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Mathematics from High School to Community College: Preparation, Articulation, and College Un-readiness

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Mathematics from High School to Community College:

Preparation, Articulation, and College Un-readiness

A dissertation submitted in partial satisfaction of the

requirements for the degree Doctor of Education

by

Louise Jaffe

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ABSTRACT OF THE DISSERTATION

Mathematics from High School to Community College:

Preparation, Articulation, and College Un-readiness

by

Louise Jaffe

Doctor of Education

University of California, Los Angeles, 2012

Professor Eugene Tucker, Co-Chair

Professor Richard Wagoner, Co-Chair

This research studied the role of mathematics as a roadblock to college completion for community college-bound students in California. Using longitudinal quantitative analysis, I observed the educational pipeline between high school and community college and analyzed how different high school mathematics histories predicted readiness, or un-readiness, for college-level mathematics. I found the pipeline metaphor inaccurate and misleading. Rather than being carried, or pumped, through a single pipeline, community college-bound students hiked diverse trails through high school mathematics. At important junctures, students chose or were directed to paths that diminished their chances of attaining college-readiness.

My sample included 2,920 students, four full graduating classes from a single ethnically and economically diverse comprehensive public high school. Student school district records were linked with community college ACT COMPASS placement assessments in mathematics for the subset of 903 students who matriculated to the community college as freshmen. In a multinomial logistic regression model, Grade 9 mathematics and the California High School Exit Exam (CAHSEE) in mathematics were significant predictors of placement in 1-, 2-, 3-, and 4-levels below college-level mathematics. The finding that the CAHSEE Math was significant is evidence that California already has in place a high stakes test for 10^{th} graders that predicts placement into below-college-level mathematics. Not taking mathematics in grade 12 was also a significant predictor of placement in below-college-level mathematics. Fifty-five percent of the students who placed 2-, 3-, or 4-levels below college-level mathematics did not take any mathematics in their senior year of high school. I conclude with recommendations for actionable and strategic shifts in practice that this research indicates will be effective in improving college-readiness in mathematics for community college-bound students.

Keywords: developmental mathematics, high school exit exam, articulation, community college placement test, college-readiness

The dissertation of Louise Jaffe is approved.

Patricia McDonough

James W. Stigler

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University of California, Los Angeles

2012

DEDICATION PAGE

To students, especially students who are feeling knocked down instead of lifted up by school. This research is for you, your families, and your families to be.

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CHAPTER 1: INTRODUCTION

Mathematics and College Completion

For hundreds of thousands of young Californians, every year, community college is the road to opportunity, the bridge between high school and a four-year college. But too many students fail to cross this bridge; many of them hit a roadblock, and often that roadblock is college-level mathematics.

Low-level mathematical skills are a significant barrier to transfer and college completion for many community college students and particularly Latino and Black[1] community college students (Adelman, 2006; Berry, 2003; Brown & Niemi, 2007; Lee, 2012). Students who enter community college in need of extensive mathematics remediation are unlikely to complete the remediation coursework sequence and unlikely to progress to transfer-level mathematics classes (Brown & Niemi, 2007).

This study explores the relationship between students' high school mathematics experience and their placement in mathematics at community college. Researchers frequently cite school-based conditions - such as lack of resources, lack of access to academically rigorous college-preparatory coursework, lack of counselors, overcrowding, and lack of credentialed and experienced teachers – as barriers to educational attainment for many students, and especially Latino and Black students (Almy & Theokas, 2010; Venezia & Kirst, 2005; Loveless, 2008; Lumina Foundation, 2009; McDonough, 2005; Oakes, 2003, 2004; Ready, Lee, &

[1] The California Community College Chancellor's Office uses seven classifications to describe student ethnicity: Asian, Black/African American, Hispanic, Native American, Pacific Islander, White, and Multi-race (CCCCO, 2009b). I use four classifications to describe student ethnicity: API (Asian/Pacific Islander), Latino, Black (may in some instances include Black students who are not African American), and White.

Welner, 2004; Rosin & Wilson, 2008; Yosso & Solorzano, 2006). This study drills past these established barriers to identify specific institutional practices and student behavior patterns that diminish student readiness for college-level mathematics. Mathematics has been selected as the study's focal point because researchers have identified mathematics achievement as both a gatekeeper and a leading indicator for transfer and college completion (Adelman, 2006; Berry, 2003; Brown & Niemi, 2007; Lee, 2012; Moore & Shulock, 2010; Offenstein, Moore, & Shulock, 2010; Stigler, Givvin, & Thompson, 2010; Venezia & Kirst, 2005).

Because mathematics plays a critical gate-keeping role in college entrance and completion, it is of great interest in and of itself. However, I also use progress in mathematics as a lens through which to analyze articulation between high school and community college. Since mathematics coursework is well defined and commonly labeled, and content mastery of the subject is assessed by standardized tests[2] across California school districts, my findings can be compared with other research and generalized, at least to some extent, to the population of California's high school students bound for community college.

Background and Context

The nation's demographics are changing; by 2050, the Latino population in the United States is projected to grow from 14% (in 2005) to 29%, and Whites will no longer be a majority (Hartley, 2009). The economic, societal, and personal significance of this changing demography lies, in part, in the low college completion rates of increasing numbers of Latino and Black students (Association of American

[2] Lee (2012) makes a similar case that mathematics achievement data are "comparable across different data sets and grade levels" (p. 44).

Colleges & Universities [AAC&U], 2002; College Board, 2008a, 2008b; Department of Education, 2006; Kirst & Bracco, 2004).

Low college completion rates for the growing Latino population focus intense pressure on American higher education to increase the educational attainment of this group (AAC&U, 2002; College Board, 2008a, 2008b; Department of Education, 2006; Lumina Foundation, 2009). Community colleges are at the center of this storm. Seventy percent of California Latino college students first enroll in a community college[3] (California Postsecondary Education Commission [CPEC], 2010), yet research documents that six years after enrollment, 80% of Latino students have not transferred to a four-year institution (Moore & Shulock, 2010). When it comes to improving college completion rates for Latino students, we must turn to community colleges; that is where the students are.

Many students enter California community colleges underprepared for college-level coursework (AAC&U, 2002; Department of Education, 2006; Greene, Marti, & McClenney, 2008; Kirst & Bracco, 2004; Sandy, Gonzalez, & Hilmer, 2006; Shulock, 2010; Stigler, et al., 2010; Venezia & Perry, 2007). The California Community College Chancellor's Office [CCCCO] 2009 *Basic Skills Accountability Report* reveals that in Fall 2007, 83.6% of community college students were assessed as below college-level in mathematics, and 72% were assessed as below college-level in English (p. 11). These students needing pre-collegiate remedial or developmental education are known as basic skills students. Latino and Black students are overrepresented among basic skills students. Forty-one percent of the

[3] This percentage is of Latino students who graduated from a public high school in 2009 and then enrolled in public higher education in California.

students enrolled in basic skills courses in 2007-2008 were Latino and 11% were Black (CCCCO, 2009a) compared to a Latino population of 29.4% and Black population of 7.5% in the general California community college student body (Perry, 2010).

Basic skills students have lower rates of academic success than do students entering with college-level skills (Adelman, 2006; Brown & Niemi, 2007; Bueschel, 2003; Rosenbaum & Person, 2003; Rosenbaum, 1998), and the more remediation students need, the less likely they are to complete a college degree (AAC&U, 2002; Panel of the Center for Student Success [RP/CSS], 2005). Furthermore, the success rate in community college classes varies by course type and student ethnicity (Brown & Niemi, 2007; Rosin & Wilson, 2008). Brown and Niemi (2007) report that the majority of Black and Latino students in basic skills classes do not pass.

The high numbers of students entering community college under-prepared for college-level coursework reflect a disjuncture between high schools and community colleges that most severely impacts students from low-income families, first-generation college-goers, and people of color (Bueschel, 2003; Kirst & Bracco, 2004; Venezia & Kirst, 2005). If California is to increase the numbers of students, especially the numbers of Latino and Black students, who complete college, improvements in articulation between high schools and community colleges must occur.

A body of research on how to improve college completion focuses on misalignment between the expectations, curriculum, and performance at the K-12 level with the expectations, curriculum, and performance requirements for college completion (AAC&U, 2002; Atkinson & Geiser, 2009; Brown & Conley, (2007); College Board, 2008a, 2008b; Lee, 2012; Jellison Holme, Richards, Jimerson, & Cohen, 2010; Kirst & Bracco, 2004; Kisker, 2006; Lumina Foundation, 2009). This disconnection is evident in the comparison of California high school graduation requirements in mathematics with community college entrance standards. Students can graduate from high school in California with just two years of mathematics, including no mathematics in their senior year, and no mathematics beyond Algebra 1 (California Department of Education, 2009a). Furthermore, the California High School Exit Exam (CAHSEE), a requirement for earning a high school diploma, only assesses content mastery of mathematics through Algebra 1 (Edsource, 2003). However, when students enter a community college, they are assessed to determine their readiness for college-level mathematics coursework. Unfortunately, most students are not ready. Instead of being eligible for college-level coursework, they are referred to remedial coursework. EdSource observes that the State's low minimum standards for high school graduation mislead students into thinking they are ready for college when they are not (Venezia & Perry, 2007).

The message conveyed to students by low high school graduation requirements and community college open admission policies is that the work students do in high school is irrelevant (Bueschel, 2003; Kirst & Bracco, 2004; Rosenbaum & Person, 2003; Rosenbaum, 1998). However, research documents that student achievement in high school influences success in college (Adelman, 1999, 2006; Atkinson & Geiser, 2009; Rosenbaum & Person, 2003; Venezia & Kirst, 2005). Rosenbaum and Person (2003) found that less than 14% of high school seniors with poor grades completed a college degree.

Research also emphasizes the importance of eighth-grade algebra as a gatekeeper to the kind of rigorous high school college-preparatory coursework that is most closely associated with college completion (Adelman, 2006; Burris, Wiley, Welner, & Murphy, 2008; Center for the Future of Teaching and Learning, 2008; Gamoran & Hannigan, 2000; Loveless, 2008; Silva & Moses, 1990; Spielhagen, 2006). Students who begin algebra in eighth grade are more likely to take more mathematics coursework and higher-level mathematics classes in high school, and are more likely to attend college (Adelman, 2006; Burris, et al., 2008; Gamoran & Hannigan, 2000; Silva & Moses, 1990; Spielhagen, 2006). In a recent national quantitative study examining performance in mathematics from kindergarten through college completion, achievement in mathematics predicted 30%-60% of the range of variance for being on track to college readiness (Lee, 2012).

While Adelman and others emphasize the importance of rigorous mathematics for high school students, progressing through mathematics for community college students is also necessary. Mathematics course-taking patterns and achievement in community college are critical stepping-stones toward college completion. Researchers have identified passing college-level mathematics within two years of enrollment in a community college as an important milestone for progress toward transfer (Moore & Shulock, 2010; Offenstein, et al., 2010). All of this research points to improving performance in mathematics, in all segments of the educational pipeline, as essential for improving college-readiness. For community college students, increased college-readiness will improve the likelihood that students will progress through mathematics to the successful completion of a transfer curriculum[4] and college completion.

Deficiencies in the Research Literature

Since California lacks a common student identifier, it is difficult to follow students longitudinally from high school into and through community college. The state also lacks high school assessments that align high school performance with college-readiness. Furthermore, there is no single common assessment instrument[5] used by all California community colleges, and when colleges do use the same assessment tool, they set their own cut scores for placement. Lee (2012) argues for a national P-16 longitudinal database since, currently, "it is unclear what levels of achievement are adequate for college-readiness (Lee, 2012, p. 44).

The lack of a student identifier to permit longitudinal study across education institutions, coupled with no common placement examination to assess college-readiness, hinders research that aligns high school with community college. However, for this study, I had access to both high school and community college academic records and was able to retroactively follow students from their high school district to their placement assessment as freshmen at the community college.

[4] The University of California and California State University systems require students who are transferring from community college to complete a transfer curriculum that includes college-level mathematics. However, a recent analysis of a cohort of 250,000 California community college students found that fewer than 50% of the students who transfer actually completed the transfer curriculum (Moore & Shulock, 2010).

[5] Legislation signed by the governor in 2012 calls for the development of a common diagnostic assessment to be used (voluntarily) by all California community colleges.

Much of the available research literature concerning Latino, Black, and low-income students describes students attending schools in low socioeconomic communities that do not offer the educational opportunities available to students in schools located in higher socioeconomic neighborhoods. This research attributes lower educational attainment in part to these inadequate and inequitable scholastic opportunities (Adelman, 2006; Almy & Theokas, 2010; AAC&U, 2002; Berry, 2003; Kirst & Bracco, 2004; McDonough, 2005; Oakes, 2003, 2004; UCLA/IDEA, 2007: Yosso & Solorzano, 2006). In contrast, the ethnically and economically diverse cohort of students in this study attended a relatively affluent California high school. By situating my study in this specific district, I controlled for frequently cited school-based barriers including lack of adequate resources, rigorous college preparation coursework, and qualified teachers.

In terms of curricular educational opportunities, researchers emphasize the importance of providing a college-preparatory curriculum for all students (AAC&U, 2002; Atkinson & Geiser, 2009; Lumina Foundation, 2009; Venezia & Perry, 2007; Venezia & Kirst, 2005). The high school in this study has multiple, somewhat flexible, mathematics pathways, all college-preparatory but diverging in rigor[6] and pacing[7] beginning in middle school. By examining different student experiences and outcomes, this study provides an explicit analysis for the local districts on the effectiveness of different high school pathways in preparing students for college-level mathematics.

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[6] Honors sections are offered in Algebra 1, Geometry, and Algebra 2 and AP sections are offered for Pre-Calculus, Calculus, and Statistics.

[7] Different mathematics pathways begin the high school curriculum sequence with Algebra 1 in seventh, eighth, or ninth grade.

Lastly, although research cites the phenomena of the "wasted senior year" (AAC&U, 2002; Berry, 2003; Miller, 2001; Venezia & Kirst, 2005; Woodrow Wilson Foundation, 2001), there is little explicit analysis of the association between California's high school graduation requirement of just two years of mathematics with the need for mathematics remediation in community college. This study analyzed the impact of not taking mathematics in grade twelve on college-readiness for entering community college freshmen.

Study Design Overview

The Sites

The Roslyn Unified School District (RUSD) and the Lawson Community College District (LCCD)[8] serve the same resident community and both institutions have a keen interest in providing educational services that support college enrollment and completion. The study sites are located in Southern California in a feeder unified school district and community college district that are both economically and ethnically diverse and relatively well-funded[9] for California. As part of a collaborative educational partnership between RUSD and LCCD, Lawson Community College outreach counselors hold regular weekly office hours at Casella High School to provide students with information about Lawson Community College, financial aid, and the LCCD application and assessment process. Education Collaborative members, including academic administrators, meet monthly and work to bridge the gap between the school district and the community college systems.

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[8] Roslyn Unified School District (RUSD), Lawson Community College District (LCCD) and Casella High School are pseudonyms.

[9] It should be noted that California's public schools are not well funded relative to the nation.

The Collaborative has several joint projects including an Early College High School model whose first cohort graduated from high school in 2011. In another joint project, the Collaborative provided me with de-identified retrospective longitudinal data to analyze the patterns of success and failure in mathematics experienced by students who matriculated from the high school to the community college.

RUSD seeks to prepare all students to attend college and has adopted many reforms and recommendations to close the achievement gap. In Fall 2003, based on an extensive review of the research and a long, inclusive planning process, Casella High School, a large, comprehensive high school, was reorganized into six small learning communities. Beginning with the Class of 2007, the district adopted a three-year mathematics requirement rather than the two-year state requirement for high school graduation, and all students are expected to complete the A-G requirements[10], a primary recommendation for improving college readiness (Venezia & Perry, 2007).

Lawson Community College is a large, destination community college in an urban region, and a recognized leader in transfer. The college has implemented many research-based best practices for student success such as orientation, provision of a "college success" course for first year students, and mandatory assessment for placement in mathematics. Placement assessment data for incoming freshmen students was essential for this study design.

[10] A-G refers to admission requirements for the University of California and California State University systems. The specific requirements are listed at http://www.ucop.edu/a-gGuide/ag/a-g/

Purpose of the Study

The purpose of this study was to isolate and analyze the effectiveness of different high school mathematics pathways as preparation for college-level mathematics. My findings provide a springboard for the Education Collaborative to discuss and implement changes in policy and practice that will improve articulation and educational outcomes for community college-bound students.

Study Design

This study examined the alignment between the actual high school mathematics experiences of students and subsequent readiness for college-level mathematics. I analyzed the high school histories of Casella High graduates from the classes of 2006, 2007, 2008, and 2009 who enrolled as freshmen at Lawson Community College. Different high school mathematics pathway markers were identified, including Grade 9 Mathematics placement, Highest-level Mathematics taken, and No Mathematics in Grade 12. Using multinomial logistic regression, I then tested these and other variables for their impact on placement in mathematics at the community college, as determined by a community college assessment test.

Analyzing retrospective longitudinal high school and community college data for four cohorts of high school graduates, the primary research questions for this study are:

1) What are the high school mathematics course-taking experiences of the high school students and of the subset of students who matriculated to the community college as freshmen?

a) How, if at all, do high school mathematics course-taking patterns differ by ethnicity?

