two found no effect. Bettinger and Long (2009) found positive effects among full-time, traditional-age, public four-year college students in Ohio. Attewell, Heil and Reisel (2011) found a negative relationship, but only in the least selective four-year colleges, using an earlier wave of the BPS survey used in this dissertation. Attewell et al.'s (2006) study using BPS:04/09 also identified a negative effect of remediation on Bachelor's degree attainment after reducing selection bias with a propensity score matching design. State-level regression discontinuity studies that analyzed public four-year institutions (Boatman & Long, 2010; Martorell & McFarlin, 2011) found no effect. This study aligns with the Attewell et al. and Attewell, Heil and Reisel findings.

What could account for the negative association of remediation and graduation for four-year college students in the present study? Some scholars have suggested that remediation depresses graduation rates by eroding student persistence (T. W. Bailey et al., 2009). Differentiating this study's sample from two of the studies cited earlier that found positive or null results, this study included students in the sample even if they initially enrolled part-time or completed few credits over six years. Boatman and Long (2010) and Bettinger and Long (2009) only included full-time students.[24] By excluding less-committed students from the outset, these studies may have missed the effect on marginal students who entered college more tentatively. It is possible that these students are most easily deterred from re-enrolling when faced with remedial requirements. This theory could be evaluated by comparing intermediate outcomes such as credits earned among remedial and nonremedial students.

Another mechanism of action for remediation is through lengthening the time to graduation, since in many institutions, students must finish the remedial sequence in a subject before attempting the gateway college-level course. It may be that a six-year window of time in this study is too short, particularly for a four-year credential; if students were tracked for a few more years, perhaps more of the remediated students would ultimately complete a Bachelor's degree. However, Attewell et al.'s (2006) negative finding for a longer eight-year window does not lend credence to this hypothesis.

The gap that remediation must fill between students' abilities and college-level work could be larger in the four-year college setting, leading to a lower success rate. A

[24] Although Bettinger and Long's (2009) sample from Ohio public colleges was predominantly made up of four-year college students, 10% first enrolled in a two-year college. Results were not reported separately for two-year college students.

study of the skills required for community college coursework found very limited reading and writing tasks, with instructors tending to re-package complex texts into slides or summaries so that students with limited literacy skills could use them (National Center on Education and the Economy, 2013). If the level of work required at a four-year college is generally higher, a larger percentage of students might fail to meet it. Further analysis could investigate whether students pass remedial courses at higher rates in the two-year colleges. Differences in remediation's fixed effects could also be assessed based on the selectivity of four-year colleges. This hypothesis might explain the positive relationship with remediation that Attewell, Heil and Reisel (2011) found in the least selective – but not more selective – four year institutions.

The different results by level could also be related to differences in how remediation is perceived in the two- and four-year environments. Some researchers have theorized that the stigma attached to remediation harms students (Kingan & Alfred, 1993), although this idea is controversial (Deil-Amen & Rosenbaum, 2002). At most two-year colleges, at least half the student body participates in remedial education (the interquartile range was 49% to 83% in this sample), making it a mainstream occurrence. By contrast, remediation is a lonelier experience at many four-year institutions, fifty percent of which have remediation rates between zero and 51% in this sample. However, at least one study casts doubt on this hypothesis: Martorell and McFarlin (2011) found negative associations between remediation and academic outcomes at community colleges with higher remediation rates, but no such relationships at two-year colleges with lower remediation rates, and no effects in the four-year colleges regardless of remediation rate.

In the present study, the more detailed remediation models homed in on more specific aspects of remediation associated with lower graduation rates among students who initially enrolled in four-year schools. Mathematics was the only remedial subject with a statistically significant negative fixed effect (English, Reading, and ESL had negative coefficients but were nonsignificant at the .05 level). Furthermore, taking just one or two remedial courses had no significant association with degree attainment, but taking three or more courses did have a negative association with the outcome. Only 6.9% of four-year college students took such a heavy load of remedial courses, but the bivariate statistics (Table 10) demonstrated their lesser outcomes: 32.9% of them earned a Bachelor's degree, compared to 50.8% of those who took only one or two remedial courses, and 68.8% of unremediated students. In sum, the negative relationship appears to be driven in large part by remedial Mathematics students and those who take large numbers of remedial courses. (The findings for subjects and number of courses are discussed in more detail later in this chapter.)

Consistent relationship of remediation and degree attainment across colleges. Finally, it is noteworthy that the relationship of remediation and Bachelor's degree attainment did not vary significantly across four-year institutions. The negative association persisted despite the diversity of four-year colleges with respect to size, mission, resources, and selectivity. Private institutional control, as well as the socioeconomic status of the student body (percent receiving federal grant aid), were significant factors for the institution's mean odds of degree attainment, but both before and after controlling for these institutional factors, remediation's relationship to the outcome remained negative and significant (although weaker). The exception was in the analysis of remedial subjects at four-year colleges. The relationships of remedial Mathematics and ESL course-taking to Bachelor's degree completion did vary significantly across institutions; however, after another random slope – representing the relationship with multi-college attendance – was allowed to vary randomly in the model, neither of these two remediation slopes exhibited significant, reliably estimated variation anymore. The remediation and transfer relationships may have varied across colleges in interrelated ways. The proportion of students at a college who transfer up or down may have some bearing on remediation dynamics; some students at less-selective institutions may be more likely to use their first year to complete remedial courses, and then transfer up to more selective campuses, for example. Some four-year college students also save on tuition by taking a few basic courses at a less-expensive community college (McCormick, 2003). These subgroups of students may have different experiences with remediation.

Mixed Results among Two-year College Students

The picture for two-year colleges was less clear. Unlike the uniformly negative results in four-year colleges, analyzing different credential outcomes for two-year students and disaggregating the number and subject of remedial courses yielded different results. The varied findings upheld the value of examining the range of credentials sought by students who start at two-year colleges. These institutions attract students who only want a short-term occupational certificate alongside those with transfer plans, as well as many unsure of their goals, and these subpopulations may interact with remedial education in different ways. The bivariate statistics (Table 9) showed that remedial two-year students had a lower Bachelor's degree attainment rate than unremediated students, but they earned certificates and Associate's degrees at approximately the same rates regardless of remediation (absent any covariate controls).

Bachelor's degree attainment in two-year colleges. The remediation relationships with Bachelor's degree attainment for two-year college students bore some resemblance to those of their four-year counterparts. Although the relationship was not statistically significant with the simple "any-remediation" predictor, taking three or more remedial courses had a negative association with transferring and earning a Bachelor's degree. However, the magnitude of this effect was small (Cox index = -0.24, Delta-*p* = -0.05). As in the four-year model, there was no significant variation in the relationships with Bachelor's attainment across institutions for any of the remedial variables. The subject-specific analysis uncovered a mix of positive and negative relationships and interactions: negative for English, but positive for ESL. These subject coefficients had moderate to large effect sizes (Cox index of -0.59 for English and 0.78 for ESL); in fact, taking ESL was associated with a 23 percentage point increase in the probability of completing a Bachelor's degree.

No prior studies were identified that analyzed Bachelor's degree attainment as a distinct outcome for two-year college students, but three did model transfer to a four-year college. Scott-Clayton and Rodriguez (2012) found no remediation effect on transfer within three years, while two studies using a longer six-year timeframe – Calcagno and Long (2008) and Crisp and Delgado (2013) – both found negative relationships for some remedial subjects. Studies of this population using broader graduation outcomes that combined different levels of credentials found no effect on completion (Attewell et al., 2011; Martorell & McFarlin, 2011) or negative effects limited to specific subjects and levels (Attewell et al., 2006; Boatman & Long, 2010). By distinguishing between students who took fewer and those who took more remedial courses, the present study uncovered the negative relationship with Bachelor's completion among those taking the heavier load.

As with the students who begin at a four-year college, some two-year college enrollees may require more than six years to transfer and complete a Bachelor's degree, meaning that some positive outcomes may not have been captured in this dataset. A substantial proportion of students starting at a community college take longer to complete degrees because of temporary pauses in enrollment or periods of part-time studies to accommodate work and family needs, and in fact as many as one quarter of community college students who earn degrees may take 10 years or longer to do so (Attewell & Lavin, 2009). The negative relationship with larger numbers of classes makes intuitive sense; since remedial courses typically cannot be transferred for credit, a student who must take three or more remedial classes would be delayed in the relatively long path from a two-year college to a Bachelor's degree.

The positive relationship with ESL courses stood out as a notable difference. The unconditional bivariate statistics (Table 9) showed that ESL students attained both Associate's and Bachelor's degrees at a remarkably higher rate than unremediated students (26.7% compared to 20.7% for Bachelor's degrees). The better results for this group may be related to differences in demographics and academic preparation compared to other remedial students. Among all two-year college students taking remedial courses, 0.5% were foreign or international students, 4.3% were Asian, and 18.8% were Hispanic; but among two-year ESL students, a much higher proportion came from these groups

(11.5% foreign, 23.3% Asian and 56.9% Hispanic).[25] ESL students also performed better than remedial students overall among Asian, Black and White students (although not among Hispanic students): 38.5% of Asian ESL students earned an Associate's degree or higher, compared to 28.7% of all Asian remedial students; and 58.4% of Black ESL students earned a degree, versus 16.1% of all Black remedial students. Although the models controlled for academic preparation with available measures, high school GPA may be less reliable for foreign students. Even for those who immigrated while still in the K-12 system, their GPA may be a poor reflection of their academic ability if they were learning English for several years. Thus, it may be that better prepared, highly motivated international students started their college careers with ESL classes at community colleges and then went on to successfully earn degrees. This study's exclusion of students older than age 24, who take ESL at a slightly higher rate than younger students and are more likely to be first-generation college students, may have contributed to this subgroup's greater success.

There was also some evidence that the ESL-Bachelor's degree relationship varied significantly across two-year institutions, although allowing this parameter to vary randomly did not improve model fit and it was ultimately fixed. The demographic and socioeconomic profile of ESL students may vary in ways that alter this relationship: for example, some community colleges actively market to more affluent, well-educated international students on a transfer path to more prestigious four-year schools. However, these results should be interpreted with caution because they were based on the experiences of a small number of students: fewer than 50 two-year college students in the

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[25] Percentages calculated using complex samples function in SPSS 21.0, including WTB000 weight.

sample took ESL courses, and fewer than five of them attended any one institution, reducing the reliability of the coefficient estimates.

Associate's degree attainment at two-year colleges. Analysis of the odds of attaining an Associate's degree but no higher found a positive relationship with remediation. While the bivariate statistics showed very similar Associate's attainment rates regardless of remedial status, the multivariate models that controlled for student and institutional factors revealed this positive association. Even taking three or more remedial courses had a positive relationship to the outcome, although with a smaller magnitude (a 7 percentage point increase in the probability of graduating associated with taking three or more remedial classes, compared to 9 percentage points associated with taking one or two classes). These coefficients met the criteria for a "substantively important" effect size (Cox index = 0.41 for any remediation, 0.37 for one-to-two classes, and 0.27 for three or more classes).

This result is unusual in the context of the literature on two-year college students. Only two studies were identified that analyzed Associate's degree attainment separately; both found no relationship with mathematics and a negative relationship with reading (Calcagno & Long, 2008; Scott-Clayton & Rodriguez, 2012). The results are mixed for intermediate persistence outcomes. Crisp and Nora (2010) demonstrated a positive association between remediation and persistence in general, but for a narrow subpopulation of Hispanic students who intended to transfer, and in a short three-year window. By contrast, Crisp and Delgado's (2013) study of the broader population of two-year college students found a negative effect on transfer to a four-year institution within six years among students who intended to do so, in particular for mathematics and English remediation.

Multiple interpretations of the Associate's degree result are possible because the reference category for the outcome includes both students who had not earned any degree and those who went on to earn a Bachelor's. Thus, remediation could be positively associated with persisting to achieve the degree, and/or negatively associated with continuing to a four-year degree. The latter seems less plausible, given the nonsignificant relationship in the Bachelor's degree model. As discussed in the previous section, it is also possible that the six-year window was too short to capture Bachelor's degree attainment, but long enough for accumulating the smaller number of credits for the lesser credential. A technical approach to better understanding the finding would be a model with an ordinal multivariate outcome to distinguish the effects from one step in the sequence to the next; a dataset with a longer time horizon would also be helpful. Including a measure of students' intentions at the time of enrollment might also distinguish differences in remediation relationships for those whose goal is a two-year degree versus those who intend to transfer.

The finding brings to mind the "cooling out" theory (Clark, 1960), which holds that community colleges function to reduce lower-skilled students' aspirations. Addressing this theory, Adelman (2005) examined the trajectories of students with aspirations for a Bachelor's degree who started at a two-year college but never transferred. He found that they tended to move onto a vocational track, taking more occupational credits than peers who transferred, and failing to complete gateway academic courses. However, those who succeeded in earning an Associate's degree did take at least one-third academic credits rather than an entirely vocational course load. Could remedial placement discourage students from academic tracks and divert them into occupationally-oriented two-year degrees? Analysis comparing remediation effects among students with different degree aspirations across different fields of study could test this possibility.

The remedial subject analysis revealed differences that might have a bearing on the positive association. Mathematics remediation had a positive (although small-magnitude) link with Associate's degree attainment, counter to the negative findings in the certificate, Bachelor's degree, and four-year college models, as well as some of the prior literature on two-year colleges (Attewell et al., 2006; Boatman & Long, 2010). Reading had a small, negative association with earning this credential, in alignment with past studies (Boatman & Long, 2010; Calcagno & Long, 2008; Scott-Clayton & Rodriguez, 2012), but its interaction with Other remedial subjects had a net-positive fixed effect. Because Other courses covered such topics as communication, support skills, developmental skills and workplace habits, these classes may have helped lower-level readers to make the best use of remediation.

Variation in the relationship of remediation to Associate's degree attainment. Finally, a key finding was that the positive association with Associate's degree completion was not uniform across two-year institutional contexts. The relationship between taking one or two remedial courses and earning an Associate's degree varied significantly across institutions. Reliable, significant variation was not found in the other remedial variables (any-remediation or subject-specific predictors), although some of the subject slopes for the Associate's degree model did exhibit signs of variation across colleges (see discussion in chapter 4). Of note is the correlation of this random slope with the institution's mean likelihood of graduating (the random intercept). Thus, at institutions where the "average" student[26] had lower odds of graduating, the relationship between remediation and graduation was more positive.

No prior research was identified that tested variation in the effect of remediation across institutions. However, it is perhaps more surprising that this model was the only one in which significant, reliably estimated variance was found, given the multiplicity of formats, methods, and content in remedial education across the country. The decade during which these data were collected (2003-2009) saw extensive policy debate about such issues as making remediation mandatory based on placement tests, offering performance incentives for improving remedial programs, and moving remediation out of four-year public colleges into the junior college system (Boswell & Jenkins, 2002). At the classroom level, although the bulk of remedial education programs still follow a traditional drill and lecture format (Cox, 2009; Grubb, 2013), during the period of this study, many community colleges had begun experimenting with a range of reforms to remedial curricula, delivery, and sequence (Goldrick-Rab, 2010; Tinto, 2012; Wathington, Pretlow, & Mitchell, 2011) that might lead to diverse outcomes.

Urgently responding to serious shortfalls in graduation rates, many of the community colleges taking the lead in innovation through initiatives such as Completion by Design and Achieving the Dream had relatively low mean graduation rates. Perhaps this phenomenon was linked to the correlation of lower graduation rates with stronger positive remediation relationships: It is possible that more strongly positive relationships

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[26] The "average" student has a value of zero on all predictors (the reference category for dummy variables, and the grand mean for continuous variables): in this case, female, White, mean high school GPA, mean income, etc.

between remediation and college completion have emerged in institutions like these when they successfully enact changes. Interventions also tend to concentrate on the most obviously needy students, while large numbers of so-called "bubble" students on the cusp of success remain invisible, are not flagged for services and fail to complete – a pattern that many colleges are now working to address. The small but growing body of evidence from experimental-design evaluations of remedial education reforms will help educators understand whether they have a causal relationship with better academic outcomes.

None of the six college-level structural/demographic and organizational factors tested in this study could account for the variation in the remediation-attainment relationship (the random slope). Three such factors (private institutional control, enrollment size, and proportion of students who were Black) were in fact predictive of an institution's average odds of graduation (the random intercept), but they did not have an association with the remedial relationship. The relatively low reliability of the remediation slope (0.13) may have limited its predictability. However, the results do not indicate that the positive associate with remediation is limited to one category of institutions by public/private control or size. There is also no evidence of differential effects for students attending colleges that serve higher proportions of low-income or minority students. In terms of organizational factors, the absence of a relationship with the percentage of full-time faculty suggests that successful remediation may not depend on an investment in more full-time instructors.

Certificate attainment at two-year colleges. Although remediation had a negative relationship with certificate attainment, particularly for mathematics, the models lacked explanatory power. Only one of the predictors tested in the certificate model (attending two institutions) was statistically significant, suggesting that certificate attainment is primarily driven by other factors not included in this study's conceptual framework. Although some of the remediation coefficients (for one-to-two courses, three-or-more courses, Mathematics, ESL, and Other subjects) had substantively large Cox index effect sizes, the absence of significant covariates raises questions about whether the remediation effects were adequately adjusted for other variables.

The certificate is a complicated outcome to study; credentials vary widely in the credit hours required, and some students may take college courses but obtain a license or certificate from an industry association outside the college itself, thereby not being counted as a "completer" (Booth & Bahr, 2013). Postsecondary variables such as field of study and completion of gateway academic courses (studied by Adelman, 2005) might serve as better covariates for the likelihood of earning a certificate but no higher degree. Institutional factors such as extent of short-term workforce training offerings, ratio of certificates to Associates degrees awarded (studied by Calcagno et al., 2008) and ties with employers might also account for some variation. This study also excluded older students, who tend to be more frequent customers for vocational certificate programs due to labor market dislocation and retraining. From a technical standpoint, it is also problematic to model a binary outcome like this one that has a very high or low population rate, since the logistic distribution is no longer linear at its extremes (Fox, 2008); in this study's sample, only 4.7% of students in a two-year college had a certificate as their highest level of attainment. Whatever the method, this outcome merits further study because of its value in the labor market (Jacobson & Mokher, 2009).

Number of Remedial Courses

This study sought to illuminate differences in remediation patterns based on the number of remedial courses taken. Students who took multiple remedial courses in their first year were either placed into lower levels and/or multiple subjects, or they failed and repeated courses, indicating some combination of deeper skill deficits and weaker motivation or study skills. Remedial students are not a homogenous population: Those who are required to take fewer courses may simply need a refresher course in one or two areas, while those placed into lower levels may have never learned the fundamentals in high school. Understanding these differences in student profiles would help educators tailor appropriate academic support and curricula to them. However, there are few rigorous studies parsing the differences between levels.

Studying Mathematics and Writing remediation in community colleges in California, Bahr (2012) found higher rates of attrition among students who started lower in the remediation sequence. His analyses indicated that the more remedial courses a student took, the more opportunities he or she had to drop out, the more time the student needed to complete a degree, and the lower the odds of completion. The lower-skilled students were also more likely to fail and repeat courses or delay re-enrollment. Attewell et al. (2006) did not uncover such differences when they analyzed outcomes for two- and four-year college students taking three or more courses; they found approximately the same relationships as with taking one or more courses. Using a different methodology, Boatman and Long's (2010) research suggests that the effects of remedial level differ by course subject. Rather than using the raw number of courses as a predictor, they modeled outcomes for students just above and below the thresholds between levels of developmental courses. In the two-year college setting, they demonstrated negative associations with degree completion for upper-level remedial Mathematics students who just missed the cut score for college-level courses compared to their unremediated peers, as well as a weak negative relationship with placement in the lower level of Reading compared to the upper remediation level. However, they found some indication of positive effects for students in lower-level Writing relative to their upper-level peers, based on intermediate outcomes such as three-year persistence and credits earned.

Like Bahr's (2012) findings for Mathematics and Writing, and Boatman and Long's (2010) findings for Reading, the current analysis supports the hypothesis that taking a longer sequence of remedial courses is associated with negative outcomes to a greater extent than taking fewer courses. The initial bivariate analysis showed that students who took more courses, and/or multiple subjects, earned credentials at lower rates. For Bachelor's degree completion among students in both the two- and four-year groups, taking one or two courses had no relationship to graduation, but taking three or more had a significant negative association with earning the credential. It may be that students on the margin with limited skill gaps have mixed results, some benefitting from remedial courses while others are discouraged, muddying the estimated effect. This mix may also explain the null result in some regression discontinuity studies (Martorell & McFarlin, 2011) that focus on these students near the placement cut score.

The exception was the positive relationship with Associate's degree attainment, which held true for both higher and lower numbers of remedial courses, albeit with a slightly weaker fixed effect associated with more courses. It stands to reason that a positive association with remedial support would diminish as the load of noncredit classes increased; in fact, it is somewhat surprising that a positive relationship continues with three or more classes.

For students who intend to transfer, this study finds no evidence that simply spending more time in noncredit remedial courses helps such students achieve a Bachelor's degree. The findings suggest that alternative course delivery forms that reduce the time spent in noncredit education are worth further consideration. Reducing the time spent in the developmental sequence through acceleration, or through blending with occupational or academic credit-bearing coursework, could be helpful to students with deeper and broader remedial needs. However, any such design must still address those students' considerable skill deficits. Further research could distinguish between the reasons students take multiple remedial courses; those who initially place into a lower-level remedial course and work their way through a long sequence may differ from those who place at a higher level but in multiple subjects, or from those who place into an upper-level remedial course but fail it repeatedly.