2) Controlling for demographic factors and other background characteristics, how do different high school mathematics course-taking patterns and achievement predict placement into community college mathematics?
   a) How, if at all, does not taking mathematics in grade 12 affect the likelihood of placing into college-level mathematics in community college?
   b) How, if at all, do characteristics of high school mathematics course-taking that are predictive of placement into college-level mathematics for all students apply to students from different ethnic groups?

Interested parties

One fourth of the nation's community college students attend a community college in California (Community College League of California, CCLC, 2010). The future prospects of the nation and state, as well of course as those of millions of individual students and their families, depend on California improving college completion rates, especially for Black and Latino students. There is intense focus on this issue across the nation, the state, and educational systems. This research contributes to the search for solutions and will be of interest to the Education Collaborative partner institutions, as well as to local students, parents, educators, and policy-makers. Given the significance and applicability of my findings, I plan to share them with educators, researchers, and policy-makers in California through discussions and presentations at conferences, and through article submissions to peer-reviewed journals.

Dissertation Overview

In the next chapter, I review the literature that inspired and informed the design of this study. This includes research on the declining rank of the United States in college completion; the demographic trends and persistent achievement gaps that contribute to this decline; the role of community colleges, specifically California community colleges, in increasing college completion rates; a brief discussion on college-readiness; and the pivotal role of mathematics for both college-readiness and college completion. Chapter 3 then details the study design and methods, and findings are presented in Chapter 4. Based on the findings, Chapter 5 provides immediately actionable recommendations for both practitioners and policy-makers, discusses the implications of the findings, and suggests areas for future research.

CHAPTER 2: A REVIEW OF THE LITERATURE

Looking at mathematics coursework, this dissertation examines the section of the educational pipeline that spans high school through community college. Given the critical gate-keeping role that mathematics plays in entrance and completion at four-year colleges, my study is concerned with progress in mathematics for its own sake. However, I also view progress in mathematics as a lens through which to examine high school-community college articulation and equity.

This literature review brings together three major areas of research: 1) the role and function of community colleges; 2) disconnections between high school and community college; and 3) the role of mathematics in college-readiness and completion. All sections of the literature review examine equity for students from different ethnic groups.

I begin with a summary of current research about the declining rank of the United States in college completion (Carnevale, Smith, & Strohl, 2010; College Board, 2008a, 2008b; Douglass, 2010b; Lumina, 2009; Matthews, 2010; Moore & Shulock, 2010). The projected decline in American college completion rates is related to the increase in the proportion of American students who are Latino and/or Black and the traditionally lower rates of educational attainment experienced by these groups (College Board 2008b; Geiser & Atkinson, 2010; Kelly, 2010; Lumina Foundation, 2009; Moore & Shulock, 2010; Offenstein, Moore, & Shulock, 2010). If current demographic trends persist, efforts to improve American college completion rates must improve college completion rates for Latino students in particular but also for Black students and students from low socioeconomic households (College Board 2008a, 2008b; Geiser & Atkinson, 2010; Lumina Foundation, 2009; McDonough, 2005; Moore & Shulock, 2010; Offenstein, Moore, & Shulock, 2010). A focus on Latino and Black students, coupled with the need to greatly increase college completion, leads directly to the next section of this chapter: an examination of the role and function of community colleges in general, and California community colleges in particular. Nationwide, half of college-age under-represented minorities attending public institutions of higher education attend two-year colleges. In California, just 5% of under-represented minority college-age students attend a four-year institution. Overwhelmingly, Latino students who attend college in California begin their postsecondary education in a community college (Geiser & Atkinson, 2010).

The literature review next briefly discusses the role of community colleges as agents of both “democratization” and “diversion” (Doyle, 2009; Geiser & Atkinson, 2010; Rouse, 1995; Sandy, Gonzalez, & Hilmer, 2006; Wellman, Desrochers, & Lenihan, 2008). I consider these competing views of community college *vis a vis* the task of increasing college completion rates in the current fiscal environment. Research analyzing the institutional quality of community colleges segues to emerging research on community college policies, practices, and current efforts to increase transfer and completion. This leads to an examination of research discussing articulation (and lack of articulation) between high schools and community colleges in terms of academic preparation. Lastly, I present research on the role of mathematics as a gatekeeper, and often as a roadblock, to college completion.

Economic Competitiveness and College Completion

Dewayne Matthews[11] from the Lumina Foundation puts it bluntly: "If you don't want to be poor, you have to have a high skill job. The only way in America today to not be poor, is to get beyond a high school education" (Matthews, 2011). Educational attainment in general, and college completion in particular, are positively associated with quality of life factors such as income level, rate of unemployment, reduced crime, and physical health (Belfield & Bailey, 2011; CPEC, 2010). Americans with four-year college degrees make more money – about $1,000,000 more in their lifetime - are less likely to be unemployed (even in the current Great Recession), and are physically healthier (Belfield & Bailey, 2011; CPEC, 2010; U.S. Department of Labor, 2011; Matthews, 2011; Mirowsky & Ross, 2003; Wellman, et al., 2008). In addition, there is an increasing wage gap and wage premium between those with a college degree and those without one. These advantages for educated individuals compound for the state and the nation. Better educated citizens earn more money, pay higher taxes, and rely less on the government-funded safety net than do those who are less educated (Matthews, 2011). Furthermore, as our economy has shifted from a manufacturing-based economy to an information- and service-based economy, there are fewer jobs for the less educated. The Center on Education and the Workforce notes that in 1973, twenty-five million jobs required some college education. That number jumped to ninety-one million jobs in 2007 (Canevale, et al., 2010). The trend of more jobs requiring more education is dramatic, persistent, and reflected in 2010 unemployment rates: 4.8% unemployed with a four-year college degree as

[11] *Dewayne Matthews* is Vice President for Policy and Strategy of the *Lumina Foundation* for Education.

opposed to 9.8% for high school graduates and 15.3% for those with less than a high school degree (U.S. Department of Labor, 2011). Furthermore, the very innovations that have created jobs and new industries for the 21st century - including computer technology, new media, and the emerging green technology industry - depend upon intellectual and creative capacities honed by rigorous education. Demonstrably, there is a high societal and personal opportunity cost associated with low college completion rates.

For all of these converging reasons, economists, educators, and politicians agree: for the United States to be economically competitive in the 21st century, it must raise college completion rates (Carnevale, et al., 2010; College Board 2008b; Douglass, 2010b; Lumina Foundation, 2009; Matthews, 2011; Moore & Shulock, 2010). However, when it comes to educational attainment, the U.S. is losing ground (Carnevale, et al., 2010; College Board 2008b; Douglass, 2010b; Geiser & Atkinson, 2010; Lumina Foundation, 2009; Matthews, 2011; Moore & Shulock, 2010). As recently as ten years ago, the United States had the highest proportion of college graduates in the world. Today, it is fourteenth relative to other nations (Matthews, 2011; Organization for Economic Cooperation and Development [OECD], 2008; Wellman, et al., 2008).

The decline in America's college completion ranking reflects both our failure to increase the educational attainment of young people and the success of other nations to increase the educational attainment of their youth. In the United States, about 40% of adults ages 55-64 have a two- or four-year post-secondary degree. These Americans earned their degrees in the late 1960s and early 1970s, more than 35 years ago. Since then, U.S. college completion rates have remained flat while other nations have increased their college completion rates (Matthews, 2011). According to OECD data, (from 2008), 42% of recent American graduates, ages 25-34, completed a two- or four-year degree. But, at 42%, the U.S. now ranks twelfth in tertiary educational attainment for ages 25-34 among 36 developed nations. Tertiary education completion rates for ages 25-34 in Korea (58%), Canada (56%), Japan (55%), the Russian Federation (55%), New Zealand (48%), Norway (46%), Ireland (45%), and Denmark (43%) all now surpass American (42%) completion rates (OECD, 2010, p. 36).

Alarmed by our decline in the international rankings on educational attainment and the consequential loss in economic competitiveness and personal opportunity, President Obama set a goal for the United States to be number one again in college completion by 2020. This means increasing our college completion rate from the current stagnant rate of around 40% to 60% - a goal of 1,000,000 more college graduates for California (Douglass, 2010a; Matthews, 2011). The goal of 60% reflects predictions that by 2018, 60% of American jobs will need higher education (Carnevale, et al., 2010). Sixty percent is an ambitious goal, but what about the remaining 40%? They too will need to increase their educational attainment in order to support their families and themselves.

Changing Demographics Add to the Challenge

The challenge of increasing college completion rates to at least 60% for young Americans is exacerbated by demographic shifts in our national population. Latino students are an increasingly larger percentage of future students. By 2050, the Latino population in the United States is projected to grow from 14% (in 2005) to 29% and Whites will no longer be a majority (Hartley, 2009). California is at the forefront of this nationwide trend. Now 34%, Latinos are projected to make up 50% of the working-age population in California by 2040 (Moore & Shulock, 2010). The California Department of Finance projects that, by 2040, three Latino babies will be born in California for every White baby (Lay, 2010). Yet Latino and Black students have significantly lower rates of college completion than their Asian/Pacific Islander (API) and White counterparts (College Board. 2008b; Lumina Foundation, 2009). For example, more than 30% of White American adults have four years of college compared to just 18% of Black Americans and 12% of Latinos (Lumina, 2009). UCLA Chicano Studies Research Center reports that, for every 100 Latino children in elementary school, only nine will graduate from a four-year college. In contrast, for every 100 White children in elementary school, 26 will complete a four-year college (Yosso & Solorzano, 2006). The US population is expected to grow by 56 million people between 2000 and 2020; 46 million of these 56 million people, 82 percent, will be "minorities" (Lumina, 2009). To remain competitive, and to improve quality of life for our young people, the United States must increase post-secondary completion rates for low-income, Black, and Latino students (AAC&U, 2002; College Board, 2008a, 2008b; EdSource, 2007; Lumina Foundation, 2009; McDonough, 2005). These students typically begin their post-secondary education at a community college (Geiser & Atkinson, 2010).

The Role and Functioning of Community Colleges

Improving U.S. college completion rates requires a laser-like focus on increasing the numbers of community college students who successfully transfer to a four-year institution. In the United States, 43% (11.8 million) of post-secondary students attend a community college. The percentages are even higher for Latino (53%) and Black (45%) students (American Association of Community Colleges, 2010).

Twenty-four percent of all community college students, almost 3,000,000 annually, attend a community college in California (CCLC, 2011). In California, 75% of first time Latino college students begin their post-secondary education at a community college (Rivas, Perez, Alvarez, & Solorzano, 2007). Geiser and Atkinson (2010) report that four out of five California underrepresented minority college students attend a community college. Of the almost 3,000,000 students in California community colleges, over 1,000,000 are Latino (813,600) or African American (193,000) (CCLC, 2011). The now defunct California Postsecondary Education Commission (CPEC) projected Latino enrollment in California community colleges would increase by 40% in the next nine years (Lay, 2010).

Community colleges are acknowledged and praised for their role in democratizing higher education. The California Master Plan for Education (California Liaison Committee, 1960), which celebrated its 50th anniversary in 2010, established an open access policy for community colleges. The Master Plan was, and continues to be, praised for "championing democracy, inclusion, and ultimately, promising prosperity and culture" (Douglass, 2010a, p. 2). Enshrined in the Master

Plan, the California community college system provided an opportunity for any interested student to begin post-secondary study. Researchers, however, see a darker side to California's reliance on community colleges, especially in view of the national and state interest in increasing college degree attainment.

Community College Institutional Quality

A growing body of research sees enrollment in a community college as a diversion from a four-year institution (Doyle, 2009; Geiser & Atkinson, 2010; Rouse, 1995). The Department of Education reports that only 21% of students who enter a community college with the intent to transfer and complete a four-year degree do so within six years (National Center for Education Statistics, 2005). The rate of degree-completion is lower and time-to-completion is longer for students who begin their post-secondary education at two-year colleges rather than at four-year colleges (Bound & Turner, 2010; Geiser & Atkinson, 2010; Sandy, et al., 2006). Researchers have analyzed whether these lower success and higher time-to-completion rates are related to institutional quality or to student quality (Bound & Turner, 2010; Doyle, 2009; Rouse, 1995; Sandy, et al., 2006). The short answer is: both.

The community college open access policy accepts, indeed encourages, students to enter college who are not as well prepared as those who enter even moderately selective four-year colleges and universities. While it is true that many community college students are less well prepared than many four-year college students, the research indicates that this is not the full story. I will discuss the lack of student preparedness in a later section on articulation between high schools and community colleges. The key point here is that, independent of student characteristics, researchers observe a disadvantage that they attribute to the institutional quality of two-year colleges (Bound & Turner, 2010; Doyle, 2009; Geiser & Atkinson, 2010; Rouse, 1995; Sandy, et al., 2006).

If we compare resources, the phenomenon of unequal outcomes is not surprising. Bound and Turner (2010) observe that two-year colleges have substantially fewer resources than four-year colleges. Analyzing college completion for a 1992 high school graduating cohort, more than 90% of students who first attended selective[12] private four-year colleges graduated; less than 57% of those at open-access public four-year institutions graduated; and only 17.6% of those who began at community colleges graduated. The differences in resources expended per student by the different institutional types were large: 2.7 times greater at the select private colleges than the public less-selective four-year colleges, and 5.2 times greater than at the community colleges. Bound and Turner (2010) calculate a "penalty in the likelihood of completion" of about 32% for community college students (p. 2).

California state funding further illustrates the substantial resource stratification by higher education sector: UC state funding is $20,641 per student; CSU state funding is $11,614 per student; and community college state funding is $5,376 per student (CCLC, 2011). With such disparate funding levels, it is not surprising that community colleges have lower degree production outcomes.

[12] Bound and Turner (2010) do not define "selective" colleges. The term is used widely however in both popular literature (including college rankings) and in research to refer to colleges with highly competitive admissions processes and large financial endowments.

It is not an accident that a growing proportion of California students begin their post-secondary education in community colleges, the segment of public higher education with the lowest level of state funding. In a series of reports from the Center for Studies in Higher Education, Douglas (2010a, 2010b), and Geiser and Atkinson (2010) examine the history of California's Master Plan for Education. Douglass (2010a) describes the Master Plan negotiations that resulted in the current tri-partite system of public higher education relying heavily on two-year community colleges as primarily a cost containment measure. "The Master Plan shifted future enrollment demand to CCC, actually reducing access to UC and CSU. Why? Largely to save money and create a more politically palatable proposal for expanding enrollment capacity" (Douglass, 2010a, p. 3). Geiser and Atkinson (2010) believe the Master Plan agreement to reduce the cap for UC and CSU eligibility was "fateful" with negative long term consequences; they describe California's heavy reliance on community colleges for higher education as rationing. They write:

> California now ranks last among the states in 4-year enrollment as a proportion of overall college enrollment…. Where a student begins college greatly affects his or her chances of completing a B.A. … Although California's low rate of baccalaureate attainment is sometimes blamed on the failure of community college to produce more transfers, the data point to a more fundamental problem: Lack of 4-year baccalaureate enrollment capacity. California's 4-year sector is simply too small in relation to the size of the state's college-age population. (Geiser & Atkinson, 2010, p. 3)

Writing in 2010, Douglass (2010a, 2010b), and Geiser and Atkinson (2010) thought the prospects were bleak for increased funding to California's public system of higher education. At this writing, in 2012, it remains highly unlikely that higher education in general and community colleges in particular will be able to rely on increased state funding to improve student outcomes. Nevertheless, in the midst of the Great Recession, or perhaps, in part, because of it, there is enormous pressure on community colleges to increase student success as measured by an increase in degree completion and transfer.

To summarize the above section: 1) a majority of the growing demographic of Latino students begin their post-secondary education in community college, and 2) for better or worse, that is unlikely to change. These students, along with their fellow community college peers, need a post-secondary degree in order to be competitive and productive in the 21st century. California community colleges, under-funded though they may be, will have to do the job.

Improving Community College Degree Completion and Transfer Rates

Although it is true that they are under-funded relative to other higher education segments, this does not let California community colleges off the hook. There is compelling research examining community college policies and practices, and the practices of community college students that, independent of funding, are associated with college completion and lack of college completion (Adelman, 1999, 2005, 2006; EdSource, 2010; McClenney, 2006, 2007, McClenney, McClenney & Peterson, 2007; Moore & Shulock, 2010; Offenstein, Moore, & Shulock, 2010;

Perry, Bahr, Rosin, & Woodward, 2010; Shulock, 2010; Shulock & Moore, 2007; Shulock, Moore, Ceja, Lang, 2007).

This following section concentrates on research that identifies patterns of student behavior in community college that are associated with success. It also lays responsibility for increasing student success on factors within the control of the institution. Furthermore, data demonstrating low rates of transfer and completion for community college students, and even lower rates of completing the transfer curriculum, indicate that the Master Plan is not operating as planned. Rather than sailing through community college on the way to a four-year degree, many students are off-course, adrift in community college, and do not complete their goals. The community college segment of the educational pipeline is awash with students who entered with the intent to transfer but failed to make progress toward transfer.