Remedial Course Subjects

Like the investigation of number of courses, the analysis by subject sought to elucidate the nuances of relationships that might be obscured by a simple binary predictor and that might call for different interventions. In studies that do not distinguish between subjects (Attewell et al., 2011; Crisp & Nora, 2010), mathematics probably dominates the estimates because it is by far the most frequently taken. However, the research that delves into specific subjects is plagued by the same contradictory mix of results.

As discussed in previous sections of this chapter, the limited literature on specific remedial subjects has found negative associations between mathematics remediation and degree attainment in two-year colleges (Attewell et al., 2006; Boatman & Long, 2010), but one study found a positive association in the four-year public setting (Bettinger & Long, 2009), and several found no relationship (Attewell et al., 2006; Boatman & Long, 2010; Calcagno & Long, 2008; Martorell & McFarlin, 2011; Scott-Clayton & Rodriguez, 2012). The present analysis contributes to the evidence for a negative relationship, with the exception of the positive two-year Associate's degree model.

Reading generally emerged as a negative factor for degree attainment at both the two- and four-year levels in the prior literature (Boatman & Long, 2010; Calcagno & Long, 2008; Scott-Clayton & Rodriguez, 2012), although Attewell et al. (2006) found positive effects for two-year students and negative effects for four-year. The present analysis was no exception. Reading had a negative coefficient in all models except the two-year Associate's degree version, and was a significant negative predictor of Bachelor's degree completion in the two-year colleges.

English remediation, which had a negative association with Bachelor's degree completion for two-year students in this study but no other significant relationships, has not been analyzed extensively. No results from large-scale studies were found for the two-year context, while prior studies' results in the four-year context included both positive and insignificant associations (Bettinger & Long, 2009; Boatman & Long, 2010).

Two remedial subjects that had not been separately analyzed in other rigorous, large-scale studies proved to be interesting positive factors for college completion. As previously discussed, ESL was positively link to degree attainment among two-year college students. Although nonsignificant in each model, the Other category (which included communication and support skills) emerged as a potential enabling factor when combined with other subjects in the two-year setting. Its interaction with Reading yielded a net positive fixed effect on degree attainment for two-year students. These findings constitute a novel contribution to the research literature. However, it is important to note that small proportions of students enrolled in ESL and Other subjects, and their coefficients had large standard error estimates, suggesting that results should be interpreted with caution.

In sum, the mix of positive and negative associations and interactions within each of these subject models underlines the value of disaggregating remediation by subject.

The mix of positive and negative fixed effects for different subjects may derive from differences in the nature of learning and teaching in these areas. Reading is a more fundamental skill, needed for success in any major, whereas mathematics is more critical for some majors than others. A 2013 study of the skills needed in community college courses (National Center on Education and the Economy, 2013) found that students lag in reading skills needed for their coursework, but seldom have reason to use the Algebra II methods required to avoid mathematics remediation. Some practitioners have called for refocusing from Algebra to applied mathematics and statistics that have more relevance to subsequent college courses in most majors.

The interactions between subjects are also a ripe topic for further study. Bahr (2007) found that weak English skills negative reinforced a negative relationship between weak mathematics skills and the likelihood of passing mathematics remediation, but also emphasized that the overall negative effects of the mathematics skill gap had greater practical importance.

Lack of Interactions between Remediation and Student Characteristics

Finally, no differential effects of remediation were found based on student characteristics. Interactions were tested between remediation and each student-level covariate. The interaction of race and remediation was of particular interest, since prior research (Attewell et al., 2006) suggested that Black students enroll in remedial courses at higher rates than their White peers matched on academic ability. It also seemed plausible that remediation might have different outcomes for students of higher and lower ability. However, only two interactions with postsecondary experience variables (declaring a major and attending two institutions) were statistically significant in any of the models. Thus, this study does not provide evidence that the relationship between remediation and persistence varies for students with different demographic characteristics or academic abilities.

Student- and Institution-level Covariates

Other predictors were included in the models primarily as controls, so their effects will not be discussed in great detail here. For the most part, this study confirmed the well-established relationships identified in the college persistence literature, with some exceptions discussed in the following sections.

Student Demographic Characteristics

The directions of the relationships of demographic characteristics with degree attainment were consistent with prior research (e.g., lower odds of completion for Black, Hispanic, Other Race, male, older, and lower income students) (Pascarella & Terenzini, 2005; Reason, 2009), but the relative importance of these factors once covariates were added differed by institutional level. The only demographic variables with significant fixed effects in the final two-year model for Associate's degree or higher were being Black or Other race. In the four-year colleges, race did not continue to be a significant predictor, but gender, income, and parental education did. Part of this difference may have to do with the distribution in these two populations: both the means and the standard deviations for the proportions of Black and Hispanic students were higher in the two-year college sample, creating more variability available for the model. Adelman (2006) and Reason (2009) have also noted a weakened effect of race when postsecondary experiences are considered, which may have come into play at the four-year level.

The finding of a significant gender association in four- but not two-year colleges echoes Bailey and Dynarski's (2011) evidence that rising graduation rates among higher-income women (who are more likely to attend four-year colleges) account for much of the gender gap. Although parental education has been found to predict graduation rates in the community college setting as well as four-year colleges in other studies (Hahs Vaughn, 2004), it is understandable that first-generation students might have an easier adjustment to a local two-year college attended by peers than to a four-year institution. The lack of an income effect in the two-year colleges was more surprising: this factor is typically a robust predictor of academic outcomes at both levels (Adelman, 2006; Reason, 2009; Ross et al., 2012). Again, four-year colleges serve a population with a higher mean income with a larger standard deviation; the generally low-income profile of two-year college students may lead to restriction of range.

Although the bivariate statistics in this study suggested the possibility of interactions between gender, race, and income (particularly among Asian and Hispanic students), none of the possible interactions between these variables were statistically significant in any of the multivariate models (in part because the main effects of these three categories were not significant in many of the models). The underlying role of academic preparation may have accounted for the bivariate findings.

Academic Preparation

The research literature has affirmed high school grades as one of the strongest predictors of college performance (Adelman, 1999; Adelman, 2006; Ross et al., 2012). Both two- and four-year college students in the present study exhibited this pattern. However, taking Algebra II was only significant in the four-year setting.

Postsecondary Experiences

Greater academic integration was positively associated with attainment in the two-year setting, while social integration was not a factor; the reverse was true in the four-year context, where social integration was a positive factor and academic integration had a null effect. The social integration scores for two-year college students were also uniformly low and had a smaller standard deviation than scores in the four-year setting. The two-year college emphasis on academic engagement with faculty over purely social engagement with clubs and friends fits with prior findings about the different ways commuter students connect with their colleges (Crisp & Nora, 2010; Deil-Amen, 2011; Karp et al., 2008).

Financial need as represented by Pell grant eligibility was not a significant factor in many of the models in this study, counter to other research (Bettinger, 2012; Chen & DesJardins, 2010). However, in the four-year colleges, this predictor was significantly negatively associated with Bachelor's degree attainment in the Student-level Model, and was only dropped once the institutional percentage of federal aid grantees was added. At those four-year institutions in which a high proportion of students rely on Pell grants, this factor may not differentiate much between individual students.

The positive association of declaring a major with college completion (Achieving the Dream, 2011; Titus, 2006b) was only confirmed in the two-year college sample.

Attending multiple colleges was a positive factor for attaining an Associate's degree or higher for students who started in a two-year college, most likely a reflection of transfer to a Bachelor's degree-granting institution; but it was a negative factor for those beginning at a four-year institution. Prior research has generally supported this conclusion (Adelman, 2005; McCormick, 2003). However, this relationship varied significantly across institutions in all of the four-year college Bachelor's degree models, as well as the two-year Associate's degree subjects model. This variation may result from the fact that not all multi-institution attendance is alike. Some patterns are associated with even better outcomes than single-institution enrollment, including "four-year drop-ins" (in Adelman's words) who primarily attend a four-year institution but accumulate some credits at a community college (Adelman, 2005; McCormick, 2003) and "vertical" dual enrollment in a more selective college than that of initial enrollment (Wang & Wickersham, 2013). Other profiles fare worse, such as lateral or reverse transfers (Adelman, 2005; Wang & Wickersham, 2013). If a student body tends to practice the positive forms of transfer, the relationship to completion could be positive within that institution, or vice versa. An additional attendance pattern variable – full-time enrollment during the first year – exhibited the expected positive relationship (Cabrera et al., 2012; Ross et al., 2012) with graduation in both institutional levels.

Environmental Pull Factors

Although prior theory and empirical research have emphasized the greater importance of external distractions for community college students (Bean & Metzner, 1985; Pascarella & Terenzini, 2005; St. John et al., 2000; Taniguchi & Kaufman, 2005), working full-time and having a dependent child were negatively associated with completion in both two- and four-year colleges in this study. This finding also runs counter to Dadgar's (2012) sample that did not demonstrate a relationship with employment for two-year students. The persistence of these factors implies that colleges at both levels could help their students succeed by offering support services such as daycare and flexible timing of course offerings.

Institutional Factors

This study incorporated the core structural and demographic features of colleges, as well as the percentage of full-time faculty.

Structural characteristics. The well-known gap in college completion rates between students who start at two- versus four-year institutions (Doyle, 2009; Pascarella & Terenzini, 2005; Ross et al., 2012; Velez, 1985) was clear from the bivariate statistics in this study. The pattern of relationships between remediation and degree attainment was also different within the two levels, as discussed in this chapter.

At the institution level, both two- and four-year students at private institutions had better odds of degree attainment than their peers at public institutions, affirming prior literature on this subject (Astin & Oseguera, 2012; Pascarella & Terenzini, 2005; Titus, 2006a; Titus, 2006b). Consistent with earlier research (T. W. Bailey et al., 2006; Calcagno et al., 2008; Pascarella & Terenzini, 2005), larger total enrollment was associated with lower odds of degree attainment among students starting at two-year colleges, although this pattern was not confirmed for four-year institutions, similar to Titus's findings (2006a; 2006b).

Aggregate demographic characteristics. Like some prior studies, this analysis found a negative relationship between persistence and the percentage of minority students in the two-year college setting (T. W. Bailey et al., 2006; Calcagno et al., 2008), but not in the four-year colleges (Titus, 2004). Unlike the prior studies, which did not disaggregate racial/ethnic minority groups, this analysis found a negative association with the percentage of Black students and students of Other races, but not with Hispanic students; and no relationship was found in the four-year colleges. In the four-year setting, the percentage of students receiving federal grant aid had a negative relationship to graduation odds, similar to Ehrenberg and Zhang's study (2005). It is possible that both of these peer effects are acting as proxies for other unmeasured characteristics of institutions that serve students of lower socioeconomic status.

Organizational characteristics. The proportion of full-time faculty was not a significant predictor of degree attainment in any of the models, counter to findings of a negative relationship to persistence by some researchers (Calcagno et al., 2008; Chingos, 2012; Ehrenberg & Zhang, 2005; Jaeger & Eagan, 2009).

It is interesting that student-level factors were so much more salient for four-year students than for two-year students. Pascarella and Terenzini's (2005) review of the literature concluded that regardless of institutional level, between-school factors explain much less of the variation in attainment and persistence than within-school factors. In the present study, however, institutional characteristics were more important predictors for the two-year setting, explaining 18% of variance in Associate's or higher attainment, but virtually none in the four-year model.

These findings also highlight the ongoing challenge of appropriately modeling two-year college experiences. The certificate models in particular lacked explanatory power. Although the well-established Astin and Tinto models have been critiqued for decades for their poor fit for nontraditional students (Crisp & Nora, 2010; Rendón et al., 2000; Tierney, 1992), robust alternative models have not yet emerged. This study suggests that in-college factors are an important place to look – more detailed course-taking patterns, for example.

Limitations

While this study sheds light on several important issues and makes a unique contribution as the first conducted using nationally representative transcript data to examine variation in remedial relationships across institutional contexts, the findings should be interpreted with awareness of the following limitations.

The findings may not be valid for older students, since those starting college at age 24 or older were excluded. Students in the analytic sample also had slightly higher socioeconomic status and academic preparation than those excluded, meaning that results may be less valid for the least able and privileged students.

It is possible that a sample with larger numbers of students per college would have detected more slope variation. Many colleges were represented in the sample by a small number of students, meaning that relationships in the smaller colleges could not be estimated with great reliability, and that the relationships found in larger colleges were given greater weight in the calculation of estimates. In seven of the 10 models in which remediation's main effect was significant, one or more remediation slopes could not be estimated reliably. Thus, it is possible that the analysis had inadequate power to detect a randomly varying slope existing in the population. An unreliable slope is also difficult to predict with institution-level covariates, leaving open the possibility of undetected relationships between remediation slopes and college structural-demographic characteristics. Although the results suggest that the association between remediation and degree attainment does not vary significantly across colleges (with the exception of Associate's degree attainment), this possibility cannot be definitively ruled out.

Because the study relied on covariates to adjust for nonremediation factors associated with degree attainment, rather than using a quasi-experimental design, the fixed effect of remediation may have been underestimated; after the covariates accounted for variation in the outcome, little unique variation may have been available for remediation to explain.

Finally, the study is limited to constructs that were measured in the two datasets used. If unobserved factors play a significant role in degree attainment, the models used here may have been misspecified and subject to bias. While many of the most critical institutional factors identified in prior research and theory were included, other institutional constructs were not measured in this dataset, such as policies and curricula. Further research is needed to determine the effects of such factors on persistence and remedial education.

Implications for Policy

Although this dissertation is a correlational study employing observational data and cannot make causal claims about the links between remediation and outcomes, it raises a number of issues relevant to policymakers.

For four-year college students, this study suggests that remedial education does not fulfill its purpose of preparing lower-skilled students to succeed. The negative relationship between remediation and graduation in this population, which did not appear to vary across institutional contexts, is cause for concern. Even if this relationship can be explained by unmeasured differences in underlying skills, it indicates that students with poor academic preparation do not receive the boost they need to earn a Bachelor's degree. At worst, something about remedial education itself may deter students from persisting and completing college – although this correlational, nonexperimental study cannot evaluate that possibility.

The differential effects by subject, number, and credential, however, do point to areas where higher education administrators might explore and leverage positive relationships in the four-year college setting. The negative association with remediation in four-year colleges appears to draw from taking larger numbers of such courses, particularly in Mathematics. The lower levels of the Mathematics sequence may be a place to investigate further for possible improvements, e.g., high-quality accelerated models like "boot camps" that allow qualified students to reach college-level courses more quickly; or models that allow students to start college-credit coursework while simultaneously completing remediation requirements.

For students starting at two-year colleges, this study offers little evidence that remedial education in the core subjects of Math, English, and Reading helps them to transfer and complete Bachelor's degrees. The lack of a relationship between remedial enrollment and Bachelor's degree attainment overall, and the negative relationship with taking larger numbers of courses, could occur for various reasons. Perhaps the courses improve students' skills, but not enough to overcome their academic and noncognitive deficits to the level required for success in a four-year college. Alternatively, perhaps other aspects of the postsecondary experience, such as gaps in enrollment and repeating courses, overwhelm any existing effect of remediation on transfer. In any case, if remedial classes are consistently helping underprepared two-year college students to transfer and complete Bachelor's degrees in a large, meaningful way, no such positive relationship was detectable.

However, the positive association between Associate's degree completion and remediation for two-year college students, particularly in Mathematics and in combination with Other subjects, points to areas where remedial education may succeed in meeting its goals. If "soft skill" courses in the Other category help students reap the benefits of remediation, further study of these courses and colleges in which they appear successful may be useful. The positive relationship between Bachelor's attainment and ESL courses at two-year colleges also deserves further consideration as an apparently successful pathway to college completion for second-language learners.

While worrying, the negative associations with remediation found for some populations and types of remediation should not be interpreted as a justification for simply eliminating remedial education. As the positive association found for specific subjects and credentials demonstrates, remediation has the potential to give under-prepared students a second chance at college success. Better-designed courses that take less time, use more effective teaching methods, and align more closely with required college skills, could lead to better outcomes.

Areas for Further Research

The goal of this nonexperimental study was to identify promising areas for deeper analysis, where the links between remedial education, college outcomes, and institutional context merited investigation. The findings suggest several rich areas for further research.

Analysis employing an ordinal degree attainment variable could further compare and quantify the differences in the relationships of remediation to attainment of different credentials. The current study pointed to a positive relationship with Associate's degrees, but no association or a negative relationship with other credentials in the sequence, among two-year college students; an ordinal logistic regression might clarify the meaning of this finding.

The correlational relationships identified here could also form the basis for a quasi-experimental analysis of causal effects. Propensity score matching could partially adjust for the selection bias involved in student placement into remedial education, thereby coming closer to an unbiased estimate of the "treatment effect" of taking remedial courses.

A deeper investigation of the fixed effects of different combinations of subjects and numbers of courses could shed light on the interaction of these factors. ESL in particular is worth analysis with a larger sample of these students to determine whether its positive fixed effects can be replicated in other studies.

Multivariate modeling of the factors that predict remedial enrollment could help identify which of these are amenable to change through educational practice, as opposed to demographic characteristics; and might help educators better understand the needs of this group of students. Path analysis could model remediation and degree attainment as a longitudinal process, estimating the strength of relationships between student factors and remedial enrollment as a forerunner to the relationship between remediation and college outcomes.

To address the limited six-year time period for observing degree attainment results, a different approach would be a survival analysis, modeling the risk of dropping out of college year to year rather than the odds of earning a degree by the end of the study.

Analysis of skill acquisition in addition to credential attainment would also provide valuable information about what students do or do not gain from college remediation. As the most recent international survey of adult literacy and numeracy skills demonstrated (OECD, 2013), earning a postsecondary credential does not necessarily mean that the student has gained competencies that translate into workplace and life success. Even among students who hold a college degree, literacy and numeracy skills are strong predictors of employment, health, and civic engagement outcomes. If remedial courses help students build these basic skills, they may have value regardless of the student’s ultimate educational attainment.

Finally, analysis of the institutional policies and practices associated with remediation would give administrators and policymakers additional insight into the differences between institutions found in this study. This study points to Associate's degree attainment at two-year colleges as an area ripe for further study. The variation in the relationship of remediation and earning this lesser credential requires further examination. What institutional characteristics might explain the varying relationship between remediation and Associate's degree attainment? Do policies governing remedial course placement or modalities of course delivery predict some of this variation? At the four-year level, what is it about the student experience of remedial education that relates to failure to graduate? In addition, information about state-level policies and aggregate completion statistics could account for further variance in the remediation-completion relationship: for example, statewide policies governing articulation agreements for transfer between two- and four-year public colleges, which standardized placement tests are used in the state system, and what proportion of students in the state successfully finish college.

Although data on state and college policies and programs are not typically available on a large scale, smaller scale case study research or mixed-methods studies might prove valuable. At the national level, data collection mechanisms such as IPEDS might serve the higher education field better if they included more such policy variables; the currently available data, such as structural characteristics and resource allocations in broad administrative categories, are less proximal to college completion and therefore not ideal for answering these difficult policy questions.

Conclusion

The purpose of this study was to understand the patterns of remedial course-taking, to investigate how remediation relates to degree attainment, and to identify any institutional factors that moderate that relationship. It is the only study to date that uses a nationally representative sample with reliable transcript data to answer questions about variation in remediation's effects across institutions. The findings make several contributions to the literature on college persistence and completion. The negative association between remediation and graduation for four-year college students, particularly for students taking Mathematics and/or multiple courses, points to a trend seldom identified in the previous literature, one that lends itself to qualitative investigation by college administrators and instructors. Other findings highlight positive associations between remediation and specific groups of students – those who start at two-year colleges and achieve an Associate's degree but no higher, as well as ESL students – that could signal beneficial aspects of remedial programs in particular settings and populations. This study also contributes a more nuanced understanding of the dynamics related to remedial course subjects and levels that were obscured in studies treating remediation as a simple binary variable. These findings suggest that specific types of remediation deserve more attention than they have previously received in persistence studies.

Finally, the study does not support the conclusion that structural and demographic characteristics of institutions play a large role in moderating the effectiveness of remediation. Although many other institutional factors should be investigated, this analysis found a consistent relationship (or lack thereof) between remediation and college completion regardless of characteristics such as enrollment, public and private control, and student body makeup. The percentage of full-time faculty, a policy-amenable variable, did not appear to play a role either. The exception was level of institution: remedial education exhibited very different patterns in two- versus four-year institutions. Future studies should disaggregate these two settings to avoid obscuring important differences.

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APPENDIX A. VARIABLES USED IN ANALYSIS

Sources of variable definitions: NCES codebooks for BPS:04/09 and Postsecondary Education Transcript Study; IPEDS Analytics Delta Cost Project Data Dictionary 1978-2010; IPEDS Data Center.

Name	Label	Description/Source	Coding
BPS 04/09: Restricted Interview/Transcript Files			
OUTCOMES			
QFHGHDEG	Highest degree attained	Categorical variable indicating highest degree attained 2004-2009 at any institution: certificate or diploma, Associate's, and Bachelor's. Source: transcripts.	Dummy variables computed to represent each of the 3 degree types, and one combined dummy for Associate's or Bachelor's degree. All were coded: 0=Did not attain 1=Attained
STUDENT-LEVEL PREDICTORS			
Student Entry Characteristics: Demographic			
RACE	Race	Categorical variable indicating respondent's race, using census categories and excluding Hispanic origin unless specified. Source: Student interview and institutional records.	Set of dummy variables computed to represent Asian, Black, Hispanic, White, and Other
GENDER	Gender	Dummy variable indicating respondent's gender. Source: Student interview, institutional records, and federal financial aid records.	Recoded to: 0=Female 1=Male
AGE	Age	Continuous variable representing respondent's age in the first year of enrollment (as of 12/31/2003). Source: Student interview, institutional records, and federal financial aid records.	
PCTPOV	Income as percent of poverty level 2003-04	Indicates the total 2002 income (taking into account student and parent income, family size, and dependency status) as a percentage of the 2002 federal poverty level thresholds, multiplied by 100 and capped at values of 1000. (100=at poverty level, 1000=10x poverty level or higher). Source: Student interview, institutional records, federal financial aid records.	
PAREDUC	Parent(s) highest level of education	Categorical variable indicating the highest level of education of either parent of the respondent during the 2003-2004 academic year. (If one parent's education was unknown, the known parent was used.) Source: Student interview, institutional records, federal financial aid records.	Computed dummy variable where: 0=Less than two years college 1=Associate's degree/two years of college or higher
Student Entry Characteristics: Academic Preparation			
HSTYPE	High school type attended	Categorical variable indicating whether the high school respondent attended was public, private, foreign, or no high school diploma/certificate. Source: Student interview.	Computed dummy variable where: 0=public, foreign, or no diploma/certificate 1= private
HCMATH	Highest level of	Categorical variable indicating the highest	Computed dummy variable

Name	Label	Description/Source	Coding
	high school mathematics	level of mathematics the respondent completed or planned to take. Source: College Board/ACT, student interview.	where: 0=lower than Algebra II 1=at least Algebra II
ACG1	ACG curriculum eligibility 2003-04 (representing rigor of high school curriculum)	Dummy variable indicating whether the respondent would have met high school curriculum requirements for the federal Academic Competitiveness Grants (ACG) if the program had been in effect in 2003-04; will be used as an indicator of the rigor of the high school curriculum. Source: College Board/ACT.	
HCGPAREP	High school GPA	Respondent's high school grade point average on the ACT/SAT test date. Source: College Board/ACT.	Ordinal variable with 7 categories: 0.5-0.9 (D- to D) 1.0-1.4 (D to C-) 1.5-1.9 (C- to C) 2.0-2.4 (C to B-) 2.5-2.9 (B- to B) 3.0-3.4 (B to A-) 3.5-4.0 (A- to A) Treated as continuous for analysis.
Postsecondary Experience			
ACAINX04	Academic integration index	Index summarizing a set of interview questions about the academic integration the respondent experienced at the NPSAS institution he/she attended during the 2003-2004 academic year. Four items (FREQ04A, FREQ04B, FREQ04C, & FREQ04G) ask student how often he/she did the following: participated in study groups, had social contact with faculty, met with an academic advisor, or talked with faculty about academic matters outside of class (response categories 0='never,' 1='sometimes,' 2='often'). NCES index calculated by taking average of the items multiplied by 100. Source: Student interview.	
SOCINX04	Social integration index	Index summarizing a set of interview questions (FREQ04D, FREQ04E, & FREQ04F) asking how often student had done the following: attended fine arts activities, participated in intramural or varsity sports, or participated in school clubs during the 2003-2004 academic year (response categories 0='never,' 1='sometimes,' 2='often'). NCES index calculated by taking average of the items multiplied by 100. Source: Student interview.	
ENRSTAT	Full-time enrollment status	Variable constructed by NCES and based on institution-reported data for students attending a single institution, self-report for those attending multiple. If the number of full-time months was greater than the number of part-	Computed dummy variable where: 0=less than full-time status during first year 1= "mostly full-time"

Name	Label	Description/Source	Coding
		time months, the response was coded by NCES as "mostly full-time." Source: Student interview.	status during first year
PELYRS09	Pell grant: Number of years received 2009	Categorical variable indicating the number of years respondent received a Pell grant through 2009. Source: Federal financial aid records.	Computed dummy variable where: 0=Never 1=received Pell grant in one or more years
MAJORS	Declared a major in first year enrolled	Categorical variable indicating the student's major during the 2003-2004 academic year, if any. Source: Student interviews.	Computed dummy variable where: 0=Did not declare a major 1=Declared a major
QSCHTOT	Total known institutions attended	Continuous variable. Source: Transcripts.	
Postsecondary Experience: Remediation			
MTTOTR*	# remedial courses taken at 1st institution	# remedial courses taken at 1st institution (using MTSCHOFA to identify order of institutions). Source: Transcripts. *Note: This NCES summary variable was adjusted by the author to account for a remedial mathematics course code not captured in the calculation.	Dummy variable will be computed where: 0=none 1=one or more
MTENGR	Remedial English: # taken at 1st institution	Total number of remedial English courses taken at 1st institution. Source: Transcripts.	Computed dummy variable indicating whether student took at least one such course.
MTREADR*	Remedial reading: # taken at 1st institution	Total number of remedial reading courses taken at 1st institution. Source: Transcripts. *Note: Variable calculated by the author based on existing remediation summary variables and course-level transcript files.	Computed dummy variable indicating whether student took at least one such course.
MTMATHR	Remedial math: # taken at 1st institution	Total number of remedial mathematics courses taken at 1st institution. Source: Transcripts.	Computed dummy variable indicating whether student took at least one such course.
MTESL	Remedial English as a second language: # taken at 1st institution	Total number of remedial ESL courses taken at 1st institution. Source: Transcripts.	Computed dummy variable indicating whether student took at least one such course.
MTOTHRR	Other remedial courses: # taken at 1st institution	Total number of remedial "other" courses taken at 1st institution. Source: Transcripts.	Computed dummy variable indicating whether student took at least one such course.

Name	Label	Description/Source	Coding
Environmental Pull Factors			
DEPCHILD, DEPANY06, DEPANY09	Dependent children	Dummy variables indicating whether the respondent had children who were dependents during each of the three interview periods. Source: Student interview.	Computed dummy variable where: 0=no dependent children during study period 1=one or more children during study period
JOBENR	Job while enrolled 2004: Work intensity (exclude work study)	Categorical variable indicating the intensity of work (excluding work-study/ assistantship/ traineeship) while enrolled during the 2003-2004 academic year. Source: Student interview.	Computed dummy variable where: 0=less than full-time 1=full-time
Filters for Exclusion from Sample			
AGE	Respondent's age at enrollment	Continuous variable representing respondent's age in the first year of enrollment (as of 12/31/2003). Source: Student interview, institutional records, and federal financial aid records.	Computed dummy variable where: 0=24 years old or older (excluded) 1= less than 24 years old
ATTENDA through ATTENDG	Reason enrolled 2004	Reasons for attending, asked of students at two-year colleges: complete Associate's degree (ATTENDA), certificate (ATTENDB), transfer to 2-yr (ATTENDE), transfer to 4-yr (ATTENDF), transfer to other college (ATTENDG). Source: Student interview.	If ATTENDA,B,E,F, and G all =0 and UGDEG=4, case is excluded.
UGDEG	Degree program 2003-2004	Whether student was enrolled in a certificate, Associate's, or Bachelor's degree program, or no program. Source: Student interview, institutional records, and federal financial aid records.	If UGDEG = 4 (not in a certificate or degree program at first enrollment) and ATTEND A, B, E, F, G= 0, case is excluded.
WTB000	Panel weight	Source: NCES.	If weight is missing or =0, data are not available for all three interview rounds and case is excluded.
WTC000	Transcript study weight	Source: NCES.	If weight is missing or =0, data are not available from transcript study and case is excluded.
MTSCHOFA	Order in which institution was attended.	Order in which institution was attended, starting with first attended. Source: Transcripts.	If multiple institutions have a value of 1, case is excluded.

Name	Label	Description/Source	Coding
Integrated Postsecondary Education Data System (IPEDS)			
INSTITUTION LEVEL PREDICTORS (2003-2004)			
Structural Characteristics			
iclevel	Level	Categorical variable indicating degree offerings of the institution. Source: IPEDS Data Center.	Used to separate institutions whose highest degree offering is two-year from those offering four-year or higher degrees. Less than 2-yr. degree institutions are excluded.
control	Institutional control	Categorical variable indicating whether the institution is private nonprofit, private for-profit, or public. Source: IPEDS Data Center.	Computed dummy variable where: 0= public 1= private nonprofit For-profit excluded.
enrtot	Total number of full-time students	The total number of undergraduate students enrolled for 12 or more semester credits, or 12 or more quarter credits, or 24 or more contact hours a week each term. Source: IPEDS Data Center.	
Student Body Characteristics			
pctenrbk	Percent of students who are Black	Based on total fall enrollment, including students enrolled in programs for credit, vocational programs, and high school students in dual enrollment. Source: IPEDS Data Center.	
pctenrhs	Percent of students who are Hispanic	Based on total fall enrollment, including students enrolled in programs for credit, vocational programs, and high school students in dual enrollment. Hispanic category does not overlap other race categories. Source: IPEDS Data Center.	
fgrnt_p	Percentage of full-time first-time degree/certificate-seeking undergraduates receiving federal grants	Percentage of full-time, first-time degree/certificate-seeking undergraduate students who received federal grants (grants/educational assistance funds). Source: IPEDS Data Center.	
Organizational			
ftfac, totfac	Share of faculty full-time	The proportion of all faculty members that are full-time employees. Source: IPEDS Data Center.	Computed new continuous variable: full-time faculty divided by total faculty

APPENDIX B. BPS COURSE CODES DESIGNATED AS REMEDIAL

Sources: Bryan, Michael & Simone, Sean. (2012). 2010 College Course Map. NCES Report No. 2012-162. Washington, DC: National Center for Education Statistics, U.S. Department of Education; and NCES SAS code for creating remedial summary variables.

Math

27.0195 Descriptive Geometry, Pre-Collegiate Geometry and/or Plane Geometry. Any mathematics course that deals with the topic of descriptive geometry, pre-collegiate geometry and/or plane geometry.
27.0196 Arithmetic. Any mathematics course that deals with the topic of arithmetic.
27.0197 Intermediate Algebra, Pre-Collegiate Algebra, Elementary Algebra, Basic Algebra, Preparatory Algebra and/or Pre-Algebra Math. Any mathematics course that deals with the topic of intermediate algebra, pre-collegiate algebra, elementary algebra, basic algebra, preparatory algebra and/or pre-algebra math.
27.0198 Pre-Collegiate Math General, Basic Concepts of Math, Elementary Math, Introductory Math, Developmental Math and/or Preparatory Math. Any mathematics course that deals with the topics of pre-collegiate math general, basic concepts of math, elementary math, introductory math, developmental math and/or preparatory math.
27.9990 Pre-Collegiate Math, Business Math, Business Computations, Business Arithmetic and/or Consumer Math. Any other mathematics and statistics course that deals with the topics of business math, pre-collegiate business math, business computations, business arithmetic and/or consumer math.
32.0104 Developmental/Remedial Mathematics. A course that focuses on the development of computing and other mathematical reasoning abilities and skills. Examples include numeracy and computational skills; adult developmental mathematics.

English

23.1397 Business English and/or Punctuation. Any rhetoric and composition/writing studies course that deals with the topics of business English and/or punctuation.
23.9989 Basic Skills English, Language Skills, Writing Skills, Grammar, Punctuation, Spelling and/or Elementary Communication. Any other English language literature/letters course that deals with the topics of basic skills English, language skills, writing skills, grammar, punctuation, spelling and/or elementary communication.
32.0108 Developmental/Remedial English. A course that focuses on the fundamental knowledge and skills in reading, writing and speaking that individuals need to function productively in society. Examples include developmental/remedial reading and writing; developmental/remedial literacy skills; literacy and communication skills.

Reading

23.9988 Basic Reading, Reading Improvement, Reading Skills and/or Reading Comprehension. Any other English language and literature/letters course that deals with the topics of basic reading, reading improvement, reading skills and/or reading comprehension.

English as a Second Language

32.0109 Second Language Learning. A course that focuses on the development of proficiency in reading, writing, and speaking a language or languages other than the mother tongue, that are needed to perform day-to-day tasks. Includes instruction in the use of basic communication skills to develop and transmit ideas and thoughts. Examples include English as a second language.

Other

23.9987 Remedial Speech, Basic Speech, Basic Oral Communication, Basic Oral Skills and/or Listening Skills. Any other English language and literature/letters course that deals with the topics of remedial speech, basic speech, basic oral communication, basic oral skills and/or listening skills.

30.9997 Multi/interdisciplinary Study: Basic Science Skills and/or Remedial Science. Any multi/interdisciplinary studies course that deals with topics of basic science skills and/or remedial science.

32.0101 Basic Skills and Developmental/Remedial Education, General. A general course that focuses on the fundamental knowledge and skills that individuals need to function productively in society. Also student development, developmental skills, adult basic education, and/or development of competence. Examples include basic skills, general; developmental education, general; remedial education, general; adult developmental education.

32.0196 Workplace Skills, Job Skills, Workplace Demeanor and/or Work Habits. Any basic skills course that deals with the topics of workplace skills, job skills, workplace demeanor and/or work habits.

32.0198 Individual in Transition, Survival Skills, and/or Support Skills. Any parks, recreation, leisure, and fitness studies course that deals with topics of individual in transition, survival skills, support skills, and/or out of class skills.

32.0199 Basic Skills and Developmental/Remedial Education, Other. Any course in basic skills not listed above.

APPENDIX C. SENSITIVITY OF ESTIMATES TO MINIMUM CLUSTER SIZE

An important technical decision for multilevel analysis is establishing the minimum number of units per cluster. Although the Empirical Bayes estimation method draws on larger, more reliable clusters to improve the accuracy of estimates for smaller, less reliable ones, this approach means that estimates undergo shrinkage toward the mean. In a study like this one with a binary outcome, cluster size is especially critical because the iterative maximum likelihood estimation procedures used in logistic regression function more effectively on larger samples. The choice must be considered in the context of the overall power to detect relationships of interest in the structure of the data in terms of sample size at levels one and two.

To inform the choice of minimum cluster size for this study, a preliminary analysis was performed to assess sensitivity to different values. Thirty models were fit that varied over five different minimum cluster sizes and across number of predictors, including interaction terms. Comparing models with greater and lesser complexity helped to pinpoint problems with estimation that might arise due to including more free parameters than the data structure can support. The estimation methods were the same as those used in the main analysis and described in chapter 3 (e.g., weight WTB000 applied at student level, Laplace estimation).

Table C1 summarizes the specifications of the 30 models tested.

Table C1.

Models Estimated for Analysis of Sensitivity to Minimum Cluster Size (Four-year College Students, Outcome = Bachelor's Degree Attainment)

Number of Predictors		*Minimum Number of Student Cases per Institution*				
Student Level	Institution Level	2	5	10	15	20
1[a]	2[g]	X	X	X	X	X
3[b]	2[g]	X	X	X	X	X
9[c]	2[g]	X	X	X	X	X
22[d]	2[g]	X	X	X	X	X
22[d] + 2 interactions[e]	2[g]	X	X	X	X	X
22[d] + 6 interactions[f]	6[h]	X	X	X	X	X
Level-1 N		7,180	6,820	5,710	4,490	3,510
Level-2 N		560	440	280	170	120

[a] Any remediation
[b] The above plus high school GPA, full-time enrollment
[c] The above plus male, income, attended 2 institutions, attended 3+ institutions, worked full-time, dependent child
[d] The above plus Asian, Black, Hispanic, other race, age, parent education, private high school, took Algebra II, rigorous high school curriculum, academic integration index, social integration index, Pell grant recipient, declared a major
[e] Interactions of any remediation with: attended 2 institutions, attended 3+ institutions
[f] The above plus interactions of any remediation with: declared major, age, high school GPA; and interaction of income X Black
[g] Private institutional control, % students receiving federal grant aid
[h] The above plus total enrollment, % Black students, % Hispanic students, % full-time faculty
Note: Sample size numbers are rounded to nearest 10, per IES data disclosure requirements.

Table C2 and the figures that follow display the differences in parameter estimates across the models tested. The regression slope coefficient for the dummy variable “any remediation” (Figure C1) and the standard error of this coefficient (Figure C2) are displayed. Although the width of the range of estimates across the five cluster minimums increased with the addition of parameters, estimates were very similar across the five different cluster minimums for all but the most complex model. This last model, which included 22 student-level predictors, six student-level interactions, and six institution-level predictors, was highly sensitive to the choice of minimum cluster size, generating parameter estimates of different signs and magnitudes. Among the five sizes tested, the minimum-five models had the most stable estimates across all levels of complexity.

As discussed in chapter 3, the decision was made to exclude institutions represented by fewer than five students in the sample. This floor was chosen to maximize generalizability while maintaining enough cases per institution to estimate slopes reliably and maintain stability in the models. These figures lent support to this decision. However, they also indicated caution in fitting very complex models with many interaction terms. The model-building process was therefore conducted in a parsimonious fashion to avoid creating such instability.

Table C2.

Variation in Parameter Estimates by Minimum Cluster Size and Model Complexity

Minimum Cluster Size	*Model A*	*Model B*	*Model C*	*Model D*	*Model E*	*Model F*
Slope Coefficient for "Any Remediation"						
>=2	-0.425	-0.268	-0.252	-0.206	-0.454	-0.883
>= 5	-0.418	-0.268	-0.251	-0.203	-0.445	-0.331
>= 10	-0.347	-0.174	-0.166	-0.119	-0.361	0.745
>= 15	-0.390	-0.220	-0.218	-0.177	-0.447	-0.415
>= 20	-0.409	-0.248	-0.238	-0.198	-0.452	1.474
Range	**0.078**	**0.094**	**0.086**	**0.087**	**0.093**	**2.357**
Standard Error of Slope Coefficient						
>=2	0.065	0.068	0.071	0.074	0.092	1.653
>= 5	0.068	0.070	0.073	0.076	0.095	0.147
>= 10	0.074	0.079	0.085	0.090	0.110	2.132
>= 15	0.083	0.088	0.096	0.104	0.128	2.493
>= 20	0.094	0.098	0.107	0.118	0.144	3.409
range	**0.029**	**0.030**	**0.036**	**0.045**	**0.052**	**3.262**

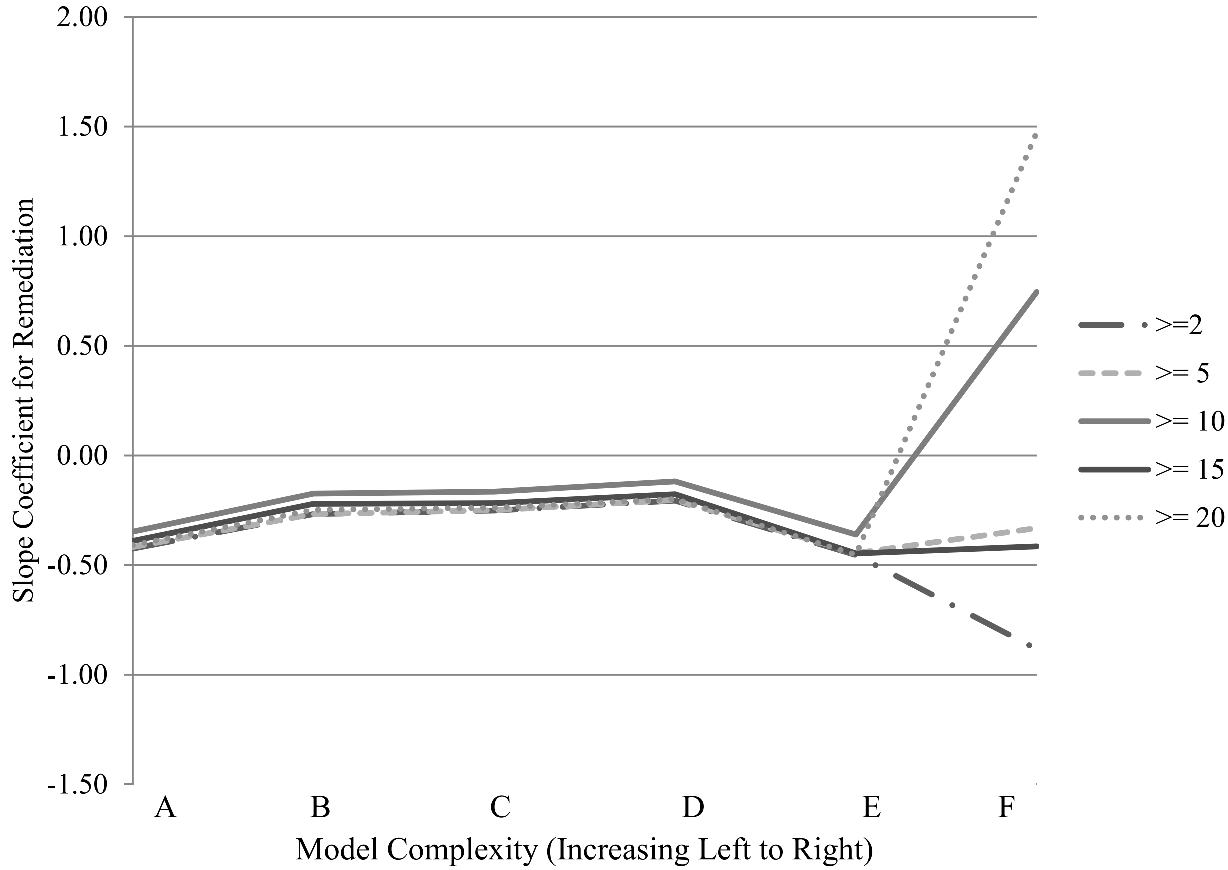

Figure C1. Variation in Remediation Slope Coefficient by Minimum Cluster Size and Model Complexity