Community college policies have unintended consequences. In a series of papers shaping the current dialogue about community college reform in California, the Institute for Higher Education Leadership & Policy (IHELP) examined California community college policies and practices as they relate to outcomes for students (Moore & Shulock, 2010; Offenstein, et al., 2010; Shulock, 2010; Shulock & Moore, 2007; Shulock, et al., 2007). Their research identified milestones and academic behaviors associated with "success patterns" as well as student behaviors associated with failure to progress (Moore & Shulock, 2010; Offenstein, et al., 2010). In an attempt to translate their findings into actionable policies and practices for community colleges and community college students, IHELP has identified “on track indicators” and “critical milestones[13].” These include earning at least 20 credits in the first year of community college; successfully completing college-level math within two years; continuous enrollment; full-time enrollment; completing attempted courses; registering on time; beginning remedial coursework, if needed, in the first term; enrolling in a transfer curriculum; and maintaining or achieving a higher GPA (Moore & Shulock, 2010; Offenstein, et al., 2010; Shulock & Moore, 2007). IHELP analyses document the validity of these indicators and milestones toward (or away from) likely degree completion. For example, based on the analysis of outcomes within six years for more than 250,000 California community college degree-seeking students[14], 59% of students who completed 20 or more credits in their first year of community college completed a degree or transferred, compared to just 21% who did not complete at least 20 credits in year one. Few students, however, followed these patterns to success; only 25% of the first-year degree-seeking community college students in the study group completed the 20-credit milestone (Moore & Shulock, 2010).

Inequitable outcomes by ethnicity. As charted by research-based indicator and milestone measures, Black and Latino community college students were less likely to follow patterns associated with success than were API and White students. Again looking at completion of 20 credits, 34% of API students, 27% of

[13] My study design builds upon this research approach, seeking success patterns and critical milestones for high school students that flag whether or not students are on track in mathematics to college-readiness.

[14] In this study, IHELP used a definition proposed by Adelman for “degree-seeking” students as students who enrolled in six or more units in their first year (Moore & Shulock, 2010).

White students, 21% of Latino students, and just 16% of Black students met this milestone in their first year of community college (Moore & Shulock, 2010).

Data regarding completion of the community college transfer curriculum further illustrates the low overall student conformity with research-identified patterns of success, and provides evidence that the Master Plan for Education is not functioning as intended. Again, Black and Latino students are disproportionately affected. For example, among all 255,253 degree-seeking students in the Moore and Shulock (2010) study group, only 23% transferred and only 15% actually completed the transfer curriculum as formulated by the California Master Plan for Education [15]. Latino (14%) and Black (20%) students were less likely to transfer than White (29%) and API (24%) students, and they were less likely to complete the transfer curriculum[16]. Twelve percent of Latino students and just 7% of African American students completed the transfer curriculum compared to 16% of White students and 23% of API students. The low transfer curriculum completion rates indicate that these community college students were not eligible to transfer as juniors to a UC or CSU.

For-profit colleges enrolled disproportionately greater numbers of Latino (16%) and Black (19%) transfer students compared to White (8%) and API (7%) transfer students (Moore & Shulock, 2010). For-profit colleges have come under scrutiny for disreputable practices in some cases: enticing students with unrealistic

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[15] "Transfer curriculum" includes a minimum of 60 transferable units and includes completing coursework in college-level English and mathematics.

[16] Paradoxically, although Latino students (14%) were the least likely to transfer, those that did transfer had a higher rate (48%) than average (43%) and than White transfer students (39%) of completing the transfer curriculum. API transfer students had the highest rate (57%) and Black transfer students had the lowest rate, with just 22% completing the transfer curriculum.

promises; encouraging students to take out large loans; having low rates of retention and student success; and incurring high rates of loan defaults (Moore & Shulock, 2010). Whether they attend a public, private, or especially a for-profit four-year college, many of the 57% of transfer students who did not complete the transfer curriculum will not complete a four-year degree.

Discrepancies between research and practice. The low completion rates for transfer and reaching the indicators and milestones that lead to transfer, prompt many questions. Do students know what it takes to complete college? Is that knowledge equitably distributed? Researchers describe the lack of "college knowledge" in high school as an access issue that negatively impacts first generation college-goers, predominantly students who are Latino, Black, and/or from low-socioeconomic households (Kirst & Bracco, 2004; McDonough, 2005; Rosenbaum, 1998; Venezia & Kirst, 2005). Similarly, the low rates of conformity to patterns of success among community college students, and the discrepancies by ethnic group, may indicate that, even once they have entered community college, many students do not know what they need to do to realize their academic goals.

Extensive research on community college student engagement (CCSE) by McClenney (2007), surveying community college students nationwide, provides additional evidence that community college students may not understand what it takes to be a successful college student; ninety percent of entering students indicated that they strongly or somewhat agreed they had the motivation to do what it takes to succeed in college (McClenney, 2010). This high percentage of students expressing self-confidence stands in stark contrast to the low percentage of community college students who actually transfer or achieve other measures of completion. McClenney's (2006, 2007) research corroborates IHELP findings about student behaviors associated with success patterns and emphasizes that "students don't do optional" (McClenney, 2010). This means that, given a choice, students make decisions that are unlikely to help them achieve their stated goals; for example, they do not follow best practices if those practices are optional. Why "students don't do optional" is not clear from the literature. What is clear from the work of McClenney (2006, 2007, 2010; McClenney, et al., 2007) and the researchers at IHELP (Moore & Shulock, 2010; Offenstein, et al., 2010; Shulock, 2010; Shulock & Moore, 2007; Shulock, et al., 2007) is: 1) students are not following patterns of success, and 2) community college policies and practices do not positively influence students to follow patterns of success.

Disconnections between High School and Community College

While researchers predict students would likely experience higher rates of degree completion and transfer if community colleges had greater resources, were more explicit about patterns of success, and provided fewer options to students, there is also overwhelming evidence that many students enter community colleges underprepared for college-level work. Again, data from the CCSE reveals a big gap between student perception and reality: eighty-four percent of community college students surveyed believed they were academically prepared to succeed (McClenney, 2010). Contrast this self-assessment with the results of community college student assessment: eighty-four percent of incoming California community college students were assessed as at least one level below college-level mathematics, and 72% assessed below college-level English (CCCCO, 2009). Contrary to the perceptions expressed in the CCSE survey, most community college students are underprepared for college. They are not college-ready.

What is College-Readiness?

College-readiness is a benchmark, or assumed intermediary step, on the path to college completion. Much of the research on college-readiness identifies it retrospectively, by studying the academic patterns and trajectories of students who have completed four-year college degrees. Other researchers use assessments to measure college-readiness. However, findings based on research examining four-year colleges, may, or may not, be equally applicable to community colleges. For example, Droogsma Musoba (2011), in a national study assessing the impact of state accountability measures, used SAT scores as the measure of college-readiness. The use of SAT scores restricts her sample to those students who intended to attend a somewhat selective four-year college or university. Since community colleges do not require SAT scores, Droogsma Musoba's sample is very different than a sample of community college-bound students. In an effort to understand differences in readiness requirements in mathematics for students attending two-year vs. four-year colleges, Lee (2012) retrospectively used completion data for both two and four-year institutions. He found that the standards for students attending and completing two-year colleges were lower than those for students who matriculated directly to a four-year college. In his discussion, Lee notes that achievement levels commensurate with college-readiness have not yet been clearly established.

Although researchers have yet to agree on a comprehensive definition of college-readiness, un-readiness for college-level mathematics, as assessed and measured by placement examinations, is a significant and well-documented problem for entering community college freshmen. As noted above, more than 80% of entering California community college freshmen were referred to remedial mathematics. These students were under-prepared for college-level coursework.

Underprepared Students Struggle in Community College

There is a big price to pay when students enter college underprepared. Underprepared community college students, known as basic skills students, must complete remedial coursework prior to entering college-level classes. Basic skills students have lower rates of academic success as measured by persistence, transfer, and other goal attainment measures, than do students entering with college-level skills (Adelman, 2006; Brown & Niemi, 2007; Bueschel, 2003; Rosenbaum, 1998; Rosenbaum & Person, 2003). The more remediation students need, the less likely they are to complete a college degree (RP/CSS, 2005). Simply put, these students are unlikely to achieve their post-secondary goals.

All community college students are not equally affected by poor preparation. Black and Latino students demonstrate higher rates of under-preparedness than do White and API students. For example, 11% of the students enrolled in basic skills courses in 2007-08 were Black and 41% were Latino (CCCCO, 2009) compared to a Black population of 7.5% and a Latino population of 29.4% in the general California community college student body (Perry, 2010). Not only are Black and Latino students disproportionately underprepared, they are more underprepared than

White and API students. Black (39% of 3,996) and Latino (30% of 17,301) students assessed into basic arithmetic, four levels below college-level mathematics, disproportionately more than did White (15% of 19,629) and API (15% of 3,865) students (Perry, et al., 2010, p. 38). Once in community college classes, success rates vary by course type and ethnicity, with Black and Latino students experiencing lower levels of successful completion, especially in remedial classes (Brown & Niemi, 2007; Rosin & Wilson, 2008). The majority of Black and Latino students placed in basic skills classes do not pass them (Brown & Niemi, 2007).

Students who begin community college needing extensive remediation are unlikely to progress. Fewer than half of the more than 10,000 students who took basic arithmetic in community college followed up with a higher-level mathematics course (Perry, et al., 2010). Examining outcomes for almost 50,000 first time students who took remedial coursework, Perry, et al. (2010) conclude, "It depends on where you start" (p. 33). This commonsense finding – "it depends on where you start" – means that while we can and must reshape community college policies and practices to optimize student success as evidenced by increased college completion rates, we must also address the issue of "where students start." At the very least[17], this requires breaking through the barriers that separate community colleges and high schools.

Academic Intensity in High School is a Pre-cursor to College Completion

In two seminal longitudinal studies, Adelman (1999, 2006) studied two nationally representative cohorts of students from National Education Longitudinal

[17] Lee (2012) traces grade level achievement as a measure of college-readiness along the P-12 continuum beginning with preK.

Study (NELS) data to “trace the elements of academic momentum” (2006, p. x). Adelman analyzed the academic histories of both cohorts, examining high school and college transcripts, GPA/class rank, socioeconomic status, ethnicity, gender, and high school exit exams to identify and then re-confirm factors associated with completion of a four-year degree. He found that the expectation of attending college was not associated with successful completion of college. “Regardless of what students *say* on a survey about their education expectations, it is what they actually *do* that counts” (Adelman, 2006, p. 10).

Adelman (1999, 2006) reports that academic intensity in high school is the factor most convincingly associated with degree completion. Academic intensity is described as a high school history that includes participating in 3.75 Carnegie units of mathematics including Calculus, Pre-Calculus, or Trigonometry. Adelman’s findings indicate that both the quality of coursework as evidenced by the student’s curriculum sequence and the quality of effort as evidenced by GPA/class rank are significant. Furthermore, Adelman found that taking remedial classes in college did not prevent students with high academic intensity in high school from completing a college degree. Ethnicity, gender, and socioeconomic status were not as important as academic intensity in high school; socioeconomic status was only moderately associated with degree completion; and ethnicity and gender were not significant (Adelman, 2006).

Unclear messages mislead high school students. Building upon Adelman’s findings, efforts to improve student success in post-secondary education include reforming California’s high schools and high school curricula. Just as we can imagine community college as a bridge between high school and a four-year college, we can imagine high school as the road to community college. Unfortunately, the signposts on that road are often unclear or misleading, misdirecting students to engage in behaviors that are inconsistent with the patterns of success associated with college-readiness and college completion.

In "Levers for Change," EdSource identifies high school curriculum as pivotal in improving post-secondary opportunities for students in California (Venezia & Perry, 2007). EdSource proposes requiring the UC and Cal State A-G requirements for high school graduation as an important mechanism for reform. Current (2012) California high school graduation requirements do not meet college entrance requirements, nor does passage of the California High School Exit Exam (CAHSEE) reflect a skill level appropriate for college-level work (California DOE, 2009a, 2009b). In fact, the CAHSEE Math only assesses content mastery leading up to and including Algebra 1, with the greatest emphasis on seventh grade mathematics (Perry, 2011). Venezia and Perry (2007) observe that the State's low minimum standards for graduation mislead students into thinking that they do not need to push themselves in high school.

Contributing further to the misleading message that academic achievement in high school is unimportant for community college-bound students, California does not specify that mathematics be taken in the junior or senior year of high school (California DOE, 2009a). Students are able to complete their two required years of high school mathematics in their freshman and sophomore year and may take no mathematics for the one or two years prior to entering community college and taking a college mathematics assessment and placement test. Miller (2001) reports only one third of U.S. high school students take a mathematics or science course in their senior year. To the extent that they communicate to high school students that open access means no standards, community colleges are complicit in setting students up to waste their senior year.

Like high school graduation requirements, assessments also convey messages. Mandatory state tests reflect state standards and express expectations for high school student achievement (Atkinson & Geiser, 2009; Brown & Conley, 2007; Brown & Niemi, 2007; Jellison Holme, et al., 2010; Rosin & Wilson, 2008; Venezia & Kirst, 2005). To check for standards alignment between the high school and community college systems in California, Brown and Niemi (2007) compared standardized high school tests with assessment tests used by community colleges to determine placement into college-level or remedial mathematics classes. For the high school assessments, they analyzed the Algebra 2 California Standards Test (CST) and the Summative High School Math Tests given to 11th graders who have completed Algebra 2. While the assessment for completion of Algebra 2 in high school is standardized, there are almost 100 different assessments in use by California community colleges. This plethora of assessments illustrates both the variety and the inconsistency of community college expectations, and contributes to the unclear messaging about the level of high school preparation necessary for college-readiness (Brown & Niemi, 2007; Bueschel, 2003; Rosin & Wilson, 2008; Venezia & Kirst, 2005).

Brown and Niemi (2007) analyzed the three assessment tests most frequently used by California community colleges, accounting for more than 360,000 of the 475,000 assessments taken by 18-24 year old community college students enrolled in 2005-2006. Their analysis determined that the content standards included in the augmented CST administered to 11th grade high school students only modestly aligned with the assessments community colleges used for placement. The subject matter that was either missing or weakly aligned on the high school test included content beyond Algebra 2. In addition to finding a weak alignment between exiting high school and entering community college expectations as demonstrated by CST and community college assessment content, Brown and Niemi (2007) report that in 2006, only about 12% of California high school students tested took the Algebra 2 CST; of the 12% tested, only 25% received a score indicating proficiency. Almost half scored below basic. Eighty-six percent of the remaining 1,731,267 high school students tested were tested for coursework below the Algebra 2 level. Thus, even if the CST did align more consistently with the requirements for placement in college-level classes, very few high school students are taking the test and even fewer are reaching levels of proficiency. Given the mismatch between high school and community college expectations and the poor performance of high school students on the CST[18], it is not surprising that so many high school graduates place into remedial mathematics courses when they enter community college (Brown & Niemi, 2007).

The California Legislative Analysts Office (LAO) and some researchers have suggested community colleges use results from the high school California Standards

[18] Teachers and researchers speculate that students, especially high school students, do not apply themselves to the CST because it is a low-stakes test with no consequences for students.

Test (CST) to determine college class placement (Atkinson & Geiser, 2009; Rosin & Wilson, 2008; Venezia & Kirst, 2005). Although Brown and Niemi's (2007) analysis reveals concerns about content alignment, there are good reasons for community colleges to accept high school standardized tests to determine college course placement. Duplication and its associated costs would be reduced, and alignment– or lack thereof– of the high school and community college systems standards and expectations would become more apparent. Colleges would be able to assess if students who pass high school standardized tests are in fact successful in college-level classes, and high school students would get timely feedback on their progress toward college-readiness. Alternatively, Bueschel (2003) and Venezia and Kirst (2005) discuss administering community college placement exams to students while they are still in high school. This, too, would provide high school students with an important and timely message, either an early warning or an early confirmation about how well they are prepared for college. Students who are not proficient on the college placement test would know that they have more work to do to be ready for college and might be motivated to apply themselves during their senior year of high school. Early placement exams "can provide concrete evidence to students that they need more math" (Berry, 2003, p. 406).

The current collective and systemic failure to alert high school students that they need to be well-prepared for community college encourages complacency and sets students up for failure (Rosenbaum, 1998; Rosenbaum & Person, 2003). Payne (1989) writes of high schools "perpetuat[ing] a cruel hoax" on under-prepared students (p. 26). Bueschel (2003) and Venezia and Kirst (2005) report that high school students are unaware of the levels of competency required for college and believe they can slack off in high school and then get serious in college. Research clearly documents, however, that student achievement in high school impacts success in college. Fewer than 14% of high school seniors with low grades who aspired to earn a college degree actually did (Rosenbaum & Person, 2003).

Under-represented minorities experience opportunity gaps. Adelman (1999, 2006) finds that academic intensity and effort in high school are far more significant factors for college completion than are ethnicity, gender, or socioeconomic status[19]. Students, including students of color, who take an intense academic curriculum in high school, significantly improve their chances of completing college. He postulates:

> By moving into the top two quintiles of the curriculum measure and completing a high school mathematics course beyond Algebra 2, African-American students who started out in a four-year college would hypothetically increase their bachelor's degree attainment rate from 45 percent to 73 percent; Latino students who did the same would hypothetically increase their bachelor's degree attainment rate from 61 percent to 79 percent. (Adelman, 2006, p.5)

Droogsma Musoba's (2011) research supports Adelman's work. She found that taking Calculus (compared to Algebra 2) in high school had the largest positive impact on college-readiness[20], with the greatest impact for Black students, followed

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[19] Adelman (2006) found that only socioeconomic status was "significantly associated with degree completion, though in a modest manner. Gender and race/ethnicity were never significant" (p. xxiii).