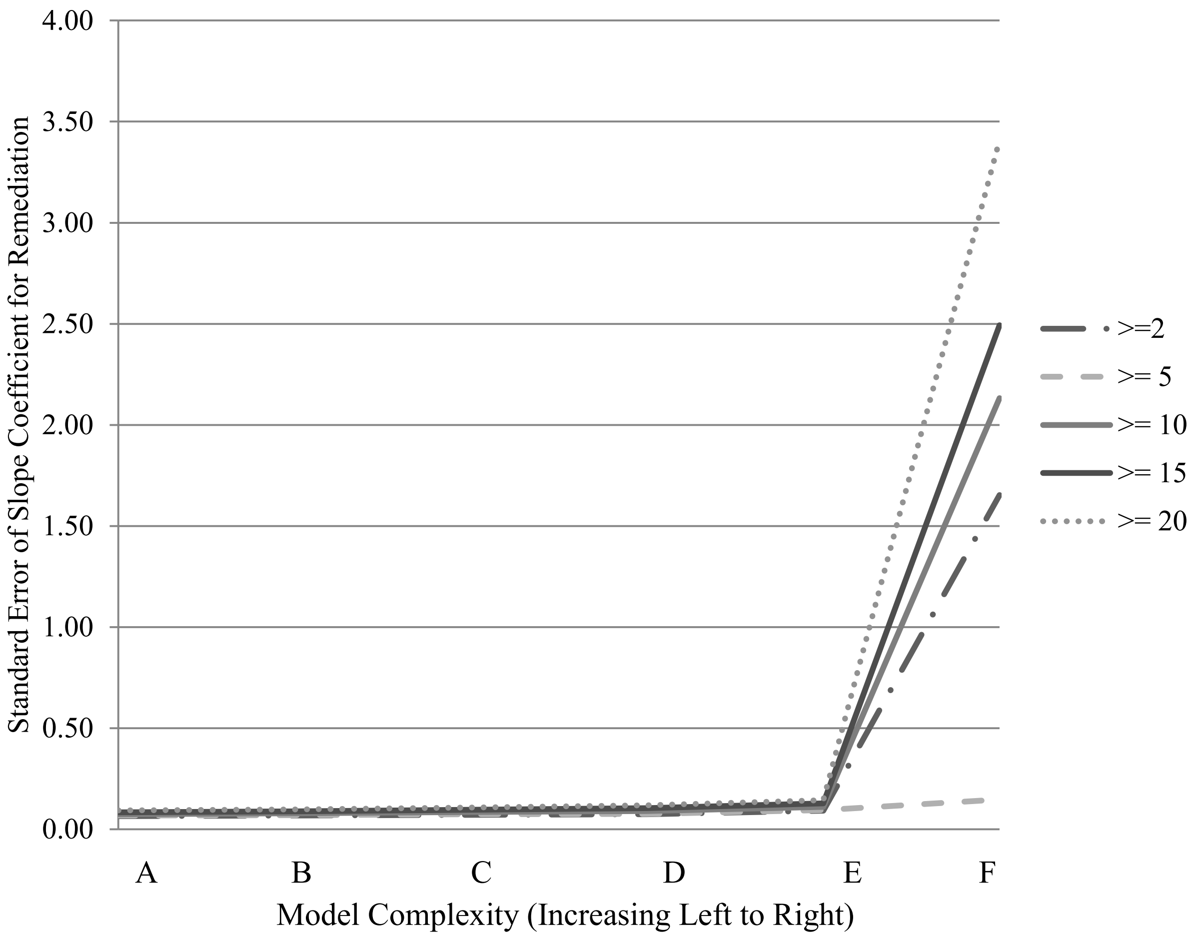

Figure C2. Variation in Standard Error of Remediation Slope Coefficient by Minimum Cluster Size and Model Complexity

APPENDIX D. MODEL-BUILDING PROCESS DETAIL

This Appendix displays the sequence of models estimated for each of the 15 model sets discussed in chapter 4. It shows the introduction of covariates in blocks and the addition of significant interaction terms and random slopes.

Table D1. Two-year colleges: Relationship between Any Remediation and Attaining an Associate's Degree or Higher

	Unconditional		*Remediation-Only*		*Demographic Block*		*Academic Preparation Block*		*Academic - Significant*		*Postsecondary Experiences Block*		*Postsecondary - Significant*		*Environmental Factors / Student-Level Final*		*All Institutional Predictors*		*Student- and Insitution-Level Final*	
	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)
STUDENT-LEVEL																				
Intercept	-0.65 a	(0.05)	-0.43 a	(0.07)	-0.43 a	(0.09)	-0.84 a	(0.13)	-0.88 a	(0.13)	-2.53 a	(0.21)	-2.29 a	(0.16)	-1.98 a	(0.17)	-2.00 a	(0.18)	-2.00 a	(0.17)
Any remediation			-0.34 a	(0.06)	-0.26 a	(0.07)	-0.16 c	(0.07)	-0.15 c	(0.07)	0.04	(0.08)	0.01	(0.07)	0.01	(0.08)	0.02	(0.08)	0.02	(0.07)
Asian					0.42 c	(0.18)	0.42 c	(0.19)	0.39 c	(0.19)	0.36 c	(0.18)	0.31	(0.18)	0.24	(0.19)	0.35	(0.20)	0.34	(0.20)
Black					-0.56 a	(0.13)	-0.52 a	(0.13)	-0.53 a	(0.13)	-0.68 a	(0.14)	-0.76 a	(0.14)	-0.64 a	(0.14)	-0.51 a	(0.16)	-0.52 b	(0.16)
Hispanic					-0.06	(0.12)	-0.06	(0.12)	-0.06	(0.12)	0.01	(0.12)	-0.05	(0.12)	0.01	(0.12)	0.09	(0.14)	0.05	(0.13)
Other race					-0.36 c	(0.16)	-0.37 c	(0.17)	-0.38 c	(0.17)	-0.45 c	(0.18)	-0.50 b	(0.17)	-0.45 b	(0.17)	-0.47 c	(0.18)	-0.48 b	(0.18)
Male					-0.19 c	(0.08)	-0.13	(0.08)												
Age					-0.14 a	(0.03)	-0.12 b	(0.03)	-0.12 b	(0.03)	-0.04	(0.04)								
Income					0.00 c	(0.00)	0.00 c	(0.00)	0.00 c	(0.00)	0.00	(0.00)								
Parent education					0.22 b	(0.07)	0.18 c	(0.07)	0.18 c	(0.07)	0.09	(0.09)								
Private HS							0.31	(0.16)												
Algebra II							0.36 b	(0.12)	0.39 a	(0.11)	0.23	(0.12)								
HS curriculum							0.04	(0.09)												
HS GPA							0.23 a	(0.04)	0.23 a	(0.03)	0.19 a	(0.04)	0.20 a	(0.04)	0.21 a	(0.04)	0.20 a	(0.04)	0.20 a	(0.04)
Academic integration											0.00 c	(0.00)	0.00 b	(0.00)	0.00 c	(0.00)	0.00 c	(0.00)	0.00 c	(0.00)
Social integration index											0.00	(0.00)								
Full-time enrollment											0.83 a	(0.12)	0.83 a	(0.11)	0.75 a	(0.12)	0.70 a	(0.12)	0.71 a	(0.11)
Pell grant											-0.03	(0.10)								
Declared a major											0.36 a	(0.10)	0.35 a	(0.09)	0.39 a	(0.10)	0.39 a	(0.10)	0.39 a	(0.09)
Attended 2 colleges											1.31 a	(0.10)	1.34 a	(0.09)	1.26 a	(0.09)	1.28 a	(0.09)	1.28 a	(0.09)
Attended 3+ colleges											1.76 a	(0.12)	1.81 a	(0.11)	1.69 a	(0.11)	1.69 a	(0.11)	1.69 a	(0.11)
Worked full-time															-0.32 b	(0.11)	-0.30 c	(0.12)	-0.30 b	(0.12)
Child															-0.69 a	(0.10)	-0.71 a	(0.10)	-0.71 a	(0.10)
INSTITUTION-LEVEL																				
Private college																	0.50 c	(0.20)	0.54 b	(0.18)
College enr. (1,000s)																	0.00 c	(0.00)	-0.02 b	(0.01)
% Black students (sqrt)																	-0.09 c	(0.04)	-0.07 c	(0.03)
% Hispanic students (sqrt)																	-0.03	(0.04)		
% students w/ federal aid																	0.00	(0.00)		
% full-time faculty																	0.00	(0.00)		
VARIANCE COMPONENTS																				
Tau_{00}	0.31 a		0.30 a		0.26 a		0.27 a		0.27 a		0.30 a		0.28 a		0.30 a		0.23 a		0.25 a	
Tau_{11}																				
Tau_{01} as Corr.																				
Tau_{00} Reliability	0.42		0.42		0.39		0.39		0.39		0.37		0.37		0.37		0.28		0.29	
Tau_{11} Reliability																				
Deviance	10,922		10,903		10,819		10,747		10,755		10,318		10,334		10,272		10,239		10,241	
(# parameters)	(2)		(3)		(11)		(15)		(12)		(19)		(13)		(15)		(21)		(18)	

[a] p<.001; [b] p<.01; [c] p<.05

Table D2. Two-year colleges: Relationship between Any Remediation and Attaining a Certificate

	Unconditional		*Remediation-Only*		*Demographic Block*		*Demographic - Significant*		*Academic Preparation Block*		*Academic - Significant*		*Postsecondary Experiences Block*		*Postsecondary - Significant*		*Environmental Factors Block*		*Environmental - Significant/ Student-Level Final*		*All Institutional*		*Student- and Insitution-Level Final*	
	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff P-v	s.e.	Coeff P-v	s.e.	Coeff P-v	s.e.	Coeff P-v	s.e.
STUDENT-LEVEL																								
Intercept	-3.44 a	(0.18)	-3.22 a	(0.20)	-2.99 a	(0.23)	-3.22 a	(0.20)	-2.98 a	(0.23)	-3.22 a	(0.20)	-3.35 a	(0.30)	-3.51 a	(0.24)	-3.59 a	(0.25)	-3.51 a	(0.24)	-3.41 a	(0.24)	-3.43 a	(0.23)
Any remediation			-0.33 c	(0.16)	-0.35 c	(0.18)	-0.33 c	(0.16)	-0.35 c	(0.17)	-0.33 c	(0.16)	-0.28	(0.16)	-0.28	(0.16)	-0.29	(0.16)	-0.28	(0.16)	-0.27	(0.17)	-0.28	(0.16)
Asian					-0.16	(0.44)																		
Black					0.21	(0.24)																		
Hispanic					-0.01	(0.29)																		
Other race					-0.75	(0.55)																		
Male					-0.31	(0.20)																		
Age					0.05	(0.07)																		
Income					0.00	(0.00)																		
Parent education					-0.15	(0.17)																		
Private HS									-0.10	(0.40)														
Algebra II									-0.31	(0.22)														
HS curriculum									0.06	(0.21)														
HS GPA									0.00	(0.09)														
Academic integration													0.00	(0.00)										
Social integration index													0.00	(0.00)										
Full-time enrollment													-0.24	(0.19)										
Pell grant													0.04	(0.19)										
Declared a major													-0.06	(0.19)										
Attended 2 colleges													0.49 c	(0.20)	0.42 c	(0.19)	0.45 c	(0.20)	0.42 c	(0.19)	0.42 c	(0.19)	0.43 c	(0.19)
Attended 3+ colleges													0.53	(0.28)	0.44	(0.26)	0.49	(0.26)	0.44	(0.26)	0.42	(0.26)	0.43	(0.26)
Worked full-time																	-0.08	(0.20)						
Child																	0.30	(0.18)						
INSTITUTION-LEVEL																								
Private college																					-0.51	(0.56)		
College enr. (1,000s)																					-0.05 c	(0.02)	-0.04 c	(0.02)
% Black students (sqrt)																					0.02	(0.06)		
% Hispanic students (sqrt)																					-0.08	(0.10)		
% students w/ federal aid																					0.00	(0.01)		
% full-time faculty																					-0.01	(0.01)		
VARIANCE COMPONENTS																								
Tau_{00}	1.24 a		1.19 a		1.19 a		1.19 a		1.17 a		1.19 a		1.27 a		1.25 a		1.23 a		1.25 a		1.05 a		1.08 a	
Tau_{11}																								
Tau_{01} as Corr.																								
Tau_{00} Reliability	0.39		0.38		0.37		0.38		0.37		0.38		0.38		0.39		0.39		0.39		0.36		0.37	
Tau_{11} Reliability																								
Deviance	7,815		7,812		7,801		7,812		7,809		7,812		7,799		7,806		7,803		7,806		7,792		7,797	
(# parameters)	(2)		(3)		(11)		(3)		(7)		(3)		(10)		(5)		(7)		(5)		(11)		(6)	

[a] p<.001; [b] p<.01; [c] p<.05

Table D3. Two-year colleges: Relationship between Any Remediation and Attaining an Associate's Degree

	Unconditional		*Remediation-Only*		*Demographic Block*		*Demographic - Significant*		*Academic Preparation Block*		*Academic - Significant*		*Postsecondary Experiences Block*		*Postsecondary - Significant*		*Environmental Factors Block*		*Environmental - Significant*		*Student-Level Final with Interaction*		*All Institutional*		*Institutional - Significant*		*Student- and Insitution-Level Final*	
	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)
STUDENT-LEVEL																												
Intercept	-1.63 a	(0.07)	-1.75 a	0.09	-1.61 a	(0.12)	-1.71 a	(0.11)	-1.77 a	(0.16)	-1.65 a	(0.13)	-2.50 a	(0.21)	-2.48 a	(0.19)	-2.41 a	(0.20)	-2.43 a	(0.20)	-2.73 a	(0.24)	-2.72 a	(0.24)	-2.77 a	(0.24)	-2.79 a	(0.24)
Any remediation			0.19 c	0.09	0.21 c	(0.09)	0.21 c	(0.09)	0.25 c	(0.10)	0.24 c	(0.10)	0.23 c	(0.10)	0.24 c	(0.10)	0.25 c	(0.10)	0.25 c	(0.10)	0.68 b	(0.21)	0.68 b	(0.21)	0.69 b	(0.21)	0.68 b	(0.21)
Asian					0.25	(0.22)	0.27	(0.22)	0.29	(0.22)	0.29	(0.22)	0.28	(0.22)	0.28	(0.22)	0.25	(0.22)	0.25	(0.22)	0.25	(0.22)	0.35	(0.24)	0.28	(0.23)	0.25	(0.23)
Black					-0.42 b	(0.16)	-0.38 c	(0.15)	-0.36 c	(0.16)	-0.36 c	(0.16)	-0.47 b	(0.17)	-0.47 b	(0.16)	-0.44 b	(0.16)	-0.44 b	(0.16)	-0.43 b	(0.16)	-0.31	(0.18)	-0.30	(0.18)	-0.32	(0.18)
Hispanic					0.02	(0.14)	0.06	(0.13)	0.07 c	(0.13)	0.07	(0.13)	0.05	(0.13)	0.04	(0.13)	0.06	(0.14)	0.05	(0.14)	0.05	(0.14)	0.13	(0.16)	0.05	(0.14)	0.01	(0.14)
Other race					-0.49 c	(0.19)	-0.48 c	(0.18)	-0.49 c	(0.19)	-0.49 b	(0.19)	-0.57 b	(0.20)	-0.57 b	(0.19)	-0.56 b	(0.19)	-0.56 b	(0.19)	-0.56 b	(0.20)	-0.58 b	(0.20)	-0.56 b	(0.20)	-0.62 b	(0.20)
Male					-0.02	(0.10)																						
Age					-0.05	(0.04)																						
Income					0.00	(0.00)																						
Parent education					-0.17	(0.09)																						
Private HS									0.10	(0.20)																		
Algebra II									0.17	(0.13)																		
HS curriculum									-0.27 c	(0.11)	-0.19	(0.10)	-0.22 c	(0.11)	-0.22 c	(0.10)	-0.23 c	(0.11)	-0.23 c	(0.11)	-0.23 c	(0.11)	-0.21 c	(0.11)	-0.23 c	(0.11)	-0.22 c	(0.11)
HS GPA									0.14 b	(0.05)	0.15 b	(0.05)	0.14 b	(0.05)	0.14 b	(0.05)	0.14 b	(0.05)	0.14 b	(0.05)	0.14 b	(0.05)	0.13 b	(0.05)	0.13 b	(0.05)	0.13 b	(0.05)
Academic integration													0.00	(0.00)														
Social integration index													0.00	(0.00)														
Full-time enrollment													0.54 a	(0.13)	0.53 a	(0.13)	0.50 a	(0.13)	0.51 a	(0.13)	0.52 a	(0.13)	0.46 b	(0.14)	0.51 a	(0.13)	0.48 b	(0.13)
Pell grant													0.21 c	(0.10)	0.21 c	(0.09)	0.25 b	(0.10)	0.25 c	(0.10)	0.25 c	(0.10)	0.22 c	(0.11)	0.26 c	(0.10)	0.25 c	(0.10)
Declared a major													0.47 a	(0.11)	0.48 a	(0.11)	0.49 a	(0.11)	0.49 a	(0.11)	0.88 a	(0.19)	0.87 a	(0.19)	0.90 a	(0.19)	0.90 a	(0.19)
Attended 2 colleges													0.03	(0.11)														
Attended 3+ colleges													0.04	(0.14)														
Worked full-time																	-0.08	(0.12)										
Child																	-0.23 c	(0.11)	-0.24 c	(0.11)	-0.23 c	(0.11)	-0.25 c	(0.12)	-0.23 c	(0.11)	-0.24 c	(0.11)
L1 INTERACTIONS																												
Remediation X Major																					-0.57 c	(0.24)	-0.57 c	(0.24)	-0.58 c	(0.24)	-0.59 c	(0.24)
INSTITUTION-LEVEL																												
Private college																							0.45	(0.26)			0.76 b	(0.23)
College enr. (1,000s)																							-0.02	(0.01)				
% Black students (sqrt)																							-0.10 c	(0.04)	-0.10 c	(0.04)	-0.09 c	(0.04)
% Hispanic students (sqrt)																							-0.04	(0.05)				
% students w/ federal aid																							0.01	(0.00)				
% full-time faculty																							0.00	(0.00)				
VARIANCE COMPONENTS																												
Tau$_{00}$	0.36 a		0.36 a		0.37 a		0.36 a		0.40 a		0.40 a		0.40 a		0.41 a		0.43 a		0.43 a		0.44 a		0.36 a		0.44 a		0.41 a	
Tau$_{11}$																												
Tau$_{01}$ as Corr.																												
Tau$_{00}$ Reliability	0.44		0.43		0.43		0.43		0.44				0.43		0.43		0.43		0.43		0.44		0.37		0.43		0.41	
Tau$_{11}$ Reliability											0.43																	
Deviance	9,743		9,740		9,720		9,726		9,710		9,712		9,656		9,661		9,655		9,656		9,650		9,623		9,643		9,633	
(# parameters)	(2)		(3)		(11)		(7)		(11)		(9)		(16)		(12)		(14)		(13)		(14)		(20)		(15)		(16)	

[a] p<.001; [b] p<.01; [c] p<.05

Table D4. Two-year colleges: Relationship between Any Remediation and Attaining a Bachelor's Degree or Higher

	Unconditional		*Remediation-Only*		*Demographic Block*		*Academic Preparation Block*		*Academic - Significant*		*Postsecondary Experiences Block*		*Postsecondary - Significant*		*Environmental Factors Block*		*Environmental- Significant/ Student-Level Final*		*All Institutional*		*Student- and Insitution-Level Final*	
	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)
<u>STUDENT-LEVEL</u>																						
Intercept	-1.76 a	(0.07)	-1.32 a	(0.09)	-1.52 a	(0.12)	-2.33 a	(0.19)	-2.31 a	(0.19)	-7.94 a	(0.87)	-7.99 a	(0.84)	-7.49 a	(0.85)	-7.31 a	(0.81)	-7.30 a	(0.84)	-7.31 a	(0.81)
Any remediation			-0.73 a	(0.08)	-0.63 a	(0.09)	-0.48 a	(0.10)	-0.48 a	(0.10)	-0.16	(0.11)	-0.16	(0.11)	-0.16	(0.12)	-0.17	(0.12)	-0.18	(0.13)	-0.17	(0.12)
Asian					0.34	(0.24)	0.34	(0.25)	0.33	(0.25)	0.14	(0.26)	0.09	(0.25)	-0.02	(0.27)	-0.07	(0.28)	-0.02	(0.29)	-0.07	(0.28)
Black					-0.56 b	(0.18)	-0.51 b	(0.18)	-0.53 b	(0.18)	-0.67 b	(0.21)	-0.72 a	(0.19)	-0.54 b	(0.21)	-0.61 b	(0.20)	-0.55 c	(0.23)	-0.61 b	(0.20)
Hispanic					-0.15	(0.20)	-0.16	(0.20)	-0.17	(0.20)	0.01	(0.20)	-0.03	(0.20)	0.02	(0.19)	-0.05	(0.19)	-0.04	(0.21)	-0.05	(0.19)
Other race					-0.12	(0.23)	-0.14	(0.25)	-0.15	(0.25)	-0.11	(0.30)	-0.15	(0.29)	-0.09	(0.30)	-0.13	(0.30)	-0.12	(0.30)	-0.13	(0.30)
Male					-0.30 b	(0.10)	-0.21 c	(0.10)	-0.22 c	(0.10)	-0.13	(0.12)										
Age					-0.21 a	(0.05)	-0.18 b	(0.05)	-0.18 b	(0.05)	-0.02	(0.06)										
Income					0.00 b	(0.00)	0.00 b	(0.00)	0.00 b	(0.00)	0.00	(0.00)										
Parent education					0.57 a	(0.11)	0.53 a	(0.11)	0.54 a	(0.11)	0.44 b	(0.13)	0.45 a	(0.12)	0.42 b	(0.12)	0.47 a	(0.12)	0.47 a	(0.13)	0.47 a	(0.12)
Private HS							0.34	(0.19)														
Algebra II							0.56 b	(0.20)	0.57 b	(0.19)	0.42 c	(0.21)	0.44 c	(0.20)	0.39	(0.21)						
HS curriculum							0.36 b	(0.12)	0.36 b	(0.12)	0.32 c	(0.14)	0.34 c	(0.13)	0.35 c	(0.14)	0.48 a	(0.12)	0.47 a	(0.12)	0.48 a	(0.12)
HS GPA							0.22 a	(0.05)	0.22 a	(0.05)	0.14 b	(0.05)	0.15 b	(0.05)	0.16 b	(0.05)	0.17 b	(0.05)	0.16 b	(0.05)	0.17 b	(0.05)
Academic integration											0.00 c	(0.00)	0.00 b	(0.00)	0.00 b	(0.00)	0.00 b	(0.00)	0.00 b	(0.00)	0.00 b	(0.00)
Social integration index											0.00	(0.00)										
Full-time enrollment											1.01 a	(0.18)	1.03 a	(0.17)	0.89 a	(0.18)	0.87 a	(0.17)	0.86 a	(0.18)	0.87 a	(0.17)
Pell grant											-0.32 c	(0.14)	-0.40 b	(0.13)	-0.22	(0.14)						
Declared a major											0.00	(0.13)										
Attended 2 colleges											5.67 a	(0.78)	5.69 a	(0.77)	5.57 a	(0.77)	5.57 a	(0.77)	5.58 a	(0.79)	5.57 a	(0.77)
Attended 3+ colleges											6.10 a	(0.79)	6.15 a	(0.78)	5.97 a	(0.78)	5.96 a	(0.77)	5.96 a	(0.80)	5.96 a	(0.77)
Worked full-time															-0.48 b	(0.17)	-0.49 b	(0.17)	-0.48 b	(0.18)	-0.49 b	(0.17)
Child															-1.29 a	(0.21)	-1.35 a	(0.20)	-1.35 a	(0.21)	-1.35 a	(0.20)
<u>INSTITUTION-LEVEL</u>																						
Private college																			-0.03	(0.29)		
College enr. (1,000s)																			-0.01	(0.01)		
% Black students (sqrt)																			-0.02	(0.05)		
% Hispanic students (sqrt)																			0.02	(0.05)		
% students w/ federal aid																			0.00	(0.00)		
% full-time faculty																			0.00	(0.00)		
<u>VARIANCE COMPONENTS</u>																						
Tau_{00}	0.50 a		0.45 a		0.37 a		0.34 a		0.34 a		0.19 c		0.22 b		0.19 c		0.19 c		0.18 c		0.19 c	
Tau_{11}																						
Tau_{01} as Corr.																						
Tau_{00} Reliability	0.41		0.40		0.35		0.34		0.34		0.14		0.14		0.11		0.10		0.09		0.10	
Tau_{11} Reliability																						
Deviance	9,499		9,447		9,334		9,254		9,258		8,504		8,512		8,439		8,447		8,445		8,447	
(# parameters)	(2)		(3)		(11)		(15)		(14)		(21)		(16)		(18)		(16)		(22)		(16)	

[a] p<.001; [b] p<.01; [c] p<.05

Table D5. Four-year colleges: Relationship between Any Remediation and Attaining a Bachelor's Degree or Higher

	Unconditional		*Remediation-Only*		*Demographic Block*		*Academic Preparation Block*		*Academic - Significant*		*Postsecondary Experiences Block*		*Postsecondary - Significant*	
	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)
STUDENT-LEVEL														
Intercept	0.73 a	(0.06)	0.89 a	(0.06)	0.97 a	(0.08)	0.32 c	(0.16)	0.33 c	(0.16)	-0.20	(0.23)	-0.24	(0.23)
Any remediation			-0.56 a	(0.07)	-0.48 a	(0.07)	-0.30 a	(0.07)	-0.30 a	(0.07)	-0.35 a	(0.07)	-0.35 a	(0.07)
Asian					0.09	(0.15)	0.07	(0.16)	0.06	(0.16)	0.14	(0.16)	0.14	(0.16)
Black					-0.49 a	(0.12)	-0.30 c	(0.13)	-0.31 c	(0.12)	-0.32 c	(0.12)	-0.31 c	(0.12)
Hispanic					-0.52 a	(0.12)	-0.45 a	(0.12)	-0.45 a	(0.12)	-0.43 b	(0.12)	-0.43 b	(0.12)
Other race					-0.11	(0.14)	-0.10	(0.14)	-0.10	(0.14)	-0.06	(0.15)	-0.06	(0.15)
Male					-0.49 a	(0.06)	-0.39 a	(0.06)	-0.39 a	(0.06)	-0.43 a	(0.06)	-0.44 a	(0.06)
Age					-0.11 b	(0.04)	-0.10 c	(0.04)	-0.11 c	(0.04)	-0.08 c	(0.04)	-0.08 c	(0.04)
Income					0.00 a	(0.00)	0.00 a	(0.00)	0.00 a	(0.00)	0.00 a	(0.00)	0.00 a	(0.00)
Parent education					0.31 a	(0.07)	0.27 a	(0.07)	0.27 a	(0.07)	0.23 b	(0.07)	0.23 b	(0.07)
Private HS							0.02	(0.09)						
Algebra II							0.54 b	(0.15)	0.61 a	(0.14)	0.52 b	(0.15)	0.51 b	(0.14)
HS curriculum							0.10	(0.08)						
HS GPA							0.50 a	(0.03)	0.50 a	(0.03)	0.49 a	(0.04)	0.49 a	(0.04)
Academic integration											0.00	(0.00)		
Social integration index											0.00 a	(0.00)	0.01 a	(0.00)
Full-time enrollment											1.09 a	(0.15)	1.10 a	(0.15)
Pell grant											-0.24 b	(0.08)	-0.23 b	(0.08)
Declared a major											-0.04	(0.07)		
Attended 2 colleges											-0.36 a	(0.06)	-0.37 a	(0.06)
Attended 3+ colleges											-0.57 a	(0.08)	-0.57 a	(0.08)
Worked full-time														
Child														
INTERACTIONS														
Remed. X Attend 3														
INSTITUTION-LEVEL														
Private college														
College enr. (1,000s)														
% Black students (sqrt)														
% Hispanic students (sqrt)														
% students w/ federal aid														
% full-time faculty														
VARIANCE COMPONENTS														
Tau_{00}	1.15 a		0.98 a		0.76 a		0.63 a		0.63 a		0.50 a		0.51 a	
Tau_{11}														
Tau_{01} as Corr.														
Tau_{00} Reliability	0.72		0.68		0.61		0.54		0.55		0.46		0.47	
Tau_{11} Reliability														
Deviance	20,571		20,516		20,292		20,055		20,057		19,861		19,863	
(# parameters)	(2)		(3)		(11)		(15)		(13)		(20)		(18)	

[a] p<.001; [b] p<.01; [c] p<.05

Table D5. Four-year colleges: Relationship between Any Remediation and Attaining a Bachelor's Degree or Higher

	Environmental Factors Block		*Environmental Factors - Significant*		*Student-Level with Interaction*		*Student-Level Final with Random Slope*		*All Institutional*		*Institutional - Significant*		*Student- and Insitution-Level Final*	
	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)
STUDENT-LEVEL														
Intercept	0.03	(0.23)	0.02	(0.23)	0.04	(0.23)	0.07	(0.24)	-0.21	(0.25)	-0.18	(0.24)	-0.27	(0.24)
Any remediation	-0.32 a	(0.07)	-0.32 a	(0.07)	-0.41 a	(0.08)	-0.42 a	(0.10)	-0.29 b	(0.10)	-0.29 b	(0.10)	-0.31 b	(0.10)
Asian	0.08	(0.16)	0.08	(0.16)	0.08	(0.16)	0.10	(0.16)	0.08	(0.15)	0.11	(0.15)		
Black	-0.23	(0.12)	-0.22	(0.12)	-0.22	(0.12)	-0.24	(0.12)	-0.15	(0.14)	-0.11	(0.13)		
Hispanic	-0.36 b	(0.12)	-0.36 b	(0.12)	-0.35 b	(0.12)	-0.36 b	(0.12)	-0.23	(0.14)	-0.19	(0.12)		
Other race	-0.04	(0.15)	-0.03	(0.15)	-0.03	(0.15)	-0.01	(0.15)	0.01	(0.15)	0.02	(0.15)		
Male	-0.52 a	(0.06)	-0.52 a	(0.06)	-0.53 a	(0.06)	-0.54 a	(0.07)	-0.53 a	(0.07)	-0.53 a	(0.07)	-0.53 a	(0.07)
Age	-0.02	(0.04)												
Income	0.00 a	(0.00)	0.00 a	(0.00)	0.00 a	(0.00)	0.00 a	(0.00)	0.00 b	(0.00)	0.00 b	(0.00)	0.00 a	(0.00)
Parent education	0.17 c	(0.08)	0.17 c	(0.08)	0.17 c	(0.08)	0.17 c	(0.08)	0.15	(0.08)	0.16 c	(0.08)	0.18 c	(0.08)
Private HS														
Algebra II	0.51 b	(0.15)	0.52 b	(0.15)	0.52 b	(0.15)	0.50 b	(0.15)	0.49 b	(0.16)	0.50 b	(0.15)	0.51 b	(0.15)
HS curriculum														
HS GPA	0.48 a	(0.04)	0.48 a	(0.04)	0.48 a	(0.04)	0.49 a	(0.04)	0.46 a	(0.04)	0.46 a	(0.04)	0.47 a	(0.04)
Academic integration														
Social integration index	0.00 a	(0.00)	0.00 a	(0.00)	0.00 a	(0.00)	0.00 a	(0.00)	0.00 a	(0.00)	0.00 a	(0.00)	0.00 a	(0.00)
Full-time enrollment	1.02 a	(0.16)	1.03 a	(0.16)	1.04 a	(0.16)	1.07 a	(0.16)	1.04 a	(0.17)	1.03 a	(0.16)	1.02 a	(0.16)
Pell grant	-0.18 c	(0.08)	-0.19 c	(0.08)	-0.18 c	(0.08)	-0.19 c	(0.08)	-0.16	(0.08)	-0.16	(0.08)		
Declared a major														
Attended 2 colleges	-0.36 a	(0.06)	-0.36 a	(0.06)	-0.37 a	(0.06)	-0.37 a†	(0.06)	-0.38 a†	(0.06)	-0.38 a	(0.06)	-0.37 a†	(0.06)
Attended 3+ colleges	-0.56 a	(0.09)	-0.56 a	(0.09)	-0.70 a	(0.10)	-0.72 a	(0.10)	-0.71 a	(0.10)	-0.71 a	(0.10)	-0.71 a	(0.10)
Worked full-time	-0.69 a	(0.15)	-0.69 a	(0.15)	-0.69 a	(0.15)	-0.71 a	(0.16)	-0.67 a	(0.16)	-0.67 a	(0.16)	-0.67 a	(0.15)
Child	-1.33 a	(0.11)	-1.34 a	(0.10)	-1.35 a	(0.10)	-1.36 a	(0.10)	-1.33 a	(0.11)	-1.33 a	(0.11)	-1.36 a	(0.10)
INTERACTIONS														
Remed. X Attend 3					0.58 b	(0.19)	0.60 b	(0.19)	0.58 b	(0.20)	0.58 b	(0.19)	0.59 b	(0.19)
INSTITUTION-LEVEL														
Private college									0.52 a	(0.11)	0.46 a	(0.09)	0.46 a	(0.09)
College enr. (1,000s)									0.00	(0.01)				
% Black students (sqrt)									0.02	(0.03)				
% Hispanic students (sqrt)									0.02	(0.03)				
% students w/ federal aid									-0.02 a	(0.00)	-0.02 a	(0.00)	-0.02 a	(0.00)
% full-time faculty									0.00	(0.00)				
VARIANCE COMPONENTS														
Tau_{00}	0.43 a		0.43 a		0.44 a		0.64 a		0.59 a		0.61 a		0.60 a	
Tau_{11}							0.88 a		0.94 a		0.94 a		0.93 a	
Tau_{01} as Corr.							-0.67		-0.73		-0.74		-0.74	
Tau_{00} Reliability	0.41		0.41		0.41		0.41		0.36		0.37		0.37	
Tau_{11} Reliability							0.22		0.22		0.22		0.22	
Deviance	19,666		19,666		19,656		19,622		19,536		19,538		19,547	
(# parameters)	(20)		(19)		(20)		(22)		(28)		(24)		(19)	

[a] p<.001; [b] p<.01; [c] p<.05; † Slope allowed to vary randomly

Table D6. Two-year colleges: Relationship between Number of Remedial Courses and Attaining an Associate's Degree or Higher

	Unconditional		*Remediation-Only*		*Demographic Block*		*Academic Preparation Block*		*Academic - Significant*		*Postsecondary Experiences Block*		*Postsecondary - Significant*		*Environmental Factors Block*		*Student-Level Final with Interaction*		*All Institutional*		*Student- and Insitution-Level Final*	
	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)
STUDENT-LEVEL																						
Intercept	-0.65 a	(0.05)	-0.43 a	(0.07)	-0.43 a	(0.09)	-0.84 a	(0.13)	-0.88 a	(0.13)	-2.54 a	(0.21)	-2.29 a	(0.16)	-1.98 a	(0.17)	-2.07 a	(0.17)	-2.09 a	(0.18)	-2.09 a	(0.17)
1-2 Remedial Courses			-0.27 a	(0.07)	-0.22 b	(0.07)	-0.14	(0.08)	-0.14	(0.08)	0.01	(0.09)	-0.01	(0.08)	-0.01	(0.08)	0.25	(0.15)	0.28	(0.15)	0.27	(0.15)
3+ Remedial Courses			-0.45 a	(0.08)	-0.33 a	(0.09)	-0.18 c	(0.09)	-0.17	(0.09)	0.10	(0.10)	0.04	(0.09)	0.04	(0.10)	0.04	(0.10)	0.05	(0.10)	0.05	(0.10)
Asian					0.42 c	(0.19)	0.42 c	(0.19)	0.40 c	(0.19)	0.36	(0.19)	0.31	(0.18)	0.24	(0.19)	0.22	(0.19)	0.33	(0.21)	0.32	(0.20)
Black					-0.55 a	(0.13)	-0.51 a	(0.13)	-0.53 a	(0.13)	-0.69 a	(0.15)	-0.77 a	(0.14)	-0.64 a	(0.15)	-0.65 a	(0.15)	-0.53 b	(0.16)	-0.53 b	(0.16)
Hispanic					-0.05	(0.12)	-0.06	(0.12)	-0.06	(0.12)	0.00	(0.12)	-0.06	(0.12)	0.00	(0.12)	0.00	(0.12)	0.08	(0.14)	0.04	(0.13)
Other race					-0.36 c	(0.16)	-0.37 c	(0.17)	-0.37 c	(0.17)	-0.45 c	(0.18)	-0.50 b	(0.17)	-0.46 b	(0.17)	-0.46 b	(0.17)	-0.48 b	(0.18)	-0.49 b	(0.18)
Male					-0.19 c	(0.08)	-0.13	(0.08)														
Age					-0.14 a	(0.03)	-0.12 b	(0.03)	-0.12 b	(0.03)	-0.04	(0.04)										
Income					0.00 c	(0.00)	0.00 c	(0.00)	0.00 c	(0.00)	0.00	(0.00)										
Parent education					0.21 b	(0.07)	0.18 c	(0.07)	0.18 c	(0.07)	0.09	(0.09)										
Private HS							0.31	(0.16)														
Algebra II							0.35 b	(0.12)	0.39 a	(0.11)	0.23	(0.12)										
HS curriculum							0.04	(0.09)														
HS GPA							0.22 a	(0.04)	0.23 a	(0.03)	0.19 a	(0.04)	0.20 a	(0.04)	0.21 a	(0.04)	0.21 a	(0.04)	0.20 a	(0.04)	0.20 a	(0.04)
Academic integration											0.00 c	(0.00)	0.00 b	(0.00)	0.00 c	(0.00)	0.00 c	(0.00)	0.00 c	(0.00)	0.00 c	(0.00)
Social integration index											0.00	(0.00)										
Full-time enrollment											0.83 a	(0.12)	0.83 a	(0.11)	0.75 a	(0.12)	0.75 a	(0.12)	0.70 a	(0.12)	0.71 a	(0.12)
Pell grant											-0.03	(0.10)										
Declared a major											0.36 a	(0.10)	0.35 a	(0.09)	0.39 a	(0.10)	0.52 a	(0.12)	0.53 a	(0.12)	0.54 a	(0.11)
Attended 2 colleges											1.32 a	(0.10)	1.35 a	(0.09)	1.27 a	(0.09)	1.27 a	(0.09)	1.29 a	(0.09)	1.29 a	(0.09)
Attended 3+ colleges											1.77 a	(0.12)	1.82 a	(0.11)	1.70 a	(0.11)	1.69 a	(0.11)	1.69 a	(0.11)	1.69 a	(0.11)
Worked full-time															-0.32 b	(0.11)	-0.32 b	(0.12)	-0.30 c	(0.12)	-0.31 b	(0.12)
Child															-0.69 a	(0.10)	-0.69 a	(0.10)	-0.71 a	(0.11)	-0.71 a	(0.10)
INTERACTIONS																						
Rem. X Major																	-0.37 c	(0.19)	-0.40 c	(0.19)	-0.40 c	(0.19)
INSTITUTION-LEVEL																						
Private college																			0.51 c	(0.21)	0.54 b	(0.19)
College enr. (1,000s)																			0.00 c	(0.00)	-0.02 b	(0.01)
% Black students (sqrt)																			-0.09 c	(0.04)	-0.08 c	(0.03)
% Hispanic students (sqrt)																			-0.04	(0.04)		
% students w/ federal aid																			0.00	(0.00)		
% full-time faculty																			0.00	(0.00)		
VARIANCE COMPONENTS																						
Tau_{00}	0.31 a		0.29 a		0.25 a		0.27 a		0.27 a		0.30 a		0.28 a		0.30 a		0.31 a		0.24 a		0.25 a	
Tau_{11}																						
Tau_{01} as Corr.																						
Tau_{00} Reliability	0.42		0.41		0.38		0.39		0.39		0.38		0.37		0.37		0.37		0.28		0.29	
Tau_{11} Reliability																						
Deviance	10,922		10,900		10,818		10,747		10,755		10,317		10,334		10,271		10,267		10,235		10,236	
(# parameters)	(2)		(4)		(12)		(16)		(13)		(20)		(14)		(16)		(17)		(23)		(20)	

[a] p<.001; [b] p<.01; [c] p<.05

Table D7. Two-year colleges: Relationship between Number of Remedial Courses and Attaining a Certificate

	Unconditional		*Remediation-Only*		*Demographic Block*		*Demographic - Significant*		*Academic Preparation Block*		*Academic - Significant*		*Postsecondary Experiences Block*	
	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)
STUDENT-LEVEL														
Intercept	-3.44 a	(0.18)	-3.19 a	(0.20)	-2.97 a	(0.23)	-3.19 a	(0.20)	-2.94 a	(0.23)	-3.19 a	(0.20)	-3.33 a	(0.30)
1-2 Remedial Courses			-0.18	(0.17)	-0.20	(0.19)	-0.18	(0.17)	-0.20	(0.18)	-0.18	(0.17)	-0.16	(0.18)
3+ Remedial Courses			-0.61 b	(0.23)	-0.67 c	(0.27)	-0.61 b	(0.23)	-0.65 b	(0.24)	-0.61 b	(0.23)	-0.54 c	(0.23)
Asian					-0.14	(0.44)								
Black					0.27	(0.25)								
Hispanic					0.04	(0.30)								
Other race					-0.71	(0.58)								
Male					-0.32	(0.20)								
Age					0.05	(0.07)								
Income					0.00	(0.00)								
Parent education					-0.17	(0.17)								
Private HS									-0.12	(0.41)				
Algebra II									-0.33	(0.22)				
HS curriculum									0.05	(0.22)				
HS GPA									0.00	(0.09)				
Academic integration													0.00	(0.00)
Social integration index													0.00	(0.00)
Full-time enrollment													-0.24	(0.19)
Pell grant													0.06	(0.19)
Declared a major													-0.06	(0.19)
Attended 2 colleges													0.47 c	(0.20)
Attended 3+ colleges													0.49	(0.28)
Worked full-time														
Child														
INTERACTIONS														
1-2 Rem. X Attend 2														
INSTITUTION-LEVEL														
Private college														
College enr. (1,000s)														
% Black students (sqrt)														
% Hispanic students (sqrt)														
% students w/ federal aid														
% full-time faculty														
VARIANCE COMPONENTS														
Tau_{00}	1.24 a		1.16 a		1.16 a		1.16 a		1.15 a		1.16 a		1.24 a	
Tau_{11}														
Tau_{01} as Corr.														
Tau_{00} Reliability	0.39		0.37		0.37		0.37		0.36		0.37		0.38	
Tau_{11} Reliability														
Deviance	7,815		7,808		7,797		7,808		7,805		7,808		7,796	
(# parameters)	(2)		(4)		(12)		(4)		(8)		(4)		(11)	