[20] Droogsma Musoba (2011) used a national sample of 100,000 students to study the impact of accountability measures on college-readiness as measured by SAT scores.

by Latino students and then White students. Taking Pre-Calculus/Trigonometry also had a significant and large effect for Black, Latino, and White students[21] relative to Algebra 2 (Droogsma Musoba, 2011).

Unfortunately, and unfairly, not all high schools provide the curriculum students require to be prepared for college. Many high schools in communities of low socioeconomic status, often serving Latino and Black students, do not offer a rigorous college preparatory curriculum (Adelman, 2006; Almy & Theokas, 2010; Geiser & Atkinson, 2010; McDonough, 2005; Oakes, 2008; UCLA/IDEA 2007; Venezia & Perry, 2007). Adelman (2006) notes that we will not be able to close the gap in student preparation if we do not close the opportunity gap in curriculum. He writes, "One can see the ripples of opportunity—or lack of opportunity—that start in high school offerings" (p.32). The 2007 California Educational Opportunity Report documents both a "national opportunity gap" between California and the rest of the nation, and a "racial opportunity gap" in California (UCLA/IDEA, 2007, p. 5). Three fourths of California's Latino and Black high school students attend majority minority schools serving a majority or super-majority of low-income students. Students from low socioeconomic status are more likely to attend schools with inequitable academic opportunities. These schools have fewer resources and provide inferior educational opportunities compared to secondary schools with fewer low-income students and more White and API students. For example, California high schools serving majority and super-majority Black and Latino students have fewer counselors, fewer qualified teachers, less access to classes that meet A-G requirements, and more teachers teaching subject matter outside of their credential

[21] Droogsma Musoba (2011) dissagregated her data for Black, Latino, and White students. She did not include API students.

(UCLA/IDEA, 2007). Adelman (2006) notes that we will not be able to close the gap in student preparation if we do not close the opportunity gap in available curriculum. "The critical boundary for math momentum now lies firmly beyond Algebra 2. But therein lies the rub, for not everyone has the chance to reach beyond Algebra 2" (Adelman, 2006, p. 31). Lack of access to a full college preparatory curriculum disproportionately affects students with low socioeconomic status (UCLA/IDEA, 2007).

Because many Black and Latino students are would-be first generation college-goers, they rely on schools to inform them about what they need to do to be successful in college. McDonough (2005) and UCLA/IDEA (2007) point out that the ratio of college counselors in high schools is low in California, and particularly low in low-income schools where students and their families have the least knowledge of college. Venezia and Kirst (2005) conclude that "first-generation college goers and students who are left out of the college cultures in their schools" (p. 297) are disproportionately impacted by the "weak and confusing signals about necessary academic preparation" (p. 285). These students, disproportionately Black and Latino, do not realize that minimum high school graduation requirements are not the same as college entry-level requirements. Students are not informed about either the quantity or quality of coursework they need in high school to be college-ready.

To summarize, the message conveyed to students by low high school graduation requirements, weak counseling, misaligned assessments, and community college open admission policies is that the work students do in high school is irrelevant (Atkinson & Geiser, 2009; Brown & Niemi, 2007; Bueschel, 2003; Rosenbaum, 1998; Rosenbaum & Person, 2003; Venezia & Kirst, 2005). These misleading messages, coupled with inequitable educational opportunities, negatively and disproportionately impact Black and Latino students in California. The information gap and the educational opportunity gap contribute to a preparation gap for college.

The Role of Mathematics in College Completion

Students who are affected by the misleading high school graduation requirements, inadequate counseling, misaligned assessments, and inequitable educational opportunities discussed above, are often most severely impacted in mathematics. For them, college-level mathematics is a particularly significant obstacle on the road to college completion.

College-level Mathematics as a Gateway or Roadblock

For many students, college-level mathematics is not a gateway; it is a roadblock. In California, high school graduates seeking admission to the University of California (UC) system or the less selective California State University (CSU) system must meet eligibility requirements including three years of mathematics with four years recommended, with completion of Algebra 1, Geometry, and Algebra 2 (California State University, 2011; Rosin & Wilson, 2008; University of California, 2007). In contrast, as discussed above, the California community college system has no pre-requisites for admission. However, although California community colleges have no entrance requirements, many community college students plan to transfer to and graduate from a four-year college. Researchers calculate that the percentage of community college students who either demonstrate[22] or state their intent to earn a degree or transfer ranges from almost 50% (LAO, 2011) to 60% (Shulock & Moore, 2007). Per the California Master Plan for Education, community college students who wish to transfer to a UC or CSU with junior status must complete a transfer curriculum that includes college-level mathematics. If students have not completed college-level mathematics prior to transferring, they will still need to complete it prior to graduating from most four-year degree granting institutions. This is how mathematics functions as a gatekeeper to a four-year degree. Completing college-level mathematics is the gateway students must pass through to transfer to the UCs or CSUs as juniors. For students who are unable to pass through that gateway, college-level mathematics becomes a roadblock. The college-level mathematics requirement blocks many community college students from completing the community college transfer curriculum or earning a four-year degree. Even for two-year degree completion, mathematics functions as a roadblock for many students since students must pass Intermediate Algebra (Algebra 2) to earn a two-year Associate of Arts or Associate of Science degree.

Duplicating mathematics credits wastes time and money. When students first matriculate to community college, they are given assessment tests in English and mathematics to determine their course placement. As already noted, high numbers of students enter California community colleges under-prepared for college-level coursework. The 2009 Basic Skills Accountability Report reported that

[22] Shulock and Moore (2007) identified students as "degree-seeking" if they were 17-19 when they first enrolled; and/or indicated a goal of degree or certificate completion or transfer; and/or completed at least 12 units and attempted a transfer or degree level English or math course. The LAO (2011) does not describe how he determined that 50% of community college students are degree-seeking.

84% of incoming community college freshmen assessed below college-level mathematics in Fall 2007 (CCCCO, 2009a). Before progressing to college-level classes, these underprepared students must repeat coursework they should have learned in high school. This duplication of coursework represents a high cost for both the student and the state in time, money, and future prospects. In mathematics, under-preparedness is doubly troublesome because the more remediation students need, the less likely they are to progress through the remedial curriculum sequence to complete a college degree. As previously noted, EdSource found Black and Latino students disproportionately placed into basic arithmetic, the lowest level of remedial coursework (Perry, et al., 2010). The Research and Planning Group for California Community Colleges, 2005 reports, "The likelihood of taking a transfer[23] level math course after starting in a basic level math course is only 10%" (Brown & Niemi, 2007, p. 2).

Mathematics is optional in twelfth grade. In a series of draft reports on "Community College Math Transitions," California Partnership for Achieving Student Success (Cal-PASS) examined data to compare "12th grade math attempters" to "12th grade math non-attempters." Report 2009027a from January 2009 (*N=214*) found that both groups had comparable success rates in their first community college math course – 53% for students who had taken mathematics in grade 12 and 55% for students who had not taken mathematics in grade 12. Key differences appeared in the level of high school mathematics completed and the level of community college mathematics attempted. Almost all of the students who took

[23] Transfer level is the same as college-level, above Algebra 2.

mathematics in grade 12 completed Intermediate Algebra[24] or higher. Eighty-four percent of 12th grade mathematics attempters took Intermediate Algebra or above as their first community college mathematics course compared to just 47% of students who did not take mathematics in grade 12 (Stern, 2009a). Another Cal-PASS report analyzing the mathematics transition for 531 students, also found that students who took mathematics in grade 12 attempted higher-level community college mathematics courses (Stern, 2009b). Cal-PASS Report 2009034a found a strong correlation (*$r=0.695$, $p=<0.001$*) between last high school mathematics course successfully completed and the first community college mathematics course attempted (Stern, 2009c).

High school students need to know they must demonstrate higher-level mathematics skills to place into and complete college-level mathematics courses. Berry (2003) reported that students who took a fourth year of rigorous high school mathematics (beyond Algebra 2) were much more likely to place into college-level mathematics and, if they placed into remedial mathematics, were much more likely to complete that coursework.

High School Mathematics as Preparation for College

Adelman's (1999, 2006) research illuminates academic behaviors that are precursors for completing college. He identifies high school achievement in mathematics as an especially significant predictor, stating, "The highest level of mathematics reached in high school continues to be a key marker in precollegiate

[24] Intermediate Algebra is one level below college level mathematics. As of 2006, Title V Regulations were revised by the California Board of Governors to require successful completion of Intermediate Algebra as a requirement for earning an Associates Degree. Intermediate Algebra and Algebra 2 are the same course.

momentum, with the tipping point of momentum toward a bachelor's degree now firmly above Algebra 2" (Adelman, 2006, p. xix). Adelman (2006) found that every mathematics course beyond Algebra 2 completed in high school more than doubled the odds of completing a college degree. Algebra 1 is therefore a requisite first step to completing high school coursework that prepares students to complete college. Yet, historically, students from different population subgroups have had inequitable access to algebra courses (Adelman, 1999, 2006; Burris, et al., 2008; Gamoran & Hannigan, 2000; Loveless, 2008; Silva & Moses, 1990; Spielhagen, 2006).

Traditionally, American high schools sort entering ninth-grade students into general mathematics, pre-algebra, algebra, or geometry courses. The logic underlying these different ninth-grade mathematics placements is that students need to master each level of mathematics before progressing to the next (Gamoran & Hannigan, 2000). However, each of these traditional ninth-grade mathematics placements lead to different course taking patterns with different and unequal preparation for college-readiness and college completion. Research provides evidence that sorting or tracking students into different mathematics courses and different high school course pathways has been implemented inequitably with the result that academically like students were provided different and unequal knowledge and opportunity (Burris, et al., 2008; Gamoran & Hannigan, 2000).

In recognition of the importance of algebra as a gatekeeper and of past and continuing failures to provide all students with equal access to algebra, California now requires that all students complete Algebra 1 to graduate from high school and has been wrestling with mandating Algebra 1 for all eighth-grade students. In July

2008, the State Board of Education approved a requirement for all eighth graders to take algebra within three years. Governor Schwarzenegger solicited and supported this decision, hailing algebra as "the key that unlocks the world of science, innovation, engineering and technology" (Associated Press, 2008; Ramirez, 2008). However, Superintendent of Public Instruction Jack O'Connell, citing insufficient public discussion, preparation, or funding for such a significant new policy, called the mandate "a recipe for disaster" (Ramirez, 2008). In December 2008, a judge ruled that the Board of Education had overstepped its authority, and the implementation of the eighth-grade algebra for all policy was halted (Ramirez, 2008). Since then, although California has not required all students to take algebra in eighth grade, schools are penalized if they do not. If eighth graders take the General Mathematics CST instead of the Algebra 1 CST, their Academic Performance Index score is dropped one level (Williams, Haertel, Kirst, Rosin & Perry, 2011).

Researchers have documented benefits to taking Algebra 1 in the eighth grade (Adelman, 2006; Burris, et al., 2008; Gamoran & Hannigan, 2000; Silva & Moses, 1990; Spielhagen, 2006). In a four-year longitudinal study of a large, 60,000 student, southeastern school district, Spielhagen (2006) analyzed the quality and quantity of high school mathematics courses taken through 11th grade by students who took algebra in grade 8 and those who did not. Completing algebra in eighth grade set students up to take Geometry, Algebra 2, and then two more years of higher mathematics in high school, increasing their college-readiness. Even though the state where Spielhagen's study occurred only had a two-year high school mathematics requirement, as does California, students who took algebra in eighth grade were more likely to continue past the minimum two-year requirement and take Calculus in the 12th grade. On the other hand, students who did not begin algebra until the ninth grade often did not advance beyond Algebra 2 by graduation (Spielhagen, 2006).

Spielhagen (2006) found that, overall, students who took algebra in eighth grade went on to take more mathematics classes and went on to attend college at a higher rate than did students who began algebra in ninth grade. In discussing her study and her findings, Spielhagen (2006) drew no conclusions regarding causality nor did the study make a case for requiring all students to take algebra in the eighth grade. However, this study correlated taking Algebra 1 in eighth grade with increased rates of college attendance, and suggested that more students could (and should) benefit from taking algebra in eighth grade. Interestingly, it was not achievement in mathematics that seemed to be impacted, but course history and college enrollment were positively affected. The role of high school mathematics course history as a precursor to college is well established by Adelman's (1999, 2006) findings that academic intensity is most closely associated with, not just enrollment, but actual completion of college.

High school mathematics pathways begin in middle school. A 2011 EdSource report (Williams, et al., 2011) examining middle school mathematics in California, adds complexity to the question of eighth-grade algebra. Williams, et al. (2011) report that far more California students, including students of color, are accessing Algebra 1 in eighth grade in 2010 (*N=271,686*) than did so in 2003 (*N=151,714*). Not only are more students taking Algebra 1 in eighth grade, 39%

more students accessed as Proficient in Algebra 1 in 2010 as in 2003. Low income, Black, and Latino children all have increased rates (and numbers) of students who are Proficient in eighth-grade algebra. Demonstrably, considerable progress has been made in expanding access to algebra. The story however is more nuanced, especially when we look at preparation, and student success.

Counter-intuitively, Williams, et al. (2011) found that middle schools in lower socioeconomic areas placed a greater percentage of students in Algebra 1 in eighth grade than did schools serving more middle class students. This difference reflects different placement practices. Of similarly prepared students who scored Far Below Basic, Below Basic, or low Basic on the seventh-grade CST, schools in lower socio-economic communities enrolled almost twice as many students (proportionately) in eighth-grade Algebra 1 as did schools in higher socioeconomic areas. Among similarly prepared students, Black and Latino students were more likely to take Algebra 1 in eighth grade than were White students. For the full study group, using seventh-grade Mathematics CST scores as a measure of preparedness, 27% of Far Below Basic, 33% of Below Basic, and 48% of low-Basic students were placed in Algebra 1 in eighth grade. The researchers found that students who had scored at these three lowest performance levels in seventh grade, were unlikely to do well on the Algebra 1 CST administered at the end of eighth grade. However, there were some surprises. As expected, students who scored Advanced on the seventh-grade CST were likely to do well on the eighth-grade CST, but the relationship was not always consistent. For example, 37% of students who scored in the high Proficient range on the seventh-grade CST scored Basic or lower on the eighth grade-CST. On the other end of mastery, only 3% of students who scored Below Basic on the seventh-grade CST scored Proficient or Advanced on the eighth-grade Algebra 1 CST.

EdSource explores the importance of seventh-grade mathematics further, describing it as the “pivot point” in California’s mathematics pipeline. How well students do in mathematics in grade 7 determines, or, at the very least, strongly influences, *what* students will do and *how* they will do. In terms of *what* they will do, the end of seventh grade marks the beginning of differentiated and diverging mathematics pathways as students advance, or don’t, from general mathematics to Algebra 1 or accelerated Algebra 1. In terms of *how* they will do, content mastery of seventh grade mathematics provides the foundation for learning Algebra 1. Demonstrating the importance of content mastery, only 11% of students who scored in the low range of Basic on the seventh- grade CST scored Proficient or Advanced on the eighth-grade Algebra 1 CST (Terry & Rosin, 2011). Accordingly, Terry & Rosin (2011) argue for placing students in eighth grade mathematics very carefully, based on their mastery of grade 7 and earlier mathematics. They find that students who have not mastered these earlier concepts and skills struggle in mathematics throughout high school.

Williams et al. (2011) concur: “Students’ preparedness to succeed in mathematics varies dramatically by the time they enter grade 8.” (p. 9). In general, based on eighth grade Algebra 1 CST scores, students (30%) who scored high Proficient or Advanced on the seventh grade Mathematics CST were well-prepared; students (40%) who scored low Basic, Below Basic, or Far Below Basic were not prepared; and the outcomes for students (30%) in the middle who scored high Basic or low Proficient were mixed. The researchers contend that placing all students in Algebra 1 in the eighth grade, a "one size fits all" approach, sets up many students for failure.

These researchers found seventh-grade Mathematics CST scores to be a useful indicator of preparedness for eighth-grade algebra. They enlisted the Algebra 1 CST as a measure of success. Williams et al. (2011) questioned but did not explore the impact of course repetition, asking how students fare who take Algebra 1 in eighth grade and then repeat it in ninth grade. They express concern that enrolling students who are not ready in eighth-grade algebra is misplacement that may negatively impact the students' attitude and high school mathematics choices. "What math content is taught, to which students, and in what grade represents a very complex systems challenge for California" (p. 14). They close with some advice:

> State leaders should start with the facts about student preparation and clarify their goals for student success in math. They should also acknowledge that all students deserve math courses that challenge them, but that all students need not follow an identical path and timeline toward college- and work-readiness. (Williams, et. al., 2011, p. 15)

The debate about eighth grade and algebra continues to evolve. In 2010, California adopted the national Common Core standards in mathematics, to be implemented statewide beginning 2014-2015. The Common Core offers pre-algebra in eighth grade, giving students more time to learn and master foundational mathematics, before beginning Algebra 1 in grade 9. As I write this

(September 2012), California has appointed a Mathematics Curriculum Framework and Evaluation Criteria Committee to weigh in on implementation options for school districts, including an "acceleration path" that would preserve Algebra 1 in eighth grade for some students (Fensterwald, 2012).