[a] p<.001; [b] p<.01; [c] p<.05

Table D7. Two-year colleges: Relationship between Number of Remedial Courses and Attaining a Certificate												
	Postsecondary - Significant		*Environmental Factors Block*		*Environmental - Significant*		*Student-Level Final with Interaction*		*All Institutional*		*Student- and Insitution-Level Final*	
	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)
STUDENT-LEVEL												
Intercept	-3.47 a	(0.24)	-3.56 a	(0.25)	-3.47 a	(0.24)	-3.34 a	(0.24)	-3.25 a	(0.24)	-3.27 a	(0.23)
1-2 Remedial Courses	-0.15	(0.17)	-0.16	(0.17)	-0.15	(0.17)	-0.51 c	(0.24)	-0.52 c	(0.25)	-0.51 c	(0.24)
3+ Remedial Courses	-0.54 c	(0.23)	-0.55 c	(0.23)	-0.54 c	(0.23)	-0.55 c	(0.23)	-0.52 c	(0.24)	-0.54 c	(0.23)
Asian												
Black												
Hispanic												
Other race												
Male												
Age												
Income												
Parent education												
Private HS												
Algebra II												
HS curriculum												
HS GPA												
Academic integration												
Social integration index												
Full-time enrollment												
Pell grant												
Declared a major												
Attended 2 colleges	0.40 c	(0.19)	0.43 c	(0.20)	0.40 c	(0.19)	0.09	(0.21)	0.08	(0.22)	0.09	(0.22)
Attended 3+ colleges	0.41	(0.26)	0.46	(0.26)	0.41	(0.26)	0.41	(0.26)	0.39	(0.26)	0.40	(0.26)
Worked full-time			-0.08	(0.20)								
Child			0.30	(0.18)								
INTERACTIONS												
1-2 Rem. X Attend 2							0.85 c	(0.35)	0.86 c	(0.37)	0.85 c	(0.36)
INSTITUTION-LEVEL												
Private college									-0.49	(0.56)		
College enr. (1,000s)									-0.05 c	(0.02)	-0.04 c	(0.02)
% Black students (sqrt)									0.03	(0.06)		
% Hispanic students (sqrt)									-0.07	(0.10)		
% students w/ federal aid									0.00	(0.01)		
% full-time faculty									-0.01	(0.01)		
VARIANCE COMPONENTS												
Tau_{00}	1.22 a		1.20 a		1.22 a		1.22 a		1.03 a		1.06 a	
Tau_{11}												
Tau_{01} as Corr.												
Tau_{00} Reliability	0.39		0.38		0.39		0.38		0.35		0.36	
Tau_{11} Reliability												
Deviance	7,803		7,800		7,803		7,797		7,783		7,788	
(# parameters)	(6)		(8)		(6)		(7)		(13)		(8)	

[a] p<.001; [b] p<.01; [c] p<.05

Table D8. Two-year colleges: Relationship between Number of Remedial Courses and Attaining an Associate's Degree

	Unconditional		*Remediation-Only*		*Demographic Block*		*Demographic - Significant*		*Academic Preparation Block*		*Academic - Significant*		*Postsecondary Experiences Block*		*Postsecondary - Significant*	
	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)
STUDENT-LEVEL																
Intercept	-1.63 a	(0.07)	-1.76 a	(0.09)	-1.62 a	(0.12)	-1.71 a	(0.11)	-1.79 a	(0.16)	-1.66 a	(0.13)	-2.51 a	(0.21)	-2.58 a	(0.19)
1-2 Remedial Courses			0.09	(0.10)	0.11	(0.10)	0.11	(0.10)	0.15	(0.11)	0.14	(0.10)	0.14	(0.11)	0.16	(0.11)
3+ Remedial Courses			0.32 b	(0.11)	0.36 b	(0.11)	0.37 b	(0.11)	0.42 b	(0.12)	0.41 b	(0.12)	0.39 b	(0.12)	0.43 b	(0.12)
Asian					0.25	(0.22)	0.27	(0.22)	0.28	(0.22)	0.28	(0.22)	0.27	(0.23)	0.27	(0.22)
Black					-0.45 b	(0.16)	-0.42 b	(0.15)	-0.40 c	(0.16)	-0.40 c	(0.16)	-0.51 b	(0.17)	-0.51 b	(0.15)
Hispanic					-0.02	(0.14)	0.02	(0.13)	0.03	(0.14)	0.03	(0.14)	0.01	(0.14)	0.00	(0.13)
Other race					-0.52 b	(0.19)	-0.51 b	(0.18)	-0.52 b	(0.19)	-0.52 b	(0.18)	-0.60 b	(0.19)	-0.59 b	(0.19)
Male					-0.01	(0.10)										
Age					-0.05	(0.04)										
Income					0.00	(0.00)										
Parent education					-0.16	(0.09)										
Private HS									0.11	(0.20)						
Algebra II									0.19	(0.13)						
HS curriculum									-0.26 c	(0.11)	-0.18	(0.10)	-0.20	(0.11)		
HS GPA									0.15 b	(0.05)	0.15 b	(0.05)	0.14 b	(0.05)	0.12 b	(0.05)
Academic integration													0.00	(0.00)		
Social integration index													0.00	(0.00)		
Full-time enrollment													0.53 a	(0.13)	0.52 a	(0.13)
Pell grant													0.20 c	(0.10)	0.21 c	(0.09)
Declared a major													0.48 a	(0.11)	0.47 a	(0.11)
Attended 2 colleges													0.05	(0.11)		
Attended 3+ colleges													0.06	(0.14)		
Worked full-time																
Child																
INTERACTIONS																
Rem2 X Major																
INSTITUTION-LEVEL																
Intercept Predictors																
Private college																
College enr. (1,000s)																
% Black students (sqrt)																
% Hispanic students (sqrt)																
% students w/ federal aid																
% full-time faculty																
1-2 REM. Slope Predictors																
Private college																
College enr. (1,000s)																
% Black students (sqrt)																
% Hispanic students (sqrt)																
% students w/ federal aid																
% full-time faculty																
VARIANCE COMPONENTS																
Tau_{00}	0.36 a		0.37 a		0.38 a		0.37 a		0.42 a		0.41 a		0.42 a		0.43 a	
Tau_{11}																
Tau_{01} as Corr.																
Tau_{00} Reliability	0.44		0.43		0.43		0.43		0.44		0.43		0.43		0.43	
Tau_{11} Reliability																
Deviance	9,743		9,736		9,715		9,721		9,704		9,707		9,651		9,661	
(# parameters)	(2)		(4)		(12)		(8)		(12)		(10)		(17)		(12)	

[a] p<.001; [b] p<.01; [c] p<.05

Table D8. Two-year colleges: Relationship between Number of Remedial Courses and Attaining an Associate's Degree

	Environmental Factors Block		*Environmental - Significant*		*Student-Level with Interaction*		*Student-Level Final with Random Slope*		*All Institutional Predictors for Intercept*		*Insitutional Predictors for Intercept - Significant*		*All Institutional Predictors for Random Slope*		*Student- and Insitution-Level Final*	
	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)
STUDENT-LEVEL																
Intercept	-2.51 a	(0.19)	-2.58 a	(0.19)	-2.74 a	(0.20)	-2.79 a	(0.21)	-2.76 a	(0.21)	-2.82 a	(0.21)	-2.83 a	(0.21)	-2.82 a	(0.21)
1-2 Remedial Courses	0.16	(0.11)	0.16	(0.11)	0.58 b	(0.19)	0.63 b†	(0.21)	0.61 b†	(0.21)	0.61 b†	(0.21)	0.67 b†	(0.23)	0.61 b†	(0.21)
3+ Remedial Courses	0.43 b	(0.12)	0.43 b	(0.12)	0.43 b	(0.12)	0.43 b	(0.13)	0.45 b	(0.13)	0.44 b	(0.13)	0.45 b	(0.13)	0.44 b	(0.13)
Asian	0.24	(0.22)	0.27	(0.22)	0.24	(0.23)	0.26	(0.23)	0.36	(0.24)	0.28	(0.23)	0.30	(0.24)	0.28	(0.23)
Black	-0.48 b	(0.15)	-0.51 b	(0.15)	-0.53 b	(0.15)	-0.52 b	(0.15)	-0.39 c	(0.17)	-0.39 c	(0.17)	-0.38 c	(0.18)	-0.39 c	(0.17)
Hispanic	0.01	(0.14)	0.00	(0.13)	0.00	(0.14)	0.00	(0.14)	0.08	(0.16)	0.00	(0.14)	0.01	(0.14)	0.00	(0.14)
Other race	-0.59 b	(0.19)	-0.59 b	(0.19)	-0.59 b	(0.19)	-0.58 b	(0.20)	-0.60 b	(0.20)	-0.59 c	(0.20)	-0.58 b	(0.20)	-0.59 c	(0.20)
Male																
Age																
Income																
Parent education																
Private HS																
Algebra II																
HS curriculum																
HS GPA	0.12 b	(0.05)	0.12 b	(0.05)	0.12 c	(0.05)	0.12 c	(0.05)	0.12 c	(0.05)	0.12 c	(0.05)	0.12 c	(0.05)	0.12 c	(0.05)
Academic integration																
Social integration index																
Full-time enrollment	0.48 b	(0.13)	0.52 a	(0.13)	0.51 a	(0.13)	0.51 a	(0.13)	0.46 b	(0.13)	0.51 a	(0.13)	0.50 a	(0.13)	0.51 a	(0.13)
Pell grant	0.24 c	(0.10)	0.21 c	(0.09)	0.21 c	(0.09)	0.22 c	(0.10)	0.19	(0.10)	0.22 c	(0.10)	0.22 c	(0.10)	0.22 c	(0.10)
Declared a major	0.48 a	(0.11)	0.47 a	(0.11)	0.69 a	(0.14)	0.70 a	(0.15)	0.70 a	(0.14)	0.72 a	(0.15)	0.73 a	(0.15)	0.72 a	(0.15)
Attended 2 colleges																
Attended 3+ colleges																
Worked full-time	-0.09	(0.12)														
Child	-0.22	(0.11)														
INTERACTIONS																
Rem2 X Major					-0.58 b	(0.21)	-0.59 b	(0.22)	-0.61 b	(0.22)	-0.60 b	(0.22)	-0.62 b	(0.23)	-0.60 b	(0.22)
INSTITUTION-LEVEL																
Intercept Predictors																
Private college									0.43	(0.28)						
College enr. (1,000s)									0.00	(0.00)						
% Black students (sqrt)									-0.11 c	(0.04)	-0.11 c	(0.04)	-0.12 c	(0.05)	-0.11 c	(0.04)
% Hispanic students (sqrt)									-0.04	(0.05)						
% students w/ federal aid									0.01	(0.00)						
% full-time faculty									0.00	(0.00)						
1-2 REM. Slope Predictors																
Private college													0.11	(0.41)		
College enr. (1,000s)													-0.01	(0.02)		
% Black students (sqrt)													0.05	(0.07)		
% Hispanic students (sqrt)													-0.01	(0.06)		
% students w/ federal aid													0.00	(0.01)		
% full-time faculty													0.00	(0.00)		
VARIANCE COMPONENTS																
Tau_{00}	0.45 a		0.43 a		0.44 a		0.58 a		0.47 a		0.57 a		0.57 a		0.57 a	
Tau_{11}							0.90 c		0.83 c		0.88 c		0.81 c		0.88 c	
Tau_{01} as Corr.							-0.53		-0.43		-0.48		-0.59		-0.48	
Tau_{00} Reliability	0.43		0.43		0.43		0.38		0.31		0.37		0.37		0.37	
Tau_{11} Reliability							0.13		0.13		0.13		0.14		0.13	
Deviance	9,656		9,661		9,654		9,648		9,622		9,641		9,637		9,641	
(# parameters)	(14)		(12)		(13)		(15)		(21)		(16)		(22)		(16)	

[a] p<.001; [b] p<.01; [c] p<.05; † Slope allowed to vary randomly

Table D9. Two-year colleges: Relationship between Number of Remedial Courses and Attaining a Bachelor's Degree or Higher

	Unconditional		*Remediation-Only*		*Demographic Block*		*Academic Preparation Block*		*Academic - Significant*		*Postsecondary Experiences Block*		*Postsecondary - Significant*		*Environmental Factors Block*		*Student-Level Final*		*All Institutional Predictors*		*Student- and Insitution-Level Final*	
	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)
STUDENT-LEVEL																						
Intercept	-1.76 a	(0.07)	-1.30 a	(0.08)	-1.51 a	(0.12)	-2.28 a	(0.19)	-2.27 a	(0.19)	-7.91 a	(0.86)	-7.68 a	(0.82)	-7.22 a	(0.82)	-7.29 a	(0.81)	-7.28 a	(0.84)	-7.29 a	(0.81)
1-2 Remedial Courses			-0.48 a	(0.10)	-0.42 a	(0.10)	-0.32 b	(0.11)	-0.31 b	(0.11)	-0.05	(0.12)	-0.07	(0.12)	-0.07	(0.13)	-0.07	(0.13)	-0.08	(0.13)	-0.07	(0.13)
3+ Remedial Courses			-1.17 a	(0.13)	-1.03 a	(0.14)	-0.82 a	(0.15)	-0.81 a	(0.15)	-0.37 c	(0.17)	-0.41 c	(0.17)	-0.39 c	(0.17)	-0.40 c	(0.17)	-0.40 c	(0.17)	-0.40 c	(0.17)
Asian					0.36	(0.25)	0.37	(0.25)	0.35	(0.25)	0.15	(0.26)	0.09	(0.25)	-0.01	(0.28)	-0.05	(0.28)	0.00	(0.30)	-0.05	(0.28)
Black					-0.50 b	(0.18)	-0.46 c	(0.18)	-0.48 b	(0.18)	-0.64 b	(0.21)	-0.67 b	(0.19)	-0.49 c	(0.21)	-0.57 b	(0.20)	-0.52 c	(0.23)	-0.57 b	(0.20)
Hispanic					-0.08	(0.20)	-0.11	(0.20)	-0.11	(0.20)	0.03	(0.20)	-0.01	(0.20)	0.04	(0.20)	-0.02	(0.19)	-0.02	(0.22)	-0.02	(0.19)
Other race					-0.08	(0.24)	-0.10	(0.25)	-0.11	(0.25)	-0.09	(0.31)	-0.13	(0.29)	-0.06	(0.30)	-0.10	(0.30)	-0.10	(0.30)	-0.10	(0.30)
Male					-0.31 b	(0.10)	-0.23 c	(0.10)	-0.23 c	(0.10)	-0.13	(0.12)										
Age					-0.21 a	(0.05)	-0.18 b	(0.05)	-0.18 b	(0.05)	-0.02	(0.06)										
Income					0.00 b	(0.00)	0.00 b	(0.00)	0.00 b	(0.00)	0.00	(0.00)										
Parent education					0.56 a	(0.11)	0.52 a	(0.11)	0.53 a	(0.11)	0.43 b	(0.13)	0.45 b	(0.13)	0.42 b	(0.13)	0.46 b	(0.13)	0.46 b	(0.13)	0.46 b	(0.13)
Private HS							0.34	(0.19)														
Algebra II							0.54 b	(0.20)	0.55 b	(0.20)	0.41	(0.21)										
HS curriculum							0.35 b	(0.12)	0.35 b	(0.12)	0.32 c	(0.14)	0.48 a	(0.12)	0.46 a	(0.12)	0.47 a	(0.12)	0.47 a	(0.12)	0.47 a	(0.12)
HS GPA							0.21 a	(0.05)	0.21 a	(0.05)	0.14 b	(0.05)	0.16 b	(0.05)	0.16 b	(0.05)	0.16 b	(0.05)	0.16 b	(0.05)	0.16 b	(0.05)
Academic integration											0.00 c	(0.00)	0.00 b	(0.00)	0.00 b	(0.00)	0.00 b	(0.00)	0.00 b	(0.00)	0.00 b	(0.00)
Social integration index											0.00	(0.00)										
Full-time enrollment											1.02 a	(0.18)	1.04 a	(0.17)	0.90 a	(0.18)	0.88 a	(0.17)	0.87 a	(0.18)	0.88 a	(0.17)
Pell grant											-0.31 c	(0.14)	-0.40 b	(0.13)	-0.23	(0.14)						
Declared a major											0.00	(0.14)										
Attended 2 colleges											5.66 a	(0.78)	5.69 a	(0.77)	5.56 a	(0.77)	5.55 a	(0.76)	5.56 a	(0.79)	5.55 a	(0.76)
Attended 3+ colleges											6.08 a	(0.79)	6.14 a	(0.77)	5.95 a	(0.77)	5.93 a	(0.77)	5.93 a	(0.79)	5.93 a	(0.77)
Worked full-time															-0.47 b	(0.17)	-0.48 b	(0.17)	-0.47 b	(0.18)	-0.48 b	(0.17)
Child															-1.30 a	(0.21)	-1.34 a	(0.20)	-1.35 a	(0.21)	-1.34 a	(0.20)
INSTITUTION-LEVEL																						
Private college																			0.00	(0.29)		
College enr. (1,000s)																			-0.01	(0.01)		
% Black students (sqrt)																			-0.02	(0.05)		
% Hispanic students (sqrt)																			0.02	(0.05)		
% students w/ federal aid																			0.00	(0.00)		
% full-time faculty																			0.00	(0.00)		
VARIANCE COMPONENTS																						
Tau_{00}	0.50	(0.00)	0.42	(0.00)	0.36 a		0.33 a		0.32 a		0.18 c		0.23 b		0.19 c		0.18	(0.04)	0.17	(0.04)	0.18	(0.04)
Tau_{11}																						
Tau_{01} as Corr.																						
Tau_{00} Reliability	0.41		0.38		0.35		0.33		0.33		0.13		0.14		0.11		0.10		0.09		0.10	
Tau_{11} Reliability																						
Deviance	9,499		9,422		9,316		9,242		9,246		8,500		8,513		8,440		8,443		8,441		8,443	
(# parameters)	(2)		(4)		(12)		(16)		(15)		(22)		(16)		(18)		(17)		(23)		(17)	

[a] p<.001; [b] p<.01; [c] p<.05

Table D10. Four-year colleges: Relationship between Number of Remedial Courses and Attaining a Bachelor's Degree or Higher