Conclusion

Mathematics plays a critical role as a gatekeeper to completion of higher education with a disproportionately negative impact on Latino and Black community college-bound students. Disproportionately, these students are impacted by inequitable access and institutional misalignments between high school and community college, underpreparing them for college-level mathematics.

My thinking has been shaped by both the findings and the methods of the research discussed in this literature review. Viewed through the lens of mathematics, my study analyzes the following co-mingled phenomena for students who attend community college as freshmen: 1) high school mathematics experience; 2) high school preparation for, and articulation with, matriculation to community college; and 3) equity in educational opportunities, experiences, and outcomes in mathematics for Black and Latino students. Chapter 3 describes my study design and methods.

CHAPTER 3: RESEARCH DESIGN, DATA COLLECTION, AND METHODS

This research focused on the role of mathematics as a roadblock to college completion. Specifically, the study examined how different high school mathematics histories aligned with and predicted readiness, or un-readiness, for college-level mathematics.

Research Questions

Analyzing retrospective longitudinal high school and community college data for four high school cohorts, the framing question for this study was "How did the experience and preparation students received at a comprehensive public high school prepare them for placement into college-level mathematics at the local community college?"

The primary research questions were:

1) What are the high school mathematics course-taking experiences of the high school students and of the subset of students who matriculated to the community college as freshmen?

    a) How, if at all, do high school mathematics course-taking patterns differ by ethnicity?

2) Controlling for demographic factors and other background characteristics, how do different high school mathematics course-taking patterns and achievement predict placement into community college mathematics?

    a) How, if at all, does not taking mathematics in grade twelve affect the likelihood of placing into college-level mathematics in community college?

b) How, if at all, do characteristics of high school mathematics course-taking that are predictive of placement into college-level mathematics apply to students from different ethnic groups?

Research Design

The research design was based on a quantitative analysis of student archival data collected for non-research purposes by a pK-12 unified school district and a community college district engaged in an education collaborative. The retrospective longitudinal cohort study of the high school graduating classes included seventh-grade California Standards Test (CST) scores to assess prior knowledge, and tracked coursework in mathematics from seventh grade continuing through high school to community college. Data was analyzed using descriptive and inferential statistics. This quantitative approach permitted analysis of the academic histories of large numbers of students and an examination of the relationships between and among high school variables and the community college placement outcome. Building upon findings by Adelman (1999, 2005, 2006) and others (Berry, 2003; Brown & Niemi, 2007; Burris, et al., 2008; Gamoran & Hannigan, 2000; Lee, 2012; Loveless, 2008: Silva & Moses, 1990; Spielhagen, 2006; Stigler, et al., 2010) that mathematics is an especially significant gatekeeper, I focused my study on academic progress in mathematics. Implicit in this study, progress in mathematics is posited as a proxy for academic progress toward college completion.

To fully understand the actual mathematics pathways that students tread pre-collegially, I examined academic records of student performance and enrollment patterns in mathematics, longitudinally, beginning with seventh grade for some students,[25] and continuing through high school graduation. After identifying key variables that characterized the different high school mathematics pathways, I used multinomial logistic regression to test the high school variables for statistical significance and predictive value relative to articulation with college, as measured by the community college assessment for placement into college-level mathematics. This methodology provided an analysis of how effectively different high school mathematics course-taking and achievement patterns prepared students for a smooth transition into college-level mathematics. The research design was predicated on the belief that examining what students do, as documented in their academic transcripts, will reveal, as Adelman (2005) put it, "where the institutional environment is functioning as intended" (p. 3) and where it is not.

The metaphor of an educational "pipeline" implies that students are conveyed through a single experience, moving from one level of education to the next. Rather than assume high school students travel a single pipeline with single points of entry and exit, I scrutinized students' high school mathematics experiences with the premise that students follow different mathematics pathways that lead to different outcomes. By observing student mathematics behavior and progress in high school and linking specific high school experiences with placement at the community college, this study illuminates both the overall functionality of the existing high school-community college continuum, and the effectiveness of specific high school mathematics experiences in preparing students for college-level mathematics. It also questions the appropriateness of the pipeline metaphor.

[25] Of the 2920 12th graders in the full sample, seventh grade records were available for just 1040 students; ninth grade records were available for 2441 students.

The study design included analyzing course-taking and achievement data from middle school to control for prior knowledge, identifying the forks in the road where student mathematics pathways and outcomes diverge, and identifying markers or turning points along the high school mathematics pathways where focused interventions are likely to have significant impact on increasing college-readiness. As discussed in Chapters 1 and 2, increasing college attainment for Latino and Black students is a particularly critical mission for the nation and the state. To add to the research supporting improved outcomes for these students, I examined equity in educational opportunity and achievement by disaggregating and analyzing each research question for the four ethnic groups prominent in the sample: Black, Latino, API, and White students.

The research of Clifford Adelman (1999, 2005, 2006), and IHELP researchers (Moore & Shulock, 2010; Offenstein, et al., 2010; Perry, et al., 2010; Shulock, 2010; Shulock & Moore, 2007; Shulock, et al., 2007; Shulock et al., 2011) provided the foundation, framework, and springboard for the research design. My study design and analyses built upon their research, utilizing concepts of benchmarks, indicators, milestones, and success patterns. However, my research design differed from theirs as follows: My study is grounded in a local context; focuses solely on progress in mathematics; identifies and analyzes characteristics of different observed high school mathematics pathways; examines the effectiveness of high school mathematics preparation as measured by community college assessment results; and tests predictive models using high school and community college demographic and mathematics variables.

In examining the alignment in mathematics between high school and community college, I use the community college mathematics placement examination as an output to measure the effectiveness of different patterns of high school preparation.[26] Figure 1 illustrates the pivotal role of the assessment in studying the high school to community college continuum.

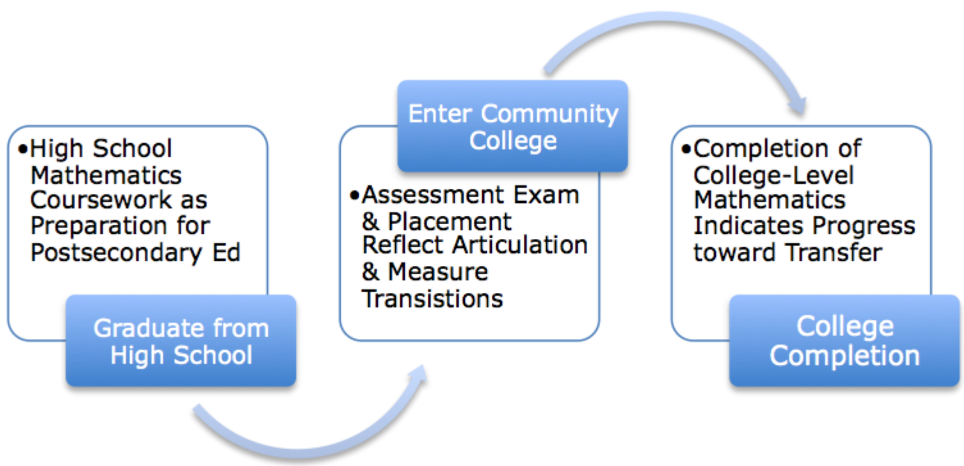

Figure 1. Community college mathematics assessment measures the effectiveness of high school preparation and of community college experience.

Rationale for Site Selection

Maxwell (2005) advises, "you are not only sampling *people*, but also *settings*, *events,* and *processes*" (p. 87). The research sites, a single urban, comprehensive high school and a large community college with ethnically and economically diverse students, are located in Southern California. Close examination of these institutions, and how they are functionally linked, provided a valuable opportunity to delve into

[26] Future research will use the placement assessment as a starting point, or input, to examine the effectiveness of different community college experiences by analyzing student progress from assessment to completion of college level mathematics.

the relationship between student course-taking and achievement patterns and progress toward transfer. By concentrating this study on a single feeder high school and community college, settings that can be described and contextualized, a detailed narrative emerged identifying the decisions and experiences that impact a smooth (or not so smooth) process of matriculation from this high school to this community college for these students.

Much of the literature regarding low educational attainment rates for low income and Latino and Black students, cites inequitable educational opportunities characterized by schools with inadequate facilities, lack of text books, lack of qualified teachers, lack of A-G curriculum offerings, lack of AP coursework, etc. (Adelman, 2006; Almy & Theokas, 2010; Geiser & Atkinson, 2010; McDonough, 2005; Oakes, 2008; UCLA/IDEA 2007; Venezia & Perry, 2007). The selected high school was a particularly attractive research site because it did not suffer from these educational resource shortcomings but did have an economically and ethnically diverse student population. Analyzing the academic progress of Latino and Black students, as evidenced by their high school mathematics course-taking history in this relatively resource-rich setting, provided an opportunity to dig past school-based educational opportunity gaps associated with inequitable school resources, to analyze the impact of specific course-taking and achievement patterns. Furthermore, many of the reforms suggested in the literature had already been implemented at the study high school, Casella High.

Casella High School. In 2002, Casella High, the 3,400 student large, comprehensive over-crowded high school, was reorganized into six houses in keeping with research on the desirability of small learning communities. In 2005, WASC reaccredited the school for six years. Casella High is considered a crown jewel of the community. Sitting on 33 acres of prime real estate, it is the largest high school in the district. In 2008, it had a renowned music program, offered 15 Advanced Placement courses, four foreign languages, Regional Occupational Programs, sports, journalism, theater, and many student-led clubs. According to the California Department of Education, the graduation rate was 93%, and 96.3% of teachers were credentialed. In terms of rigor and expectations, the Board of Education adopted policy encouraging all high school graduates to complete A-G requirements, preparing them for a four-year college. And, although the state has only a two-year mathematics requirement for graduation, the school district required three years. While there are many other factors that relate to a student's academic achievement, those commonly cited as missing school-based elements were present at the selected site. These conditions facilitated examining other institutional structures and coursetaking patterns for their relationship to student success.

Research documents the importance of taking a college preparatory mathematics sequence with successful completion of Algebra 1 in eighth grade opening the door to a higher math sequence in high school (Adelman, 2006; Burris, et al., 2008; Center for the Future of Teaching and Learning, 2008; Gamoran & Hannigan, 2000; Loveless, 2008; Silva & Moses, 1990; Spielhagen, 2006; Terry & Rosin, 2011; Williams et al., 2011). Adelman (1999, 2005, 2006) identified completion of Algebra 2 in high school as the "tipping point" for college completion. The study high school offered college preparatory mathematics to all students.

However, the different mathematics sequences varied in pacing and rigor. For example, students in this sample began Algebra 1 in grade 7, 8, 9, or even 10. Regular and honors sections were available at the high school for Algebra 1, Geometry, and Algebra 2, and Advanced Placement (AP) sections were offered for Pre-Calculus, Calculus, and Statistics (see Appendix A). The different mathematics sequences correspond to differences in academic intensity.

The high school's mathematics teachers identify four general mathematics sequences or pathways that flow from the different mathematics courses offered in ninth grade. For the students in my sample, the four ninth-grade mathematics offerings were general math/Pre-Algebra, Algebra 1, Geometry, or Algebra 2. All four of these general mathematics pathways theoretically permitted students to complete Algebra 2 prior to graduating from high school. Table 1 illustrates the four basic high school mathematics pathways.

Table 1.
Basic High School Mathematics Pathways

	Pathway 1	*Pathway 2*	*Pathway 3*	*Pathway 4*
Grade 9	Pre Algebra or Gen Math	Algebra 1	Honors Geometry	Honors Algebra 2
Grade 10	Algebra 1	Geometry	Honors Algebra 2	Pre-Cal
Grade 11	Geometry	Algebra 2	Pre-Calc	AP B/C Calculus
Grade 12	Algebra 2	Pre-Calc or Statistics	AP Calculus or AP Statistics	AP Statistics

Note. Algebra 2 is shaded in the table to emphasize its role as a tipping point for college completion (Adelman, 1999, 2005, 2006).

As depicted in Table 1, the high school mathematics pathways were generally defined by coursework beginning in grade 9, and an assumption that students take four years of mathematics with no course repeats.

Lawson Community College. The study community college, Lawson (LCC), is also relatively[27] educationally resource rich and has a diverse student body. In 2008, LCC served 24,000 full time equivalent students in credit courses. The student body was 10% Black, 22% Latino, 17% API, and 35% White. Situated within walking distance of the high school, LCC is known as a transfer institution with a highly qualified faculty and a broad menu of student support services. LCC has implemented many research-based student success practices, such as student orientation, student success counseling, supplemental instruction, and mandatory assessment. Mandatory assessment[28] is essential to the design of this study as it provides the outcome/dependent variable for measuring the effectiveness of high school preparation in mathematics for college-readiness.

Since so many recommended practices and reforms were already in place at Casella High School, my research delved past lack of resources and obvious reforms to observe and analyze the core process of high school student course-taking patterns, and the effectiveness of those patterns as preparation for college-level mathematics. Lastly, and perhaps most importantly in terms of site selection, the school district and the community college district entered into a collaborative partnership in 2008. Both institutions have a strong interest in working together to improve student success. Their commitment and cooperation made this research possible.

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[27] Both Roslyn Unified School District and Lawson Community College are relatively resource rich compared to similar educational institutions in California. However, both California public K-12 and higher education are under-financed relative to other states.

[28] Lawson Community College uses the ACT COMPASS assessment test. Although California community colleges use almost 100 different assessments, according to Brown and Niemi (2007), ACT COMPASS is one of the two most commonly used assessment tools, which together account for almost half of all assessments. Hughes and Scott-Clayton (2011) report that ACT COMPASS is used by 46% of community colleges (nationwide) using placement exams.

Rationale for Sample Selection

This study is particularly interested in the subset of high school graduates who attended community college as freshmen. The study sample began with four high school graduating classes from a community college's local feeder high school. This was an economically and ethnically diverse group of students. Inclusion of the entire class permitted an analysis of the functioning of the high school experience in mathematics for all students, as well as a comparison of the academic experiences and demographic characteristics of the subset of students who matriculated to the community college as freshmen. Beyond initial descriptive statistics exploring the high school experience of the full class of 2,920 12^{th} graders, the study focused on the 953 students from the high school who matriculated directly to the community college as first-year students. Although many students access community colleges at different times and in different ways, my research was motivated by the need to increase college completion rates and was based on an assumption that improving articulation in mathematics between high schools and community colleges is essential for increasing student success. Accordingly, analyzing the academic histories of students who matriculated directly to community college as freshmen was most appropriate.

All analyses were disaggregated by ethnicity. To ensure that the sample would be large enough for valid statistical analyses, and that ethnic subgroups would also be large enough for valid statistical analyses, the dataset included student records for four high school graduating classes. Including four high school graduating cohorts also protects the identity of students.

Sample description. The universe of subjects begins with 2,920 students; this group is evenly comprised of all students in the high school graduating classes of 2006, 2007, 2008, and 2009[29]. The full sample is evenly split by gender, and includes students from four major ethnic groups: Black, Latino, API, and White. Ethnicity[30] is unknown for fewer than 1% of students. Table 2 presents demographic data for the sample.

Table 2.
Demographic Overview of Students Subdivided by the Subset of Students Who Matriculated as Freshmen to the Community College (CC Freshmen) and Those Who Did Not (Not CC Freshmen)

	Full Sample's Attendance as Freshmen at the Community College		Total All 12th Graders *n=2920* *100%*	*% All 12th Graders*
	CC Freshmen *n=953* 32.6%	Not CC Freshmen *n=1967* *67.4%*		
Gender				
Male	34%	66%	1452	49.7%
Female	31%	69%	1468	50.3%
Ethnicity				
Black	36%	64%	260	9%
API	27%	73%	248	8%
Latino	39%	61%	862	30%
White	30%	70%	1525	52%
Other	12%	88%	25	1%
Parent Education				
High School or Lower	46%	54%	480	16%
Some College	46%	54%	520	18%
College Graduate	34%	66%	696	24%
Grad School	23%	77%	787	27%
Not Indicated	18%	82%	437	15%
Free/Reduced Fee Lunch	42%	58%	651	22%

Student records[31] included in the study begin in academic year 2001/02 when students in the high school graduating class of 2006 were eighth graders.

[29] The class of 2006 includes 725 students or 24.8% of the full sample; 716 students (24.5%) are from the class of 2007; 756 (25.9%) from the class of 2008; and 723 (24.8%) from the class of 2009.

[30] School district records were the first source for demographic data. In the case of ethnicity, if school district records indicated "unknown" but community college records indicated ethnicity, the community college records were used.

[31] Student records for grade 7 were only available for students from the classes of 2008 and 2009.

Data collection ended in Spring 2011 when students had had the opportunity to complete two to five years of community college[32].

From the full sample of high school students, 953 (32.6%) matriculated to the community college as first year students and 903 of these took the placement test in mathematics. These students form the sample for Research Question 2, which examined articulation from high school to community college.