	Unconditional		*Remediation-Only*		*Demographic Block*		*Academic Preparation Block*		*Academic - Significant*		*Postsecondary Experiences Block*		*Postsecondary - Significant*		*Environmental Factors Block*		*Student-Level Final with Random Slope*		*All Institutional Predictors*		*Institutional Predictors - Significant*		*Student- and Insitution-Level Final*	
	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)
STUDENT-LEVEL																								
Intercept	0.73 a	(0.06)	0.89 a	(0.06)	0.97 a	(0.08)	0.33 c	(0.16)	0.34 c	(0.16)	-0.18	(0.23)	-0.25	(0.22)	0.04	(0.23)	0.07	(0.24)	-0.22	(0.25)	-0.19	(0.24)	-0.28	(0.24)
1-2 Remedial Courses			-0.49 a	(0.07)	-0.42 a	(0.08)	-0.26 b	(0.08)	-0.26 b	(0.08)	-0.30 a	(0.08)	-0.30 a	(0.08)	-0.27 b	(0.08)	-0.28 b	(0.10)	-0.17	(0.10)	-0.17	(0.10)	-0.18	(0.10)
3+ Remedial Courses			-0.99 a	(0.14)	-0.80 a	(0.15)	-0.53 b	(0.16)	-0.54 b	(0.16)	-0.62 a	(0.16)	-0.62 a	(0.15)	-0.59 a	(0.16)	-0.59 b	(0.18)	-0.38 c	(0.17)	-0.37 c	(0.17)	-0.41 c	(0.17)
Asian					0.10	(0.15)	0.07	(0.16)	0.06	(0.16)	0.14	(0.16)	0.14	(0.16)	0.08	(0.16)	0.09	(0.16)	0.08	(0.15)	0.10	(0.15)		
Black					-0.47 a	(0.12)	-0.29 c	(0.13)	-0.29 c	(0.12)	-0.30 c	(0.12)	-0.29 c	(0.12)	-0.21	(0.12)	-0.22	(0.12)	-0.14	(0.14)	-0.11	(0.13)		
Hispanic					-0.50 a	(0.12)	-0.44 b	(0.12)	-0.44 a	(0.12)	-0.41 b	(0.12)	-0.40 b	(0.12)	-0.34 b	(0.12)	-0.35 b	(0.12)	-0.23	(0.14)	-0.19	(0.13)		
Other race					-0.10	(0.14)	-0.10	(0.14)	-0.09	(0.14)	-0.05	(0.15)	-0.04	(0.15)	-0.03	(0.15)	-0.01	(0.15)	0.00	(0.15)	0.02	(0.15)		
Male					-0.49 a	(0.06)	-0.39 a	(0.06)	-0.39 a	(0.06)	-0.44 a	(0.07)	-0.46 a	(0.06)	-0.52 a	(0.07)	-0.54 a	(0.07)	-0.53 a	(0.07)	-0.53 a	(0.07)	-0.52 a	(0.07)
Age					-0.11 b	(0.04)	-0.10 c	(0.04)	-0.10 c	(0.04)	-0.08	(0.04)												
Income					0.00 a	(0.00)	0.00 a	(0.00)	0.00 a	(0.00)	0.00 a	(0.00)	0.00 a	(0.00)	0.00 a	(0.00)	0.00 a	(0.00)	0.00 b	(0.00)	0.00 b	(0.00)	0.00 a	(0.00)
Parent education					0.31 a	(0.07)	0.26 b	(0.07)	0.27 a	(0.07)	0.22 b	(0.07)	0.22 b	(0.07)	0.17 c	(0.08)	0.17 c	(0.08)	0.15	(0.08)	0.16 c	(0.08)	0.18 b	(0.08)
Private HS							0.02	(0.09)																
Algebra II							0.53 b	(0.15)	0.60 a	(0.14)	0.51 b	(0.14)	0.52 b	(0.14)	0.50 b	(0.15)	0.49 b	(0.15)	0.48 b	(0.16)	0.49 b	(0.15)	0.50 b	(0.15)
HS curriculum							0.10	(0.08)																
HS GPA							0.50 a	(0.03)	0.50 a	(0.03)	0.48 a	(0.04)	0.48 a	(0.03)	0.47 a	(0.04)	0.48 a	(0.04)	0.45 a	(0.04)	0.46 a	(0.04)	0.46 a	(0.04)
Academic integration											0.00	(0.00)												
Social integration index											0.00 a	(0.00)	0.01 a	(0.00)	0.00 a	(0.00)	0.01 a	(0.00)	0.00 a	(0.00)	0.00 a	(0.00)	0.00 a	(0.00)
Full-time enrollment											1.08 a	(0.16)	1.11 a	(0.15)	1.02 a	(0.16)	1.05 a	(0.16)	1.03 a	(0.17)	1.02 a	(0.16)	1.00 a	(0.16)
Pell grant											-0.23 b	(0.08)	-0.24 b	(0.08)	-0.18 c	(0.08)	-0.20 c	(0.08)	-0.16	(0.08)	-0.16	(0.08)		
Declared a major											-0.05	(0.07)												
Attended 2 colleges											-0.37 a	(0.06)	-0.37 a	(0.06)	-0.36 a	(0.06)	-0.37 a†	(0.06)	-0.37 a†	(0.06)	-0.37 a†	(0.06)	-0.37 a†	(0.06)
Attended 3+ colleges											-0.58 a	(0.08)	-0.58 a	(0.08)	-0.57 a	(0.09)	-0.57 a	(0.09)	-0.57 a	(0.09)	-0.57 a	(0.09)	-0.57 a	(0.08)
Worked full-time															-0.70 a	(0.16)	-0.72 a	(0.16)	-0.68 a	(0.16)	-0.68 a	(0.16)	-0.68 a	(0.16)
Child															-1.33 a	(0.10)	-1.35 a	(0.11)	-1.32 a	(0.11)	-1.32 a	(0.11)	-1.35 a	(0.10)
INSTITUTION-LEVEL																								
Private college																			0.52 a	(0.11)	0.46 a	(0.09)	0.46 a	(0.09)
College enr. (1,000s)																			0.00	(0.01)				
% Black students (sqrt)																			0.02	(0.03)				
% Hispanic students (sqrt)																			0.02	(0.04)				
% students w/ federal aid																			-0.02 a	(0.00)	-0.02 a	(0.00)	-0.02 a	(0.00)
% full-time faculty																			0.00	(0.00)				
VARIANCE COMPONENTS																								
Tau_{00}	1.15 a		0.94 a		0.75 a		0.61 a		0.62 a		0.49 a		0.51 a		0.43 a		0.63 a		0.58 a		0.60 a		0.59 a	
Tau_{11}																	0.86 a		0.92 a		0.92 a		0.90 a	
Tau_{01} as Corr.																	-0.67				-0.74		-0.74	
Tau_{00} Reliability	0.72		0.67		0.61		0.54		0.54		0.45		0.47		0.41		0.40		0.36		0.37		0.36	
Tau_{11} Reliability																	0.22		0.22		0.22		0.21	
Deviance	20,571		20,503		20,285		20,051		20,053		19,856		19,862		19,661		19,628		19,543		19,545		19,554	
(# parameters)	(2)		(4)		(12)		(16)		(14)		(21)		(18)		(20)		(22)		(28)		(24)		(19)	

[a] p<.001; [b] p<.01; [c] p<.05; † Slope allowed to vary randomly

Table D11. Two-year colleges: Relationship between Remedial Subjects and Attaining an Associate's Degree or Higher														
	Unconditional		*Remediation-Only*		*Demographic Block*		*Academic Preparation Block*		*Academic - Significant*		*Postsecondary Experiences Block*		*Postsecondary - Significant*	
	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)
STUDENT-LEVEL														
Intercept	-0.65 a	(0.05)	-0.46 a	(0.07)	-0.47 a	(0.09)	-0.88 a	(0.14)	-0.92 a	(0.13)	-2.55 a	(0.22)	-2.30 a	(0.17)
Remedial Math			-0.20 b	(0.07)	-0.15 c	(0.07)	-0.08	(0.08)	-0.07	(0.08)	0.04	(0.08)	0.02	(0.08)
Remedial English			-0.23 c	(0.11)	-0.14	(0.12)	-0.08	(0.13)	-0.07	(0.13)	0.01	(0.13)	-0.02	(0.13)
Remedial Reading			-0.45 a	(0.11)	-0.39 b	(0.12)	-0.33 b	(0.12)	-0.32 b	(0.12)	-0.18	(0.13)	-0.20	(0.13)
ESL			0.97 b	(0.35)	1.06 b	(0.36)	1.14 b	(0.37)	1.12 b	(0.37)	1.27 b	(0.40)	1.17 b	(0.38)
Other Remedial			0.41 c	(0.17)	0.45 c	(0.18)	0.54 b	(0.19)	0.53 b	(0.18)	0.52 b	(0.19)	0.51 b	(0.19)
Asian					0.32	(0.20)	0.32	(0.20)	0.29	(0.20)	0.24	(0.20)	0.20	(0.19)
Black					-0.52 a	(0.13)	-0.50 a	(0.13)	-0.51 a	(0.13)	-0.68 a	(0.14)	-0.75 a	(0.14)
Hispanic					-0.06	(0.12)	-0.07	(0.12)	-0.07	(0.12)	-0.01	(0.12)	-0.07	(0.12)
Other race					-0.32	(0.17)	-0.33	(0.17)	-0.34 c	(0.17)	-0.42 c	(0.18)	-0.47 b	(0.18)
Male					-0.20 c	(0.08)	-0.13	(0.08)						
Age					-0.15 a	(0.03)	-0.13 a	(0.04)	-0.13 a	(0.03)	-0.05	(0.04)		
Income					0.00 c	(0.00)	0.00 c	(0.00)	0.00 c	(0.00)	0.00	(0.00)		
Parent education					0.21 b	(0.08)	0.18 c	(0.08)	0.18 c	(0.08)	0.09	(0.09)		
Private HS							0.33	(0.17)						
Algebra II							0.35 b	(0.12)	0.39 b	(0.11)	0.23	(0.12)		
HS curriculum							0.05	(0.10)						
HS GPA							0.23 a	(0.04)	0.24 a	(0.04)	0.19 a	(0.04)	0.20 a	(0.04)
Academic integration											0.00 c	(0.00)	0.00 b	(0.00)
Social integration index											0.00	(0.00)		
Full-time enrollment											0.83 a	(0.12)	0.83 a	(0.12)
Pell grant											0.00	(0.10)		
Declared a major											0.36 a	(0.10)	0.35 a	(0.09)
Attended 2 colleges											1.31 a	(0.10)	1.34 a	(0.09)
Attended 3+ colleges											1.76 a	(0.12)	1.82 a	(0.11)
Worked full-time														
Child														
L1 INTERACTIONS														
Reading X Other Rem.														
INSTITUTION-LEVEL														
Private college														
College enr. (1,000s)														
% Black students (sqrt)														
% Hispanic students (sqrt)														
% students w/ federal aid														
% full-time faculty														
VARIANCE COMPONENTS														
Tau_{00}	0.31 a		0.31 a		0.27 a		0.29 a		0.28 a		0.30 a		0.29 a	
Tau_{11}														
Tau_{01} as Corr.														
Tau_{00} Reliability	0.42		0.43		0.40		0.40		0.40		0.39		0.38	
Tau_{11} Reliability														
Deviance	10,922		10,869		10,790		10,718		10,726		10,296		10,313	
(# parameters)	(2)		(7)		(15)		(19)		(16)		(23)		(17)	

[a] p<.001; [b] p<.01; [c] p<.05

Table D11. Two-year colleges: Relationship between Remedial Subjects and Attaining an Associate's Degree or Higher										
	Environmental Factors Block		*Student-Level with Interaction*		*Student-Level Final with Random Slope*		*All Institutional Predictors*		*Student- and Insitution-Level Final*	
	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)
STUDENT-LEVEL										
Intercept	-1.99 a	(0.18)	-1.98 a	(0.18)	-2.03 a	(0.19)	-2.04 a	(0.19)	-2.04 a	(0.19)
Remedial Math	0.03	(0.08)	0.03	(0.08)	0.04	(0.10)	0.05	(0.10)	0.04	(0.10)
Remedial English	-0.01	(0.13)	-0.02	(0.13)	-0.05	(0.13)	-0.10	(0.14)	-0.09	(0.14)
Remedial Reading	-0.23	(0.13)	-0.30 c	(0.13)	-0.28 c	(0.13)	-0.25	(0.13)	-0.25	(0.13)
ESL	1.06 b	(0.38)	1.10 b	(0.38)	1.16 b	(0.38)	1.18 b	(0.38)	1.17 b	(0.38)
Other Remedial	0.44 c	(0.19)	0.27	(0.21)	0.27	(0.21)	0.28	(0.21)	0.28	(0.21)
Asian	0.14	(0.20)	0.13	(0.20)	0.09	(0.20)	0.21	(0.21)	0.20	(0.21)
Black	-0.63 a	(0.15)	-0.62 a	(0.15)	-0.61 a	(0.14)	-0.49 b	(0.16)	-0.50 b	(0.16)
Hispanic	-0.01	(0.12)	-0.02	(0.12)	-0.01	(0.13)	0.08	(0.14)	0.04	(0.13)
Other race	-0.42 c	(0.18)	-0.42 c	(0.18)	-0.41 c	(0.17)	-0.42 c	(0.18)	-0.43 c	(0.18)
Male										
Age										
Income										
Parent education										
Private HS										
Algebra II										
HS curriculum										
HS GPA	0.21 a	(0.04)	0.21 a	(0.04)	0.21 a	(0.04)	0.20 a	(0.04)	0.20 a	(0.04)
Academic integration	0.00 c	(0.00)	0.00 c	(0.00)	0.00 c	(0.00)	0.00 c	(0.00)	0.00 c	(0.00)
Social integration index										
Full-time enrollment	0.76 a	(0.12)	0.76 a	(0.12)	0.77 a	(0.12)	0.72 a	(0.13)	0.73 a	(0.13)
Pell grant										
Declared a major	0.38 a	(0.10)	0.39 a	(0.10)	0.38 a	(0.10)	0.39 a	(0.10)	0.39 a	(0.10)
Attended 2 colleges	1.26 a	(0.09)	1.26 a	(0.09)	1.29 a†	(0.09)	1.30 a†	(0.10)	1.31 a†	(0.10)
Attended 3+ colleges	1.70 a	(0.12)	1.70 a	(0.12)	1.76 a	(0.12)	1.74 a	(0.12)	1.74 a	(0.12)
Worked full-time	-0.33 b	(0.12)	-0.33 b	(0.12)	-0.33 b	(0.12)	-0.31 c	(0.12)	-0.31 c	(0.12)
Child	-0.67 a	(0.11)	-0.67 a	(0.11)	-0.68 a	(0.11)	-0.70 a	(0.11)	-0.69 a	(0.11)
L1 INTERACTIONS										
Reading X Other Rem.			1.15 b	(0.37)	1.20 b	(0.37)	1.21 b	(0.36)	1.23 b	(0.36)
INSTITUTION-LEVEL										
Private college							0.51 c	(0.21)	0.54 b	(0.19)
College enr. (1,000s)							-0.02 c	(0.01)	-0.02 b	(0.01)
% Black students (sqrt)							-0.08 c	(0.04)	-0.07 c	(0.03)
% Hispanic students (sqrt)							-0.03	(0.04)		
% students w/ federal aid							0.00	(0.00)		
% full-time faculty							0.00	(0.00)		
VARIANCE COMPONENTS										
Tau_{00}	0.30 a		0.31 a		0.58 a		0.47 a		0.48 a	
Tau_{11}					0.56 c		0.58 c		0.57 c	
Tau_{01} as Corr.					-0.91				-0.77	
Tau_{00} Reliability	0.38		0.39		0.36		0.28		0.29	
Tau_{11} Reliability					0.07		0.08		0.08	
Deviance	10,254		10,248		10,241		10,211		10,212	
(# parameters)	(19)		(20)		(22)		(28)		(25)	

[a] p<.001; [b] p<.01; [c] p<.05; † Slope allowed to vary randomly

Table D12. Two-year colleges: Relationship between Remedial Subjects and Attaining a Certificate

	Unconditional		*Remediation-Only*		*Demographic Block*		*Demographic - Significant*		*Academic Preparation Block*		*Academic - Significant*		*Postsecondary Experiences Block*		*Postsecondary - Significant*		*Environmental Factors Block*		*Environmental-Significant / Student-Level Final*		*All Institutional Predictors*		*Student- and Insitution-Level Final*	
	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)
STUDENT-LEVEL																								
Intercept	-3.44 a	(0.18)	-3.14 a	(0.19)	-2.91 a	(0.23)	-3.14 a	(0.19)	-2.89 a	(0.23)	-3.14 a	(0.19)	-3.27 a	(0.29)	-3.42 a	(0.23)	-3.51 a	(0.24)	-3.42 a	(0.23)	-3.33 a	(0.23)	-3.34 c	(0.22)
Remedial Math			-0.53 b	(0.18)	-0.55 b	(0.20)	-0.53 b	(0.18)	-0.55 b	(0.19)	-0.53 b	(0.18)	-0.51 b	(0.18)	-0.50 b	(0.18)	-0.52 b	(0.19)	-0.50 b	(0.18)	-0.49 c	(0.19)	-0.49 b	(0.18)
Remedial English			-0.09	(0.28)	-0.12	(0.32)	-0.09	(0.28)	-0.10	(0.28)	-0.09	(0.28)	-0.06	(0.30)	-0.07	(0.28)	-0.07	(0.28)	-0.07	(0.28)	-0.08	(0.30)	-0.13	(0.28)
Remedial Reading			0.00	(0.26)	-0.01	(0.27)	0.00	(0.26)	-0.02	(0.26)	0.00	(0.26)	0.04	(0.28)	0.05	(0.27)	0.04	(0.27)	0.05	(0.27)	0.04	(0.27)	0.07	(0.27)
ESL			0.38	(0.66)	0.42	(0.78)	0.38	(0.66)	0.35	(0.68)	0.38	(0.66)	0.39	(0.67)	0.37	(0.66)	0.43	(0.66)	0.37	(0.66)	0.53	(0.69)	0.52	(0.68)
Other Remedial			0.45	(0.35)	0.43	(0.36)	0.45	(0.35)	0.43	(0.36)	0.45	(0.35)	0.45	(0.35)	0.44	(0.34)	0.46	(0.33)	0.44	(0.34)	0.45	(0.35)	0.46	(0.34)
Asian					-0.30	(0.55)																		
Black					0.23	(0.26)																		
Hispanic					0.01	(0.30)																		
Other race					-0.70	(0.59)																		
Male					-0.33	(0.20)																		
Age					0.05	(0.07)																		
Income					0.00	(0.00)																		
Parent education					-0.16	(0.17)																		
Private HS									-0.09	(0.41)														
Algebra II									-0.31	(0.22)														
HS curriculum									0.04	(0.22)														
HS GPA									0.00	(0.09)														
Academic integration													0.00	(0.00)										
Social integration index													0.00	(0.00)										
Full-time enrollment													-0.25	(0.19)										
Pell grant													0.07	(0.20)										
Declared a major													-0.07	(0.19)										
Attended 2 colleges													0.47 c	(0.20)	0.41 c	(0.19)	0.44 c	(0.20)	0.41 c	(0.19)	0.40 c	(0.19)	0.41 c	(0.19)
Attended 3+ colleges													0.51	(0.29)	0.42	(0.26)	0.48	(0.27)	0.42	(0.26)	0.39	(0.26)	0.41	(0.26)
Worked full-time																	-0.09	(0.20)						
Child																	0.33	(0.19)						
INSTITUTION-LEVEL																								
Private college																					-0.45	(0.55)		
College enr. (1,000s)																					-0.05 c	(0.02)	-0.04 c	(0.02)
% Black students (sqrt)																					0.02	(0.06)		
% Hispanic students (sqrt)																					-0.07	(0.09)		
% students w/ federal aid																					0.00	(0.01)		
% full-time faculty																					-0.01	(0.01)		
VARIANCE COMPONENTS																								
Tau_{00}	1.24 a		1.11 a		1.11 a		1.11 a		1.09 a		1.11 a		1.18 a		1.17 a		1.14 a		1.17 a		0.98 a		1.00 a	
Tau_{11}																								
Tau_{01} as Corr.																								
Tau_{00} Reliability	0.39		0.36		0.36		0.36		0.35		0.36		0.37		0.38		0.37		0.38		0.34		0.35	
Tau_{11} Reliability																								
Deviance	7,815		7,803		7,792		7,803		7,800		7,803		7,791		7,798		7,794		7,798		7,783		7,788	
(# parameters)	(2)		(7)		(15)		(7)		(11)		(7)		(14)		(9)		(11)		(9)		(15)		(10)	

[a] p<.001; [b] p<.01; [c] p<.05

Table D13. Two-year colleges: Relationship between Remedial Subjects and Attaining an Associate's Degree