Methods

To answer the research questions for this quantitative study, student record data from a feeder school district and community college were linked to provide retrospective longitudinal data for analysis and interpretation using descriptive and inferential statistics.

Data Collection

The research proposed a retrospective analysis of existing data collected for non-research purposes by the Education Collaborative, a partnership between the Roslyn Unified School District (RUSD) and Lawson Community College District (LCCD). To prepare the data for me and to ensure total subject anonymity, random subject numbers were assigned to all members of the four graduating high school classes. The community college district provided the unified school district assigned random subject numbers for students from the high school classes of 2006, 2007, 2008, and 2009 who had attended the feeder high school and had enrolled at the community college. The unified school district assigned different subject numbers to

[32] Future research is planned to examine progress from community college assessment to completion of college-level mathematics within two years.

students who had never enrolled at the community college. Once the same students in the different data systems had the same new random subject numbers, the respective districts stripped the student records of all identifiers. The unified school district and the community college district then, respectively, provided me with the relevant records, with matched subject numbers but no identifying data. Since student records from both institutions had common identifiers, I was able to link the records from the two separate institutions for longitudinal analysis.

Variables

Along with demographic variables, I requested mathematics coursework and CST scores in English Language Arts and in Mathematics from the end of elementary school and through middle school to establish prior knowledge. Unfortunately, elementary school records were no longer available and grade 7 mathematics placement and CST scores were only available for students from the classes of 2008 and 2009. Records were available for all cohort groups for grade 8, the last year of middle school, although roughly 25% of the sample were not in district schools for eighth grade. Variables derived from high school records, grades 9 through 12, were more complete. Student records encompassing two to five years of community college, ending as of Spring 2011, were received for the subset of students who matriculated as freshmen to the community college. Both data sources provided demographic information such as socioeconomic status[33], highest

33 School district data provided participation in the National School Lunch Program as an indicator of lower socio-economic status. For those students who matriculated to the community college as freshmen, I supplemented the school district data with community college data for students who were awarded financial aid in their freshman year. Only 115 (42%) of the 276 CC Freshmen who participated in the NSLP received financial aid in their first academic year at the community college. Conversely, 104 (47%) of the 219 students who received financial aid as CC Freshmen had no record

level of parent education[34], English Language Learner, and control variables such as participation in special programs. Mathematics coursework and achievement metrics (i.e., GPA, CST, CAHSEE, and community college placement scores) are included in the dataset. Additional variables (e.g., highest mathematics course, no mathematics in grade 12, unsatisfactory completion, course repetition) were derived from the data provided. Appendix B presents data collected from the two institutions including variables of interest, coding, and a data analysis matrix.

Data Analysis

I analyzed preparation, attainment, and articulation in mathematics from high school to community college. The research questions were answered with descriptive and inferential statistical analysis using SPSS. To examine equity, questions were analyzed for student subgroups by ethnicity, sample size permitting.

Preparatory analysis.

Progress in mathematics from high school to community college was the focus of this study. First, however, to better understand the characteristics of my sample, I examined high school non-mathematics-related academic and demographic variables. Appendix C1 presents utilization rates of community college enrollment opportunities by demographic characteristics.

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of having participated in NSLP. While outside the scope of this study, this may be a loop that needs closing and/or an area for future study.

[34] School district data was used for highest level of parent education. In some instances, the school district did not have the information but the community college did. In these instances, the community college data filled in the gaps. This is the same process that was used for ethnicity.

Background and high school experience. Using descriptive statistics, I did some preparatory analysis to examine demographic and general academic characteristics of the full set of high school students, and of the subset of students that matriculated to the local community college as freshmen. Table 3 presents the categories of demographic and non-mathematics-related variables that I analyzed using frequency and cross-tabulation for all high school students.

Table 3.
Categories of Demographic and General Academic Variables

Variable Category	Independent and Predictor Variables
Demographics	
	Gender
	Ethnicity
	Highest level of parent education
	Free and/or reduced lunch
General Academics	
	Met A-G requirements
	Total Units
	California High School Exit Exam - English Language Arts (ELA)
	California Standards Tests – ELA, grades 7 through 11
	Grade 8 GPA
	Grade 12 GPA
Other	
	AVID participant
	English Language Learner status
	Special needs student
	Feeder middle school
	Graduating class
	Utilization of community college enrollment opportunities

General academic characteristics of the high school students.

Consistent with the literature, the CC Freshmen subset exhibited weaker academic performance, indicated by lower mean GPAs, as well as a less rigorous high school enrollment pattern, indicated by lower mean total credits and a lower percentage of students completing A-G requirements. Appendix C2 presents general academic performance measures for all 12th graders subdivided into two subsets: CC Freshmen and Not CC Freshmen. Appendix C3 presents this data disaggregated by ethnicity.

California High School Exit Exam. The California High School Exit Exam (CAHSEE) is administered, in both English language arts and in mathematics, to all high school students in California as a pre-requisite for high school graduation. Therefore, it is perceived by students to be, and indeed is, a high-stakes test. Scale scores range from 275-450, with 350 passing and 380 considered proficient. CAHSEE results are returned to the school district within 8 weeks of the testing date (http://CAHSEE.cde.ca.gov/). CAHSEE ELA results for this sample of students are included in Appendix D1 and D2.

State standardized tests in English language arts and mathematics. California Standards Tests in English Language Arts (CST ELA) and Mathematics (CST Math) are administered annually and scored by the state to measure progress in mastery of the state's established standards. The ELA and Math CSTs are scaled from 150-600 with five performance levels: Far Below Basic, Below Basic, Basic, Proficient, and Advanced. Districts receive both scale scores (SS) and performance levels for each student. This dataset included CST scores and performance levels in ELA and Mathematics in grades 7 through 11. Appendix D presents this information for all students, for the subset of students who attended the community college as freshmen, and disaggregated by ethnicity.

CST data for this sample demonstrated that students with lower proficiency in ELA and in mathematics were more likely to attend the community college as freshmen than were students who were Proficient or Advanced[35]. Table 4 presents community college freshmen enrollment per different levels of performance in ELA and mathematics. Based on 11th grade CST scores, 47% of students who scored Far Below Basic on the mathematics test matriculated as CC Freshmen, compared to just 6% of the students who scored Advanced. The high utilization rates for Far Below Basic and Below Basic performing students and lower utilization rates for students performing at the advanced levels, particularly in mathematics, indicate this CC Freshmen subset population is skewed to the low achieving end of the spectrum. This is consistent with the research literature.

Table 4.
Community College Freshmen Enrollment (CC Freshmen) by Performance Levels on 11th Grade English Language Arts and Mathematics State Standards Tests

	Community College Freshmen Enrollment		Total All 12th Graders *n=2920* *100%*	
	CC Freshmen *n=953* 32.6%	Not CC Freshmen, *n=1967* 67.4%	*N*	*%*
English Language Arts				
Far Below Basic	43%	57%	226	7.7%
Below Basic	46%	54%	298	10.2%
Basic	44%	56%	627	21.5%
Proficient	32%	68%	719	24.6%
Advanced	15%	85%	782	26.8%
missing	--	--	268	9.2%
Mathematics				
Far Below Basic	47%	53%	607	20.8%
Below Basic	35%	65%	820	28.1%
Basic	29%	71%	557	19.1%
Proficient	13%	87%	382	13.1%
Advanced	6%	94%	130	4.5%
missing	--	--	424	14.5%

The above examinations demonstrated that this sample subset of CC Freshmen underperformed the remainder of the class and the full high school class

[35] CC Freshmen also underperform all students on both the ELA and Math CAHSEE (see Appendix D1).

in both general and mathematics achievement measures, consistent with the literature describing community college students. The next section examines the relationship between ELA and mathematics for evidence to support or discourage the study premise that mathematics is both a valid proxy for academic progress and a roadblock for many students.

Math as a proxy. The study construct that progress in mathematics is a valid proxy for overall academic progress presumes that students who do well in mathematics also do well in ELA and in other measures of academic success. Supporting this premise, correlation was moderate to strong between English language arts and mathematics as measured by the CST and also by the CAHSEE. There is a strong correlation (pairwise) between CST scores in ELA and in mathematics for all students, and all subgroups of students.[36] Correlations between ELA and mathematics on the CAHSEE were even stronger than the high school CST correlations. Table 5 presents correlations beginning with seventh-grade CST scores.[37]

[36] The strength of the correlation between CST ELA and CST Mathematics weakened as students moved through high school. Appendix E1 presents this correlation matrix, pairwise, for all students.

[37] Most seventh graders (97%) in the sample took a course below Algebra 1 and the same CSTs in mathematics and in ELA. Students were placed in different mathematics coursework by grade 9 and CST math scores then and thereafter represent "end-of-course" specific assessments.

Table 5.
Correlation Between Performance in English Language Arts and Mathematics as Measured by the California Standards Test Scale Scores (CST SS) and California High School Exit Exam (CAHSEE) Scores, by Grade Level, for All Students and by Ethnicity

	All	Black	Latino	API	White
CST SS					
Grade 7	.757**	.786**	.749**	.686**	.677**
Grade 8	.673**	.602**	.639**	.484**	.617**
Grade 9	.657**	.582**	.623**	.551**	.596**
Grade 10	.606**	.443**	.541**	.532**	.566**
Grade 11	.587**	.501**	.485**	.557**	.555**
CAHSEE	.687**	.634**	.681**	.592**	.591**

** $p < .01$ (two-tailed).

High school mathematics achievement variables (i.e. GPA, CST scores, CAHSEE) also correlated significantly and strongly with Grade 12 cumulative GPA[38]. The correlation between high school mathematics variables and total high school credits was weaker but still affirmed that the high school students who did well in mathematics also tended to do well in English language arts and other school metrics. Appendix E2 presents a correlation matrix of high school mathematics variables, Grade 12 cumulative GPA, and total high school units that supports the premise that math is a valid proxy for overall academic progress for high school students.

Math as a roadblock. With evidence supporting the study premise that progress in mathematics is a useful proxy for overall academic progress, I next examined my second premise that mathematics plays a singular role in college completion or lack of college completion. I focused my study on mathematics because mathematics is perceived to be a particularly difficult obstacle for students to overcome (Adelman, 1999, 2005, 2006; Berry, 2003; Brown & Niemi, 2007;

[38] The only mathematics variable with only moderate correlation to grade 12 GPA *(r=.514, p<.01)* was Grade 9 Mathematics course, the input or starting point for each student's high school mathematics experience.

Burris, et al., 2008; Gamoran & Hannigan, 2000; Lee, 2012; Loveless, 2008: Silva & Moses, 1990; Spielhagen, 2006)). Therefore, prior to answering my research questions, I examined, for my sample of high school students, the validity of this assumption that mathematics functions as a roadblock.

Even though correlations between CST scores in mathematics and English language arts, and between mathematics variables and grade 12 GPA, were strongly correlated (see Table 5 and Appendix E respectively), achievement in ELA and mathematics did not necessarily go hand in hand. Consistent with the literature, students in my sample performed less well in mathematics than in English language arts. Table 6 illustrates this disparity by comparing performance levels on the grade 11 CSTs in ELA and mathematics as ratios. For the full sample, below Basic and above Basic students performed better in ELA than in mathematics on grade 11 CSTs by a ratio of three to one.

Table 6.
Comparison of English Language Arts (ELA) and Mathematics Performance Levels on California Standards Tests for 2403 11th graders.

	ELA		Mathematics		Ratio ELA: Math
Far Below Basic and Below Basic	426	(18%)	1378	(57%)	1: 3
Basic	575	(24%)	529	(22%)	1: 1
Proficient and Advanced	1402	(58%)	496	(21%)	2.8: 1

Table 7 examines the relationship between achievement in ELA with achievement in mathematics at the individual student level. Almost one fifth of the students who scored Far Below Basic in mathematics were Proficient in ELA. Of the students who were Below Basic in mathematics, half were Proficient or Advanced in ELA.

Table 7.
California Standards Tests Performance Levels in Mathematics for 11th Graders, Who Scored Proficient or Advanced in English Language Arts (n=2403)

	English Language Arts	
Mathematics	% Proficient	% Advanced
Far Below Basic, *n=577*	18.7	5.4
Below Basic, *n=801*	32.2	17.6
Basic, *n=529*	37.8	38.9
Proficient, *n=370*	23.0	67.6
Advanced, *n=126*	11.1	86.5

Disparities between achievement in ELA and mathematics by ethnicity. All student groups demonstrated lower levels of competency in mathematics than in ELA, but there were notable differences among ethnic groups. Almost 80% of Black students, more than three fourths of Latino students, almost half of White students, and almost one third of API students performed below Basic on the grade 11 CST Math (see Table 8). Because, depending on which course they have been taking, students take different end-of-course CSTs in mathematics, the mathematics performance levels are measuring proficiency in different content. Bearing that in mind, for all ethnic groups, more 11th grade students scored below Basic in end-of-course mathematics than in ELA. Table 8 presents ratios comparing the performance of 11th graders on the CST ELA with their performance on the CST Mathematics, by ethnicity. At the higher end of the content mastery continuum, ratios of performance levels illustrate a wide disparity for Black and Latino students between proficiency in ELA and mathematics: Eight times as many Black students assessed above Basic in ELA as assessed above Basic in mathematics, and 6.5 times as many Latino students assessed above Basic in ELA as assessed above Basic in mathematics (Table 8).

Table 8.
Comparison of 11th Grade Performance Levels as Measured by California Standards Tests in English Language Arts and End-of-Course Mathematics, by Ethnicity.

		English Language Arts	Mathematics	Ratio ELA:Math
BLACK	Below "Basic"	36.8%	79.8%	1:2
	"Basic"	33.5%	16.4%	2:1
	Above "Basic"	29.7%	3.7%	8:1
LATINO	Below "Basic"	32.7%	76.3%	3:7
	"Basic"	32.2%	18.3%	1.75:1
	Above "Basic"	35.0%	5.4%	6.48:1
API	Below "Basic"	12.0 %	32.3%	3:8
	"Basic"	22.7%	23.6%	1:1
	Above "Basic"	65.4%	44.1%	1.5:1
WHITE	Below "Basic"	10.8%	47.5%	2:9
	"Basic"	17.3%	25.1%	2:3
	Above "Basic"	72.0%	27.5%	2.62:1

Note. Below "Basic" includes students with performance levels of Far Below Basic and Below Basic; Above "Basic" includes students who scored Advanced and Proficient.

Summary of preparatory analysis. In summary, these preparatory analyses affirmed that the overall academic characteristics of the study sample were consistent with the literature, and that the premises behind the study design were valid for this sample. In terms of the student sample, consistent with the literature, the CC Freshmen subset underperformed all students in general measures of high school academic achievement, as well as CST and CAHSEE scores in ELA and in mathematics (see Appendices C2, D1, D3 and D4). Also consistent with the research literature, Black and Latino students in this sample were over-represented at the lower performance levels in general measures of high school academic performance as well as in measures of ELA and mathematics (see Appendices C3 and D2, D3 and D4).

The preparatory analyses also supported the foundational premises of the study design. Mathematics performance measures correlated with measures of general academic performance and ELA, providing evidence that mathematics is a valid proxy for academic progress (see Appendix E). However, students from all ethnic groups who were Proficient or Advanced in ELA, scored below Basic in mathematics, evidence that mathematics is challenging for many students who are otherwise academically competent. In particular, Black and Latino students in this sample, again consistent with the literature, were assessed at lower levels of performance in mathematics (see Table 8). Thus the preliminary analyses supported the fundamental premise behind the study design: focus on mathematics.

Research Question 1 – High School Mathematics History

Research Question 1 (RQ1) asks: What are the high school mathematics course-taking experiences of the high school students and of the subset of students who matriculated to the community college as freshmen?

Having confirmed the validity of mathematics as both a proxy for and a roadblock to educational attainment in high school, I concentrated on documenting students' actual mathematics history[39] or mathematics pathways. My intent was to define new institutional mathematics pathways that were more explicit and detailed than the four pathways the high school referenced (see Table 1). I used concatenation and descriptive statistics, primarily cross-tabulation tables, and frequencies, to identify and observe characteristics, patterns, distributions, and differences in course-taking patterns in high school mathematics for all students and for the CC Freshmen subset. Table 9 presents the mathematics variables that were examined and compared in answering RQ1.

[39] Appendix F presents the list of mathematics courses offered by the school district and my coding.

Table 9.
High School Mathematics Variables for RQ1.

Independent & Predictor Variables
Mathematics coursework: grades 7-12
Mathematics course grade point: grades 7-12
California Standards Test Scaled Scores in Mathematics: grades 7-11
California Standards Test Proficiency Levels in Mathematics: grades 7-11
California High School Exit Exam in Mathematics
Mathematics Pathway Markers [a]
Grade 9 mathematics placement/course
Highest-level high school mathematics [a]
No mathematics in Grade 12[a]
Unsatisfactory completion of a mathematics course [a]
Mathematics course repetition [a]

Note. Grade 7 data is only available for the class of 2008 and 2009, and grade 8 data is only available for 77% of the full sample. [a]These variables were derived from the data set.

To characterize my proposed system of mathematics pathways, discrete high school variables such as Highest-Level Mathematics course, No Mathematics in Grade 12, Repetition of a mathematics course, and Unsatisfactory Completion of a mathematics course, were derived from the original data, coded as dichotomous or ordered, and explored in the research. Conceptually, these variables are markers along different high school mathematics pathways. The first marker for high school mathematics is a student's Grade 9 Mathematics course.

Placement into eighth and ninth grade mathematics. Ninety-seven percent of students in the sample of seventh graders took below-Algebra coursework (see Appendix G). Using cross-tabulation and correlation, I examined seventh-grade CST scores and seventh-grade mathematics GPA as measures of prior knowledge, to determine if placement in eighth-grade mathematics was appropriate, based on that evidence, and if placement was similar or different among student groups. The same method was applied to examine whether or not the placement of eighth graders into ninth-grade mathematics was appropriate (see Appendix H).

Equity. Research question 1a examines equity by asking: How do patterns of high school mathematics course-taking differ for students by ethnicity? As cited in the literature review, improved and equitable outcomes for Latino and Black students are of special importance for the future of the state and of the nation, as well, of course, for the future of the students and their families. Improving outcomes for these students is the motivation for this study. Therefore, while answering RQ1 by analyzing course-taking patterns for all students and the CC Freshmen subset, in every instance, I also disaggregated and examined distributions by ethnicity.

Research Question 2 – Articulation: High School to Community College

Research Question 2 (RQ2) asks: Controlling for demographic factors and other characteristics, how do different high school mathematics course-taking patterns and achievement predict student placement into community college mathematics?

My findings from RQ1 identified markers to characterize high school mathematics course-taking patterns observed in this sample. The markers or variables that were identified as particularly characteristic of differences in mathematics pathways included Grade 9 Mathematics or *where students started*; Highest-Level Mathematics, or *where students stopped*; and No Mathematics in Grade 12 or *when students stopped*. I tested these (and other) variables as predictors of college placement level as determined by the community college mathematics assessment test, ACT COMPASS.

Nine hundred and three (out of 953) students who matriculated from Casella High to Lawson Community College as freshmen, took the ACT COMPASS test in mathematics and were assessed as placing into a mathematics course at one of five different levels: college-level, one-level below, two-levels below, three-levels below, or four-levels below college-level mathematics. Appendix I1 presents the community college mathematics courses at each of these levels. These placement assignments, determined by cut scores[40] assigned by the college to the assessment test results, are the dependent variable for RQ2. Since this variable is discrete, with five ordered, mutually exclusive levels, I used multinomial logistic regression to answer RQ2.

Stage One: Selection of variables for multinomial logistic regression equation. RQ2 is concerned with the predictive value of high school mathematics course-taking patterns. To answer this question, I used multinomial logistic regression. To select variables to test in the model, I considered my prior findings that identified Grade 9 Mathematics, Highest-Level Mathematics, and No Mathematics in Grade 12 as key markers defining differences in high school mathematics pathways. I examined these along with my full set of variables as possible predictors. First, I converted variables of interest into dichotomous, ordered, or continuous, as appropriate. Next, to gauge the viability of using particular variables in a regression, I ran descriptives to determine the valid

[40] Appendix I2 presents the cut scores for course placement. Each community college determines the cut scores they consider appropriate.

number of cases. Appendix J1 provides a table with number, mean, and standard deviation for potential predictor variables.

I used correlation to analyze the independence of variables and to compare associations. To better understand the strength of the relationships between variables, I ran correlations pairwise for the full sample of students. Although I knew from the descriptive data that the sample of grade 7 and grade 8 students was too small to include as predictors in my regression equation, I included grade 7 and grade 8 variables in some of the correlation matrices to better understand the strength of the association of prior knowledge with the high school variables.

Since my study is based in part on the premise that progress in mathematics is a reliable proxy for progress toward college completion, as discussed in the preparatory analysis section, I also examined the correlation between non-mathematics high school variables and mathematics high school variables, expecting and confirming a high correlation among them. Appendix E1 includes Math and ELA CST and CAHSEE scores for all students, pairwise, from grade 7 to 11. The correlation matrix in Appendix E2 includes just high school (grades 9-12) mathematics variables, including mathematics course, course GPA, end-of-course CST, CAHSEE Math, and Grade 12 GPA. I also created bivariate correlation matrices to compare the relationships between mathematics variables to the dependent outcome, community college placement in mathematics. Appendix J2 presents values from bivariate correlation with the community college placement assessment, for the subset of CC Freshmen, for all considered variables including demographic and general academic variables.

Research Question 2a specifically asks whether or not taking mathematics in grade 12 increases the likelihood of placing into college-level mathematics in community college. To answer this question, a dichotomous variable, No Math in Grade 12, was used as a predictor in the multinomial logistic regression model.

These analyses of association and redundancy with the outcome variable, along with my focus on mathematics pathway markers and equity, led to my choice of variables to test in the multinomial logistic regression model. The next sections present the selected variables.

Demographic independent variables. Gender, ethnicity, highest-level of parent education, and indication of lower socioeconomic status were included in the model as independent variables. Each of these variables showed significant ($p<.01$) but weak correlation with the outcome variable (see Appendix J2). However, even though correlation values were low between ethnicity and the academic variables in this sample, the distribution of Black and Latino students skewed to the lower-achieving end of the spectrum for all variables (see Tables 5, 8, and Appendices C3, D2,3,4, and K). And, equity is a key focus of this study. Therefore, these demographic variables were included in the model.

CAHSEE Math. Surprisingly and intriguingly, CAHSEE Math was the variable most strongly correlated to community college placement results of all of my variables. Since the CAHSEE Math only measures mastery through the beginning of Algebra 1, this was unexpected. Nevertheless, even though this variable primarily measures pre-high school content mastery, the CAHSEE Math had the strongest correlation with community college placement of CC Freshmen. Grade 7 CST Math had the second strongest correlation.[41]

Table 10 presents the "top ten" most highly correlated school district predictor variables for the dependent variable, placement on the community college mathematics assessment. State standardized measures of achievement in mathematics, the CAHSEE and CST scores, were more strongly correlated with placement results than were mathematics coursework including Grade 9 Mathematics, highest-level mathematics, and not taking mathematics in grade 12[42], none of which made the top ten list. GPA and demographic factors, including ethnicity, lower socioeconomic status, and highest-level of parent education, also did not make the top ten list. CST scores for grades 10 and 11 that test end-of-course material for different mathematics coursework had a weaker correlation to CC placement than did CST math scores from middle school.

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[41] Content on the CAHSEE Math includes number sense, statistics, data analysis, and probability; algebra and functions; measurement and geometry; mathematical reasoning; and Algebra 1 (http://CAHSEE.cde.ca.gov/). Terry and Rosin (2011) note the CAHSEE Math mostly tests seventh-grade math content.

[42] Correlation values for all variables, including those that did not make the top ten list are presented in Appendix J2. For those cited above: Grade 9 Mathematics course ($r = .466, p < .01$); Highest Level Mathematics ($r = .317, p < .01$); No Mathematics in Grade 12 ($r = -.189, p < .01$).

Table 10.
Top Ten Most Highly Correlated Predictor School District Variables to RQ2 Dependent Variable Community College Mathematics Placement Results for CC Freshmen.

Predictor Variable	*r*
1. CAHSEE Mathematics Score	.669**
2. Grade 7 Mathematics CST	.624**
3. Grade 9 CST Mathematics scaled score	.610**
4. Grade 8 Mathematics CST scaled score	.608**
5. Grade 11 CST Mathematics scaled score	.577**
6. Grade 10 CST Mathematics scaled score	.573**
7. Grade 10 CST ELA scaled score	.506**
8. Grade 11 Mathematics course	.499**
9. Grade 12 GPA (all subjects)	.489**
10. Grade 10 Mathematics course	.488**

Note. Correlations are pairwise for subset of students who matriculated to the community college as freshmen and took the mathematics placement assessment.
** $p < .01$

I selected the CAHSEE Math, the variable with the strongest correlation to the outcome variable, to test as a predictor in my model. To avoid redundancy with the CAHSEE Math, I rejected CST scores and grade 10 and 11 mathematics courses as predictor variables. As referenced earlier, correlation matrices that explore the relationships and redundancies between and among school district variables are presented in Appendix E.

GPA. For this sample, GPA was relatively independent[43] of both CAHSEE and CST scores, measures of content mastery (see Appendix E2). This indicates that, rather than representing what the student learned, GPA was more representative of *what the student did in class*, reflecting, or at least incorporating, student behavior rather than just content mastery[44]. I included GPA for 9th, 10th, and 11th grade

[43] In most of these correlations, *r* is close to *.5*, and $p<.01$. See Appendix E2 for specific values.

[44] Discrepancies between CST scores and GPA are evident when comparing student performance on the CSTs in Math from grades 7-11 (Appendix D) with GPA (Appendix K). For example, notice that performance on the CST Math declines dramatically as students progress through high school, but this trend is less pronounced for GPA. Adelman (2006) considers GPA and class rank as indicators of effort.

mathematics as predictor variables in the model. GPA in grade 12 mathematics was not included because of the small size of the 12th grade mathematics sample.

Grade 9 mathematics course. Grade 9 Mathematics course represents the input, the starting point for each student's high school mathematics experience. It also, to the extent that grade 9 mathematics placement is appropriately evidence-based, represents prior-knowledge. These are important considerations in analyzing the effectiveness of high school mathematics preparation for community college, and so I included Grade 9 Mathematics course, even though there is moderate correlation between this variable and the CAHSEE Math ($r=.512$, $p<.01$)[45]. The correlation between Grade 9 Mathematics course and grade 9 GPA is low ($r= .221$, $p<.01$)[46] for CC Freshmen, indicating that, while these variables are somewhat related, it is appropriate to include both as predictor variables in the model.

Highest-level mathematics course. The foundation for this study was Adelman's (1999, 2005, 2006) finding that Algebra 2 is a tipping point and every high school course above Algebra 2 doubles the odds of completing college. Thus, Algebra 2 is an important marker for my study in gauging the effectiveness of high school preparation and Highest-Level Mathematics is an important variable. In examining the independence of Highest-Level Mathematics for the CC Freshmen population, I found that although the correlation between Highest-Level Mathematics and Grade 9 Mathematics course was significant, it was weak ($r=.220$, $p<.01$), as were the correlations between Highest-Level Mathematics and CAHSEE

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[45] This correlation between ninth grade math course and CAHSEE Math is for the CC Freshmen (see Appendix L). For all students, the association was even stronger ($r= .632$, $p< .01$) as reported in Appendix E2.

[46] The correlation between ninth grade math course and ninth grade GPA for all students (see Appendix E2) is slightly higher but still weak ($r= .306$, $p<.01$).

Math (*$r=.286$, $p<.01$*), and Highest-Level Mathematics and math GPA in grades 9, 10, and 11 *($r<.3$, $p<.01$).* These findings, presented in Appendix L, indicate sufficient independence to justify including Highest-Level Mathematics in the model.

No mathematics in grade 12. Testing the significance of no math in grade 12 was an important feature of the study design, discussed in the literature, explicit in my research question, and supported by the fact that more than one third of all of the high school students in this sample, and more than 40% of the Black and Latino students, took no mathematics in grade 12 (see Tables 13 and 14). This is a dichotomous variable. The correlation between No Mathematics in Grade 12 and Highest-Level Mathematics was *$r=-.354$, $p<.01$* for CC Freshmen, permitting inclusion of both variables in the model (see Appendix L).

Stage Two: Developing a model to predict below college-level mathematics placement. Having examined association and redundancy, and narrowed the field of variables in stage one, in stage two, I used multinomial logistic regression to determine which of the variables, if any, were significant predictors of mathematics placement in community college as determined by assessment. Multinomial logistic regression allows for both continuous and non-continuous variables, which I had. Assessment into college-level mathematics was the reference level outcome and was coded 0. Assessment into mathematics one-level below college-level was coded 4; two-levels below was coded 3; three-levels below was coded 2; and four-levels below was coded 1. Although these outcomes are ordered, they are not interval.

The ordered logistic regression equation is

$$\hat{Z}_1 = \sum_{k=1}^{K} \beta_k X_{ik}$$

where

$\hat{Z}_1$ = Predicted mathematics placement level in community college for individual

K = Variety of determining variables

k = 1, …., K

β_k = Coefficient associated with variable k

X_{ik} = Individual score for the variable k

The total number of variables that could appropriately be included in the model was limited by the number of students in the sample. Grimm and Yarnold (1995) recommend at least 50 subjects per each predictive variable. Based on my pre-screenings for association, significance, and redundancies, I chose 11 independent and predictor variables; my final model included 606 students, which would allow for 12 variables.

Once I ran the model, to better interpret the results of the multinomial logistic regression, I calculated Delta-p values from the Odds Ratio and the means from dummy variables for the different levels of placement.

Stage Three: Further exploration of significant predictors with ANOVA and cross-tabulation. Having established significant predictor variables in the multinomial logistic regression model, I ran Analysis of Variance (ANOVA) tests to better understand the differences in groupings for those variables that were significant predictors at multiple levels of placement.

To further examine the relationship between CAHSEE Math scores and placement on the community college mathematics assessment, I created a new CAHSEE Math variable with five rankings. To do this, I first examined a histogram of the CAHSEE Math Scale Scores, and, looking at breaks in this distribution, I sub-divided the scale scores into ordered groups. My original ordered groups did not include a break at 380, the score for proficiency. Therefore, I adjusted my performance levels to accommodate the CAHSEE point values with specific meaning: 350 for passing and 380 for proficiency. The CAHSEE scale scores for my five rankings are: 275-349, 350-379, 380-400, 401-430, and 431-451. Appendix M presents the histogram for the CAHSEE Math scale scores and a histogram of this new ordered variable for CAHSEE Math.

Once I had an ordered variable for CAHSEE Math, I did a cross-tabulation to get a clearer picture of how students were distributed in the different college mathematics placement levels relative to their CAHSEE Math scores. Then, to better understand the differences between groups, I ran a One-way ANOVA with a Tukey post-hoc test to analyze and compare the means of the CAHSEE Math scale scores with the five different levels of placement in mathematics as determined by the community college placement assessment. I used the same procedures, cross-tabulation and ANOVA, to examine other variables that were significant predictors of placement.

Further exploration of highest-level mathematics. I also ran cross-tabulations and ANOVA for highest-level mathematics with community college placement levels. Since, based on Adelman's research, I was particularly interested in Algebra 2 as a tipping point, I coded Highest-Level Mathematics into three groups: Below Algebra 2, Algebra 2, and Above Algebra 2 and did additional analysis for this marker of *where students stopped*.

Mapping trails. Lastly, I identified mathematics pathways, from high school to community college placement, retrospectively. Using concatenation, I plotted the history of each student in my RQ2 sample at each of the key high school markers – Grade 9 Mathematics, CAHSEE Math scores, Highest-Level Mathematics, and taking math in grade 12 – with the student's respective college placement level. This documented the actual pathways, the number of pathways, and the popularity, effectiveness, and reliability of the different pathways travelled.

Equity. To examine differences among student groups, I also ran cross-tabulations by ethnicity for all of the independent variables with placement results. These distributions are presented as findings throughout Chapter 4 and are documented in tables or appendices.

Ethical Concerns

Ensuring the anonymity and confidentiality of the student subjects was the primary ethical concern. The study was designed as a retrospective analysis of existing data collected for non-research purposes. All subjects were unidentified and anonymous and unknown to the researcher. I had no contact with any subjects in the study. All data is presented in the aggregate. In instances where there were variables with less than five subjects, (presenting the possibility of subject identification), exact numbers are not reported. The anonymity of the educational institutions is also protected. Pseudonyms are used in this dissertation and will be used in future publications for the institutions unless written permission is provided by the Superintendents at both of the research sites. Due to the complete anonymity of all subjects and the retrospective nature of the study, full confidentiality was ensured and there were no ethical or legal conflicts.

Reliability and Validity

The study design is based on prior work utilizing variables and concepts that include benchmarks, on track indicators, milestones, and patterns of success identified by researchers including Adelman (1995, 2005, 2006), Brown and Niemi (2007), McClennney (2010), Moore and Shulock (2010), Offenstein, Perry, Bahr, Rosin and Woodward (2010), Riegle-Crumb and King (2010), Shulock and Moore (2007), and Stern (2008, 2009). Using variables and a methodology similar to that reported in large-scale research projects by established and respected researchers increases the external validity and utility of the proposed research project and provides a basis for evaluating the generalizability of the study findings. Furthermore, the study examines progress in high school mathematics as measured by both course-taking and standardized state measures of achievement. Although the study is limited to progress in mathematics at a single high school, state standards and state standardized assessments enhance the comparability, external validity, and utility of the research.

Internal validity was protected by having a sample large enough to ensure a sufficient number of subjects for statistically reliable findings. For this reason, the study sample included four cohorts of graduating high school classes. Validity was also ensured by following established statistical analyses practices using SPSS.

Summary

Working with this Education Collaborative data provided a unique opportunity to closely examine how one particular educational pipeline actually functions as students transition from high school to community college. Viewed through the lens of mathematics, my research design analyzed three interrelated and important phenomena: 1) actual high school mathematics experiences and pathways, 2) articulation between high school and community college mathematics, and 3) equity in educational opportunity and outcomes for Latino and Black students. I am grateful to the Education Collaborative; their partnership made this study possible.