	Unconditional		*Remediation-Only*		*Demographic Block*		*Demographic - Significant*		*Academic Preparation Block*		*Academic - Significant*		*Postsecondary Experiences Block*		*Postsecondary - Significant*		*Environmental Factors Block*		*Environmental Factors - Significant*		*Student-Level Final with Interaction*		*All Institutional Predictors*		*Student- and Insitution-Level Final*	
	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)
STUDENT-LEVEL																										
Intercept	-1.63 a	(0.07)	-1.76 a	(0.09)	-1.62 a	(0.12)	-1.72 a	(0.10)	-1.78 a	(0.16)	-1.67 a	(0.12)	-2.50 a	(0.22)	-2.58 a	(0.19)	-2.50 a	(0.20)	-2.58 a	(0.19)	-2.58 a	(0.20)	-2.56 a	(0.20)	-2.61 a	(0.19)
Remedial Math			0.21 c	(0.09)	0.24 c	(0.09)	0.24 b	(0.09)	0.26 b	(0.09)	0.25 b	(0.09)	0.24 c	(0.10)	0.26 b	(0.09)	0.27 b	(0.10)	0.26 b	(0.09)	0.26 b	(0.09)	0.27 b	(0.09)	0.26 b	(0.09)
Remedial English			0.21	(0.13)	0.24	(0.14)	0.25	(0.14)	0.25	(0.14)	0.25	(0.14)	0.20	(0.15)	0.23	(0.14)	0.23	(0.14)	0.23	(0.14)	0.22	(0.14)	0.16	(0.15)	0.25	(0.14)
Remedial Reading			-0.38 b	(0.14)	-0.37 c	(0.15)	-0.36 c	(0.14)	-0.32 c	(0.14)	-0.32 c	(0.14)	-0.30 c	(0.15)	-0.30 c	(0.15)	-0.31 c	(0.15)	-0.30 c	(0.15)	-0.40 b	(0.15)	-0.36 c	(0.15)	-0.41 b	(0.15)
ESL			0.83 c	(0.40)	0.74	(0.42)	0.71	(0.41)	0.72	(0.42)	0.71	(0.41)	0.74	(0.41)	0.78	(0.41)	0.74	(0.41)	0.78	(0.41)	0.83 c	(0.42)	0.87 c	(0.43)	0.82	(0.42)
Other Remedial			0.43 c	(0.19)	0.44 c	(0.20)	0.43 c	(0.20)	0.48 c	(0.20)	0.47 c	(0.20)	0.47 c	(0.20)	0.47 c	(0.20)	0.45 c	(0.20)	0.47 c	(0.20)	0.22	(0.21)	0.23	(0.21)	0.23	(0.21)
Asian					0.21	(0.23)	0.24	(0.23)	0.25	(0.23)	0.25	(0.23)	0.24	(0.24)	0.23	(0.23)	0.21	(0.23)	0.23	(0.23)	0.22	(0.23)	0.32	(0.24)	0.25	(0.23)
Black					-0.43 b	(0.16)	-0.40 c	(0.15)	-0.38 c	(0.16)	-0.38 c	(0.16)	-0.48 b	(0.17)	-0.48 b	(0.15)	-0.46 b	(0.15)	-0.48 b	(0.15)	-0.47 b	(0.15)	-0.34 c	(0.17)	-0.34 c	(0.17)
Hispanic					-0.02	(0.14)	0.03	(0.13)	0.04	(0.13)	0.03	(0.13)	0.02	(0.14)	0.01	(0.13)	0.02	(0.14)	0.01	(0.13)	0.00	(0.13)	0.09	(0.16)	0.00	(0.13)
Other race					-0.48 c	(0.20)	-0.46 c	(0.19)	-0.47 c	(0.19)	-0.48 c	(0.19)	-0.56 b	(0.20)	-0.55 b	(0.19)	-0.54 b	(0.20)	-0.55 b	(0.19)	-0.54 b	(0.20)	-0.56 b	(0.20)	-0.54 b	(0.20)
Male					-0.01	(0.11)																				
Age					-0.06	(0.04)																				
Income					0.00	(0.00)																				
Parent education					-0.17	(0.09)																				
Private HS									0.12	(0.20)																
Algebra II									0.17	(0.13)																
HS curriculum									-0.25 c	(0.11)	-0.17	(0.10)	-0.20	(0.11)												
HS GPA									0.14 b	(0.05)	0.15 b	(0.05)	0.13 b	(0.05)	0.12 c	(0.05)	0.12 c	(0.05)	0.12 c	(0.05)	0.12 c	(0.05)	0.11 c	(0.05)	0.12 c	(0.05)
Academic integration													0.00	(0.00)												
Social integration index													0.00	(0.00)												
Full-time enrollment													0.53 a	(0.13)	0.51 a	(0.13)	0.48 b	(0.14)	0.51 a	(0.13)	0.52 a	(0.13)	0.47 b	(0.13)	0.51 a	(0.13)
Pell grant													0.21 c	(0.10)	0.22 c	(0.09)	0.25 c	(0.11)	0.22 c	(0.09)	0.22 c	(0.09)	0.19	(0.10)	0.22 c	(0.09)
Declared a major													0.47 a	(0.11)	0.46 a	(0.11)	0.47 a	(0.11)	0.46 a	(0.11)	0.47 a	(0.11)	0.47 a	(0.11)	0.49 a	(0.11)
Attended 2 colleges													0.02	(0.11)												
Attended 3+ colleges													0.03	(0.14)												
Worked full-time																	-0.09	(0.12)								
Child																	-0.21	(0.12)								
INTERACTIONS																										
Reading X Other Rem.																					1.52 b	(0.51)	1.55 b	(0.51)	1.54 b	(0.53)
INSTITUTION-LEVEL																										
Private college																							0.40	(0.26)		
College enr. (1,000s)																							-0.02	(0.01)		
% Black students (sqrt)																							-0.10 c	(0.04)	-0.11 c	(0.04)
% Hispanic students (sqrt)																							-0.04	(0.05)		
% students w/ federal aid																							0.00	(0.00)		
% full-time faculty																							0.00	(0.00)		
VARIANCE COMPONENTS																										
Tau$_{00}$	0.36 a		0.36 a		0.37 a		0.36 a		0.41 a		0.40 a		0.40 a		0.41 a		0.43 a		0.41 a		0.43 a		0.35 a		0.43 a	
Tau$_{11}$																										
Tau$_{01}$ as Corr.																										
Tau$_{00}$ Reliability	0.44		0.43		0.42		0.42		0.43		0.43		0.43		0.43		0.43		0.43		0.44		0.38		0.42	
Tau$_{11}$ Reliability																										
Deviance	9,743		9,722		9,703		9,709		9,694		9,696		9,642		9,651		9,646		9,651		9,642		9,616		9,635	
(# parameters)	(2)		(7)		(15)		(11)		(15)		(13)		(20)		(15)		(17)		(15)		(16)		(22)		(17)	

[a] p<.001; [b] p<.01; [c] p<.05

Table D14. Two-year colleges: Relationship between Remedial Subjects and Attaining a Bachelor's Degree or Higher

	Unconditional		*Remediation-Only*		*Demographic Block*		*Academic Preparation Block*		*Academic - Significant*	
	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)
STUDENT-LEVEL										
Intercept	-1.76 a	(0.07)	-1.34 a	(0.08)	-1.54 a	(0.11)	-2.33 a	(0.19)	-2.32 a	(0.19)
Remedial Math			-0.53 a	(0.09)	-0.49 a	(0.10)	-0.38 a	(0.10)	-0.39 a	(0.10)
Remedial English			-0.86 a	(0.19)	-0.76 a	(0.20)	-0.65 b	(0.21)	-0.64 b	(0.21)
Remedial Reading			-0.33	(0.17)	-0.24	(0.18)	-0.16	(0.18)	-0.16	(0.18)
ESL			0.64	(0.38)	0.92 c	(0.40)	1.09 b	(0.40)	1.08 b	(0.40)
Other Remedial			0.22	(0.25)	0.27	(0.29)	0.35	(0.30)	0.35	(0.30)
Asian					0.23	(0.26)	0.24	(0.26)	0.23	(0.26)
Black					-0.48 c	(0.19)	-0.45 c	(0.19)	-0.47 c	(0.19)
Hispanic					-0.11	(0.20)	-0.14	(0.21)	-0.15	(0.20)
Other race					-0.06	(0.24)	-0.09	(0.25)	-0.10	(0.25)
Male					-0.32 b	(0.10)	-0.23 c	(0.10)	-0.23 c	(0.10)
Age					-0.22 a	(0.05)	-0.19 b	(0.05)	-0.19 b	(0.05)
Income					0.00 b	(0.00)	0.00 b	(0.00)	0.00 b	(0.00)
Parent education					0.56 a	(0.11)	0.52 a	(0.11)	0.53 a	(0.11)
Private HS							0.35	(0.19)		
Algebra II							0.56 b	(0.20)	0.57 b	(0.20)
HS curriculum							0.34 b	(0.13)	0.35 b	(0.13)
HS GPA							0.22 a	(0.05)	0.22 a	(0.05)
Academic integration										
Social integration index										
Full-time enrollment										
Pell grant										
Declared a major										
Attended 2 colleges										
Attended 3+ colleges										
Worked full-time										
Child										
INTERACTIONS										
English X Reading										
INSTITUTION-LEVEL										
Private college										
College enr. (1,000s)										
% Black students (sqrt)										
% Hispanic students (sqrt)										
% students w/ federal aid										
% full-time faculty										
VARIANCE COMPONENTS										
Tau_{00}	0.50 a		0.48 a		0.41 a		0.37 a		0.36 a	
Tau_{11}										
Tau_{01} as Corr.										
Tau_{00} Reliability	0.41		0.39		0.35		0.33		0.33	
Tau_{11} Reliability										
Deviance	9,499		9,414		9,307		9,230		9,234	
(# parameters)	(2)		(7)		(15)		(19)		(18)	

[a] p<.001; [b] p<.01; [c] p<.05

Table D14. Two-year colleges: Relationship between Remedial Subjects and Attaining a Bachelor's Degree or Higher

	Postsecondary Experiences Block		*Postsecondary - Significant*		*Environmental Factors Block*		*Environmental Factors - Significant*		*Student-Level Final with Interaction*		*All Institutional Predictors*		*Student- and Insitution-Level Final*	
	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)
STUDENT-LEVEL														
Intercept	-7.98 a	(0.89)	-8.04 a	(0.86)	-7.55 a	(0.87)	-7.35 a	(0.83)	-7.32 a	(0.83)	-7.30 a	(0.86)	-7.32 a	(0.83)
Remedial Math	-0.18	(0.12)	-0.18	(0.12)	-0.17	(0.12)	-0.18	(0.12)	-0.16	(0.12)	-0.16	(0.13)	-0.16	(0.12)
Remedial English	-0.51 c	(0.24)	-0.50 c	(0.23)	-0.51 c	(0.24)	-0.52 c	(0.24)	-0.97 b	(0.32)	-0.98 b	(0.33)	-0.97 b	(0.32)
Remedial Reading	0.16	(0.20)	0.16	(0.19)	0.11	(0.20)	0.09	(0.20)	-0.19	(0.24)	-0.20	(0.24)	-0.19	(0.24)
ESL	1.47 b	(0.53)	1.39 b	(0.51)	1.33 c	(0.52)	1.28 c	(0.51)	1.28 c	(0.52)	1.31 c	(0.52)	1.28 c	(0.52)
Other Remedial	0.30	(0.35)	0.32	(0.34)	0.24	(0.35)	0.25	(0.35)	0.25	(0.36)	0.28	(0.38)	0.25	(0.36)
Asian	-0.05	(0.27)	-0.09	(0.27)	-0.20	(0.29)	-0.25	(0.29)	-0.27	(0.30)	-0.21	(0.32)	-0.27	(0.30)
Black	-0.67 b	(0.21)	-0.72 b	(0.20)	-0.53 c	(0.22)	-0.59 b	(0.21)	-0.57 b	(0.21)	-0.51 c	(0.24)	-0.57 b	(0.21)
Hispanic	0.03	(0.20)	-0.02	(0.20)	0.03	(0.20)	-0.03	(0.20)	-0.01	(0.20)	-0.01	(0.22)	-0.01	(0.20)
Other race	-0.07	(0.31)	-0.11	(0.30)	-0.04	(0.31)	-0.08	(0.30)	-0.08	(0.31)	-0.08	(0.31)	-0.08	(0.31)
Male	-0.14	(0.12)												
Age	-0.04	(0.06)												
Income	0.00	(0.00)												
Parent education	0.44 b	(0.13)	0.45 b	(0.13)	0.42 b	(0.13)	0.47 b	(0.13)	0.45 b	(0.13)	0.46 b	(0.13)	0.45 b	(0.13)
Private HS														
Algebra II	0.44 c	(0.21)	0.46 c	(0.21)	0.41	(0.22)								
HS curriculum	0.31 c	(0.14)	0.33 c	(0.14)	0.34 c	(0.14)	0.47 a	(0.12)	0.47 a	(0.13)	0.46 b	(0.13)	0.47 a	(0.13)
HS GPA	0.15 b	(0.05)	0.16 b	(0.05)	0.16 b	(0.05)	0.17 b	(0.05)	0.16 b	(0.05)	0.16 b	(0.05)	0.16 b	(0.05)
Academic integration	0.00 c	(0.00)	0.00 b	(0.00)	0.00 b	(0.00)	0.00 b	(0.00)	0.00 b	(0.00)	0.00 b	(0.00)	0.00 b	(0.00)
Social integration index	0.00	(0.00)												
Full-time enrollment	1.04 a	(0.19)	1.06 a	(0.18)	0.92 a	(0.19)	0.90 a	(0.18)	0.89 a	(0.18)	0.88 a	(0.19)	0.89 a	(0.18)
Pell grant	-0.30 c	(0.14)	-0.38 b	(0.13)	-0.21	(0.14)								
Declared a major	0.00	(0.14)												
Attended 2 colleges	5.68 a	(0.80)	5.71 a	(0.79)	5.59 a	(0.79)	5.59 a	(0.78)	5.60 a	(0.79)	5.61 a	(0.82)	5.60 a	(0.79)
Attended 3+ colleges	6.11 a	(0.81)	6.17 a	(0.80)	5.99 a	(0.79)	5.98 a	(0.79)	5.98 a	(0.79)	5.98 a	(0.83)	5.98 a	(0.79)
Worked full-time					-0.50 b	(0.18)	-0.50 b	(0.18)	-0.51 b	(0.18)	-0.50 b	(0.18)	-0.51 b	(0.18)
Child					-1.28 a	(0.22)	-1.34 a	(0.21)	-1.34 a	(0.21)	-1.34 a	(0.22)	-1.34 a	(0.21)
INTERACTIONS														
English X Reading									1.23 c	(0.50)	1.26 c	(0.50)	1.23 c	(0.50)
INSTITUTION-LEVEL														
Private college											0.06	(0.32)		
College enr. (1,000s)											-0.01	(0.01)		
% Black students (sqrt)											-0.02	(0.05)		
% Hispanic students (sqrt)											0.02	(0.05)		
% students w/ federal aid											0.00	(0.00)		
% full-time faculty											0.00	(0.00)		
VARIANCE COMPONENTS														
Tau$_{00}$	0.21 c		0.24 b		0.20 c		0.21 c		0.21 c		0.19 c		0.21 c	
Tau$_{11}$														
Tau$_{01}$ as Corr.														
Tau$_{00}$ Reliability	0.15		0.15		0.12		0.11		0.12		0.10		0.12	
Tau$_{11}$ Reliability														
Deviance	8,485		8,494		8,423		8,431		8,423		8,420		8,423	
(# parameters)	(25)		(20)		(22)		(20)		(21)		(27)		(21)	

[a] p<.001; [b] p<.01; [c] p<.05

Table D15. Four-year colleges: Relationship between Remedial Subjects and Attaining a Bachelor's Degree or Higher

	Unconditional		*Remediation-Only*		*Demographic Block*		*Academic Preparation Block*		*Academic - Significant*		*Postsecondary Experiences Block*		*Postsecondary - Significant*		*Environmental Factors Block*		*Environmental Factors - Significant*		*Student-Level Final with Random Slope*		*All Institutional Predictors*		*Institutional-Significant*		*Student- and Insitution-Level Final*	
	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)	Coeff.	(s.e.)
STUDENT-LEVEL																										
Intercept	0.73 a	####	0.89 a	(0.06)	0.97 a	(0.08)	0.33 c	(0.16)	0.34 c	(0.16)	-0.18	(0.24)	-0.22	(0.23)	0.05	(0.24)	0.05	(0.24)	0.08	(0.24)	-0.20	(0.26)	-0.17	(0.25)	-0.19	(0.24)
Remedial Math			-0.55 a	(0.07)	-0.50 a	(0.07)	-0.33 a	(0.08)	-0.33 a	(0.07)	-0.37 a	(0.08)	-0.36 a	(0.07)	-0.35 a	(0.07)	-0.35 a	(0.07)	-0.35 a	(0.08)	-0.27 b	(0.08)	-0.28 b	(0.08)	-0.28 a	(0.07)
Remedial English			-0.55 a	(0.15)	-0.42 b	(0.15)	-0.22	(0.15)	-0.22	(0.15)	-0.25	(0.16)	-0.24	(0.16)	-0.18	(0.16)	-0.19	(0.16)	-0.17	(0.16)	-0.07	(0.17)	-0.07	(0.17)	-0.08	(0.16)
Remedial Reading			-0.24	(0.17)	-0.16	(0.17)	-0.09	(0.18)	-0.10	(0.18)	-0.16	(0.20)	-0.15	(0.20)	-0.12	(0.20)	-0.12	(0.20)	-0.12	(0.21)	-0.03	(0.21)	-0.02	(0.21)	-0.02	(0.20)
ESL			-0.89 b	(0.29)	-0.63 c	(0.29)	-0.65 c	(0.30)	-0.65 c	(0.30)	-0.66 c	(0.29)	-0.67 c	(0.29)	-0.70 c	(0.28)	-0.70 c	(0.28)	-0.74 c	(0.31)	-0.16	(0.33)	-0.14	(0.33)	-0.20	(0.29)
Other Remedial			0.09	(0.23)	0.15	(0.24)	0.17	(0.25)	0.16	(0.25)	0.09	(0.23)	0.09	(0.23)	0.08	(0.23)	0.08	(0.23)	0.08	(0.23)	0.05	(0.22)	0.05	(0.22)	0.05	(0.21)
Asian					0.09	(0.15)	0.07	(0.16)	0.07	(0.16)	0.14	(0.16)	0.15	(0.16)	0.09	(0.16)	0.09	(0.16)	0.10	(0.18)	0.07	(0.17)	0.09	(0.17)		
Black					-0.46 a	(0.12)	-0.29 c	(0.13)	-0.29 c	(0.13)	-0.30 c	(0.12)	-0.29 c	(0.12)	-0.21	(0.12)	-0.21	(0.12)	-0.22	(0.13)	-0.14	(0.13)	-0.10	(0.13)		
Hispanic					-0.50 a	(0.12)	-0.43 b	(0.12)	-0.43 b	(0.12)	-0.41 b	(0.12)	-0.40 b	(0.12)	-0.33 c	(0.13)	-0.33 c	(0.13)	-0.34 c	(0.13)	-0.24	(0.14)	-0.21	(0.13)		
Other race					-0.09	(0.14)	-0.09	(0.14)	-0.09	(0.14)	-0.05	(0.15)	-0.05	(0.15)	-0.03	(0.15)	-0.03	(0.15)	-0.01	(0.15)	0.00	(0.16)	0.02	(0.16)		
Male					-0.49 a	(0.06)	-0.39 a	(0.06)	-0.40 a	(0.06)	-0.44 a	(0.07)	-0.44 a	(0.06)	-0.52 a	(0.07)	-0.52 a	(0.06)	-0.54 a	(0.07)	-0.53 a	(0.07)	-0.53 a	(0.07)	-0.53 a	(0.10)
Age					-0.11 b	(0.04)	-0.10 c	(0.04)	-0.10 c	(0.04)	-0.08 c	(0.04)	-0.08	(0.04)	-0.02	(0.04)										
Income					0.00 a	(0.00)	0.00 a	(0.00)	0.00 a	(0.00)	0.00 a	(0.00)	0.00 a	(0.00)	0.00 a	(0.00)	0.00 a	(0.00)	0.00 a	(0.00)	0.00 b	(0.00)	0.00 b	(0.00)	0.00 b	(0.00)
Parent education					0.31 a	(0.07)	0.27 b	(0.07)	0.27 a	(0.07)	0.22 b	(0.07)	0.22 b	(0.07)	0.17 c	(0.08)	0.17 c	(0.08)	0.17 c	(0.08)	0.15	(0.08)	0.16 c	(0.08)	0.16 c	(0.08)
Private HS							0.02	(0.09)																		
Algebra II							0.53 b	(0.15)	0.60 a	(0.14)	0.50 b	(0.15)	0.50 b	(0.15)	0.50 b	(0.15)	0.50 b	(0.15)	0.49 b	(0.16)	0.47 b	(0.16)	0.48 b	(0.16)	0.48 b	(0.16)
HS curriculum							0.10	(0.08)																		
HS GPA							0.49 a	(0.03)	0.50 a	(0.03)	0.48 a	(0.04)	0.48 a	(0.04)	0.47 a	(0.04)	0.47 a	(0.04)	0.48 a	(0.04)	0.45 a	(0.04)	0.45 a	(0.04)	0.46 a	(0.04)
Academic integration											0.00	(0.00)														
Social integration index											0.00 a	(0.00)	0.01 a	(0.00)	0.00 a	(0.00)	0.00 a	(0.00)	0.00 a	(0.00)	0.00 a	(0.00)	0.00 a	(0.00)	0.00 a	(0.00)
Full-time enrollment											1.08 a	(0.16)	1.09 a	(0.16)	1.01 a	(0.16)	1.02 a	(0.16)	1.05 a	(0.16)	1.03 a	(0.17)	1.02 a	(0.16)	1.01 a	(0.16)
Pell grant											-0.23 b	(0.08)	-0.23 b	(0.08)	-0.18 c	(0.08)	-0.18 c	(0.08)	-0.19 c	(0.08)	-0.16	(0.08)	-0.16 c	(0.08)	-0.18 c	(0.08)
Declared a major											-0.05	(0.07)														
Attended 2 colleges											-0.37 a	(0.06)	-0.37 a	(0.06)	-0.36 a	(0.06)	-0.36 a	(0.06)	-0.37 a†	(0.06)	-0.37 a†	(0.06)	-0.37 a†	(0.06)	-0.37 a†	(0.06)
Attended 3+ colleges											-0.58 a	(0.09)	-0.58 a	(0.09)	-0.57 a	(0.09)	-0.57 a	(0.09)	-0.58 a	(0.09)	-0.57 a	(0.09)	-0.57 a	(0.09)	-0.56 a	(0.09)
Worked full-time															-0.69 a	(0.16)	-0.70 a	(0.16)	-0.72 a	(0.16)	-0.68 a	(0.16)	-0.68 a	(0.16)	-0.69 a	(0.16)
Child															-1.33 a	(0.11)	-1.34 a	(0.10)	-1.35 a	(0.10)	-1.32 a	(0.11)	-1.32 a	(0.11)	-1.33 a	(0.11)
INSTITUTION-LEVEL																										
Private college																					0.51 a	(0.12)	0.45 a	(0.10)	0.45 a	(0.09)
College enr. (1,000s)																					0.00	(0.01)				
% Black students (sqrt)																					0.02	(0.03)				
% Hispanic students (sqrt)																					0.02	(0.04)				
% students w/ federal aid																					-0.02 a	(0.00)	-0.02 a	(0.00)	-0.02 a	(0.00)
% full-time faculty																					0.00	(0.00)				
VARIANCE COMPONENTS																										
Tau_{00}	1.15 a		0.93 a		0.74 a		0.61 a		0.62 a		0.49 a		0.49 a		0.42 a		0.42 a		0.63 a		0.58 a		0.59 a		0.60 a	
Tau_{11}																			0.85 a		0.92 a		0.92 a		0.90 a	
Tau_{01} as Corr.																			-0.68				-0.74		-0.75	
Tau_{00} Reliability	0.72		0.67		0.61		0.54		0.54		0.45		0.46		0.40		0.41		0.40		0.36		0.36		0.36	
Tau_{11} Reliability																			0.22		0.22		0.22		0.22	
Deviance	20,571		20,492		20,275		20,044		20,046		19,850		19,852		19,655		19,655		19,621		19,540		19,542		19,546	
(# parameters)	(2)		(7)		(15)		(19)		(17)		(24)		(22)		(24)		(23)		(25)		(31)		(27)		(23)	

[a] p<.001; [b] p<.01; [c] p<.05; † Slope allowed to vary randomly