CHAPTER 4: FINDINGS

To improve readiness for college-level mathematics, this research identified markers of progress in high school that are actionable for students, parents, teachers, counselors, and policy-makers. I report on five major findings, including three significant predictors, that impact assessing into below college-level mathematics:

1) Mastery of mathematics fundamentals matters. Grade 7 CST Math and the CAHSEE Math had the highest correlation of all my variables with college placement scores, indicating that mastery of lower-level mathematics, coursework that precedes high school instruction, is critical. Taking a lower level of mathematics in grade 9 and lower scores on the CAHSEE Math were significant predictors of placement at all levels below college-level mathematics.

2) The CAHSEE Math scale scores are under-utilized; they predict placement in below-college-level mathematics and can provide a useful, timely alarm when students are not on track for college-readiness.

3) If students are not on track for college-readiness, they should take mathematics in grade 12. Not taking mathematics in grade 12 was a significant predictor of placement 2-, 3-, and 4-levels below college-level mathematics; 55% of the students who placed at these levels took no mathematics in grade 12.

4) Gender, ethnicity, lower socioeconomic status, and parent education were not significant predictors of placement in community college mathematics. Students from all ethnicities scored at all levels of placement; however, consistent with the

literature, Black and Latino students were more highly represented at the lower placement levels.

5) The pipeline metaphor doesn’t fit. A pipeline has a single entry point and a single exit point; what goes in at the beginning of a pipe comes out at the end. However, a student’s experience of high school mathematics is more like hiking a trail than being shunted along a pipeline. Although there are many possible trails, hikers would be more likely to reach their destination, college-readiness, if they knew where they were going, how to get there, and what to watch out for.

In this study, high school mathematics pathways or trails are identified by *where students start* (Grade 9 Math), *where students stop* (Highest-Level Math), and *when students stop* (No Math in Grade 12). These trail markers, or landmarks, reflect choices and decisions made by the school, the student, or both as they hiked the high school mathematics mountain. Near the beginning of the trailhead, in grade 10, all students got a check-up, the CAHSEE Math, which measured the hikers’ condition and fitness. The mountain peak, the destination, was college-readiness.

High school students, with different levels of preparedness, were placed in, followed, chose, and hiked different mathematics trails, leading to different outcomes, or levels of placement in community college. Outcomes were predicted by Grade 9 Math, CAHSEE Math scores, and whether or not students took mathematics in Grade 12.

Findings for Research Question 1 – The High School Experience

Research Question 1 asks: What are the high school mathematics course-taking experiences of the high school students and of the subset of students who matriculated to the community college as freshmen? To answer this question, I first observed course-taking patterns in high school mathematics, or, in other words, *what* students did.

Observed High School Mathematics - *What* Students Did

This study began based on the conceit of the educational pipeline. Accordingly, I assumed students' high school mathematics experiences followed institutionally determined course-taking patterns, initially defined by placement in grade 9 mathematics and then flowing forth accordingly, course-by-course, grade-by-grade, to high school graduation. The high school mathematics department presents this view, laying out pathways that begin in grade 9 and then continue sequentially to completion of Algebra 2 or higher in grade 12 (See Table 1). My intention was to elaborate on and refine these pre-set paths by studying students' actual high school mathematics histories. To do this, I observed *where students started*, *where they stopped*, and *when they stopped*.

Grade 9 mathematics course - *where they started.* In high school, the assignment of students to different mathematics sequences begins with ninth grade placement.[47] This dataset includes three different ninth grade mathematics

[47] Since grade 9 mathematics is the starting point of the high school mathematics experience, I examined mathematics performance in grades 7 and 8 for evidence that placement in grade 9 mathematics was appropriate. Prior year mathematics GPA and CST scores correlated with grade 8 and with grade 9 mathematics placement; CST scale scores had a stronger correlation to placement

placements that begin student pathways through high school mathematics. Of the full sample of ninth graders,[48] 20% were in a slower-paced, extended algebra course[49], either taking Algebra 1 over a two-year time frame or for two periods in one school year. Students who repeated first semester algebra are also included in this "below-Algebra 1" grouping. Another 21% of ninth graders were in a one-year Algebra 1 course, and 56% were in Geometry.[50] Appendix N1 presents the grade 9 mathematics placements for each graduating class.

The subset of students who attended the community college as freshmen are overrepresented in the lower-level ninth grade mathematics courses, Algebra 1 and below Algebra 1. Table 11 compares grade 9 mathematics coursework for the CC Freshmen subset in comparison to fellow students who did not matriculate to the community college as freshmen.

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than did letter grades. Appendix H presents correlations and cross-tabulations that indicate placement into 8th grade mathematics and 9th grade mathematics was evidence-based.

[48] Placement data is available for 2441 ninth graders or 84% of the full sample, which includes 82% of the CC Freshmen subset.

[49] During the time that students in the graduating high school classes of 2006 to 2009 were in middle school, the district shifted students out of the extended algebra program in eighth grade into Algebra 1 and also expanded offerings in accelerated Algebra 1. Among All Students, 85% of the students who took extended algebra or lower in grade 9 were from the class of 2006 or 2007. In the sample of students who took Algebra 1 in grade 9, 71% come from the class of 2008 or 2009. For details, see Appendix N.

[50] Another 3% took Algebra 2 or higher in grade 9.

Table 11.
Grade 9 Mathematics Coursework of Students who attended the Community College as Freshmen (CC Freshmen) and Those Who Did Not (Not CC Freshmen).

	Grade 9 Mathematics Coursework			
	Below Algebra 1[a]	Algebra 1	Geometry	Above Geometry
CC Freshmen, *n=779*	28.6%	30.9%	39.4%	1.0%
Not CC Freshmen, *n=1662*	16.2%	16.1%	63.6%	4.2%
Total, *n=2438*	20.1%	20.8%	55.9%	3.2%

Note. The full sample of 12th graders includes 2920 students with 953 of these students matriculating to the community college as freshmen.
[a] In this table, students in Below Algebra 1 took Extended Algebra 1, meaning Algebra 1 was extended over two years or over two periods in one academic year.

The distribution of students in the different grade 9 mathematics offerings also differed by ethnicity. Sixty-five percent of Black students and 58% of Latino students took Algebra 1 or lower in grade 9 compared to 17% of API students and 32% of White students. Appendix N2 presents the distribution of students from each ethnic group in the three primary grade 9 mathematics course placements.

Highest-level mathematics - *where they stopped.* Of students who began ninth grade in coursework below or equal to Algebra 1, just 1% took more than one course above Algebra 2 by high school graduation. In contrast, 70% of the students who began ninth grade in a Geometry class completed more than one course above Algebra 2. Table 12 presents the highest levels of high school mathematics coursework taken compared to students' placement in grade 9 mathematics. The table compares enrollment in Algebra 2, and coursework above and below Algebra 2, reflecting the literature's finding that Algebra 2 is a "tipping point" and every course beyond Algebra 2 doubles the odds of completing college (Adelman, 1999, 2005, 2006).

Table 12.
Mathematics Coursework through Grade 12 per Grade 9 Mathematics coursework
N=2441, 84% of all 12th graders.

Grade 9 Mathematics	*N*	Highest-level Mathematics taken through grade 12				
		More than one course above Algebra 2	One course above Algebra 2	Algebra 2	Below Algebra 2	No math in grade 11 or 12
Below, Extended or Repeated Algebra 1	494	1%	27%	57%	12%	4%
Algebra 1	508	1%	36%	52%	7%	4%
Geometry	1362	70%	23%	3%	1%	3%
Algebra 2 and above	77	100%				2%

Note. Highest-level mathematics course is the 12th grade mathematics course unless mathematics was not taken in grade 12, in which case it is 11th grade mathematics. Students who took no mathematics in grade 11 or 12 are included in the last column.

Comparing the highest level of mathematics taken by all students with the subset of students who attended the community college reveals that less than one half of the CC Freshmen in the sample surpassed the Algebra 2 tipping point and took coursework above Algebra 2 in high school; more than one third advanced no further than Algebra 2. For the full sample of high school students, 24% did not advance beyond Algebra 2. Table 13 compares highest-level mathematics course for the subset of CC Freshmen with the full class.

Table 13.
Last High School Grade and Highest-Level Mathematics for All students and the CC Freshmen Subset

Students	Last Grade	Above Algebra 2	Algebra 2	Geometry	Algebra 1 and below	Gr 12 No Math
All	12	52%	9%	1%	2%	36%
n=2920	11	11%	15%	3%	1%	--
Total		***63%***	***24%***	***4%***	***4%***	***36%***
CC Freshmen	12	34%	14%	1%	3%	47%
n=953	11	12%	23%	4%	2%	--
Total		***46%***	***37%***	***6%***	***5%***	***47%***

Note. Highest-level mathematics course is the 12th grade mathematics course unless mathematics was not taken in grade 12, in which case it is 11th grade mathematics. Highest-level mathematics is not included for students who took no mathematics in grade 11 or 12.

Although students from all four ethnic groups took coursework above Algebra 2 by the end of grade 12, almost 40% of Black students and 36% of Latino students did not make it past the Algebra 2 tipping point. This is consistent with the research literature on achievement in mathematics and a college-readiness gap for students of color. An examination of course repetition found that more than 18% of Black and Latino students in this sample repeated at least one course in mathematics in grades 10 through 12 which would also, of course, affect highest-level mathematics. Table 14 presents data including highest-level mathematics and course repetition, disaggregated by ethnicity.

Table 14.
Highest-Level High School Mathematics, Repeated Mathematics Course, and No Mathematics in Grade 12, by Ethnicity

Ethnicity	Highest Level High School Mathematics									
	Above Algebra 2		Algebra 2		Below Algebra 2		Repeated Course [a]		No Math in Grade 12	
	#	%	#	%	#	%	#	%	#	%
Black	103	(39.6)	100	(38.5)	41	(15.8)	48	(18.5)	114	(43.8)
Latino	397	(46.1)	306	(35.5)	108	(12.5)	157	(18.2)	356	(41.3)
White	1108	(72.7)	256	(16.8)	71	(4.7)	80	(5.2)	495	(32.5)
API	213	(85.9)	23	(9.3)	5	(2.0)	8	(3.2)	69	(27.8)

Note. Highest-Level Math is mathematics course taken in grade 12 or, if no math was taken in grade 12, then highest-level math is the math course taken in grade 11. There is no record of math in grade 11 or 12 for 164 students or 5.6% of the sample.
[a] Repeated at least one mathematics course in grades 10-12.

No mathematics in grade 12 - *when they stopped.* Since California does not require four years of high school mathematics, the highest level taken by students is determined in part by when they stop taking mathematics. More than one third of all students in this sample took no mathematics in grade 12 (see Table 13), including more than 25% of every ethnic group (see Table 14). Although greater percentages of Black and Latino students took no mathematics in grade 12 (over 40% each), significant percentages of White (32.5%) and API (28%) students also opted out of mathematics in their senior year. Students who went on to enroll at the community college as freshmen were notably less likely to take a mathematics course in grade 12 than all other students. Specifically, 64% of all students took mathematics in grade 12 compared to slightly more than one half (53%) of the CC Freshmen subset (see Table 13).

Students' mathematics course-taking patterns as high school seniors differed according to their starting points. Almost half of the students who began grade 9 in below Algebra 1 coursework took no mathematics in grade 12. In contrast, three fourths of students who began the ninth grade in Geometry went on to take a mathematics course in their senior year. Table 15 cross-tabulates the three primary ninth grade mathematics placements with students' mathematics course-taking patterns in grade 12. The table documents that the students who began further behind tended to quit sooner.

Table 15.
No Mathematics in Grade 12 by Students' Grade 9 Mathematics
n=2438, 83% of all 12th graders

Grade 9 Math Course	No Math in Grade 12
Below-Algebra 1, n= 491	48%
Algebra 1, n= 508	44%
Geometry or above, n=1439	24%

Note. Below-Algebra 1 coursework consists of extended or repeated Algebra 1 courses. Extended refers to coursework traditionally offered in one year extended over two years or offered with double periods of instruction. The school district discontinued this option mid-way through the study period.

The intersection of highest-level mathematics and no math in grade 12. When students stopped taking mathematics impacted the highest-level of high school mathematics they completed. Although research (Adelman, 1999, 2005, 2006) demonstrates the importance of continuing beyond Algebra 2, 15% of all students and almost a quarter of the CC Freshmen subset took Algebra 2 in grade 11 as their highest-level mathematics course in high school. These students had the opportunity to take above Algebra 2 mathematics in grade 12 but did not. Similarly, 11% of all students and 12% of the CC Freshmen subset took mathematics above Algebra 2 in grade 11 but did not pursue an additional year of above Algebra 2 mathematics in grade 12 (see Table 13).

Looking past highest-level course taken to performance, almost two thirds of all students and 58% of CC Freshmen who took Algebra 2 as their highest-level mathematics course in grade 11 passed with a "C" or better. The pass rate was higher for students who took coursework above Algebra 2 in grade 11. Table 16 presents letter grades for highest-level mathematics when taken in grade 11. In the higher-level coursework,[51] the CC Freshmen subset under-performs the full sample, and also therefore, the remainder of students.

Table 16.
Letter grade in Geometry, Algebra 2, or Above Algebra 2 for 11th Graders who took No Math in Grade 12

		A	B	C	D	Fail
All Students						
	Geometry, n=86	7%	10%	19%	37%	27%
	Algebra 2, n=438	12%	20%	33%	17%	18%
	Above Algebra 2, n=313	21%	27%	33%	12%	6%
CC Freshmen						
	Geometry, n=39	10%	13%	18%	41%	18%
	Algebra 2, n=218	11%	17%	30%	20%	22%
	Above Algebra 2, n=110	8%	26%	36%	19%	10%

I also examined the intersection between highest-level math, GPA, and not taking mathematics in grade 12, by ethnicity. More than one third of Black and Latino students completed their highest-level of high school mathematics as 11th graders, taking no mathematics in grade 12. Majorities of students from every ethnic group who took their highest-level mathematics course in grade 11, passed

[51] Note that students in higher-level mathematics courses tend to receive higher letter grades than do the students in lower level coursework.

Algebra 2 or above with a letter grade of "C" or higher. Pass rates in Algebra 2 (about 60% earned a "C" or better) were lower for Black and Latino students than for API and White students. Pass rates for students who took above Algebra 2 coursework as 11th graders were even higher than Algebra 2 pass rates, for most groups. These findings are presented in Appendix O.

Students move through high school mathematics on different trails. My observations of how students progress through high school mathematics identified differences in mathematics experiences that are distinctly marked by *where students start*, *where students stop*, and *when students stop*. However, rather than treading well-worn pre-set pathways en masse, students exercised different options and built their own trails through high school mathematics. Looking at only three markers[52] - grade 9 math, grade 12 math, and highest-level math - there are twelve possible pathways. Students followed every possible permutation. The most frequently followed path, and presumedly the most optimal, was taken by 36% of all students, and just 18% of the CC Freshmen subset. These students began grade 9 in coursework above Algebra 1, took mathematics in grade 12, and took highest-level coursework above Algebra 2. Only 12% of all students share the next most common pathway pattern. These students began grade 9 in Algebra 1 or below coursework, took no mathematics in grade 12, and did not advance beyond Algebra 2. At 20%, this was the most frequently observed pattern for the students who went on to enroll at the community college as freshmen. Other pathways look more like deer trails, not beaten paths. Table 17

[52] Grade 9 math is coded into two levels: Algebra 1 or below/above Algebra 1; grade 12 math is coded into two levels: yes/no; and highest-level math is coded into three levels: below Algebra 2/Algebra 2/ above Algebra 2.

presents the 12 observed routes travelled through high school mathematics for all students and for the subset of students who attended the community college as freshmen.

Table 17.
Observed High School Mathematics Paths for students with no missing values. N=2920 including missing values for All Students, and 953 for CC Freshmen.

Grade 9 Math Class	High School Mathematics Math in Grade 12	Highest-Level	All Students N=2363	CC Freshmen N=739
Above Algebra 1	Yes	Above Algebra 2	36.5%	17.7%
Above Algebra 1	Yes	Algebra 2	.4%	.5%
Above Algebra 1	Yes	Below Algebra 2	.4%	.6%
Above Algebra 1	No	Above Algebra 2	9.6%	10.3%
Above Algebra 1	No	Algebra 2	.9%	1.3%
Above Algebra 1	No	Below Algebra 2	.1%	.2%
Algebra 1 and Below	Yes	Above Algebra 2	11.0%	11.6%
Algebra 1 and Below	Yes	Algebra 2	6.0%	10.4%
Algebra 1 and Below	Yes	Below Algebra 2	1.5%	2.2%
Algebra 1 and Below	No	Above Algebra 2	.2%	.2%
Algebra 1 and Below	No	Algebra 2	12.4%	19.5%
Algebra 1 and Below	No	Below Algebra 2	2.0%	2.9%
TOTAL			81%	78%

Note. Grade 9 Math marks the starting point for high school mathematics, Math in Grade 12 indicates the length of time high school students took mathematics, and Highest-Level presents the end of the high school mathematics pathway.

Summary of Findings from Observing Students' High School Mathematics Experiences

To characterize and document high school mathematics history, I observed three primary markers - *where students start*, or grade 9 coursework; *when students stop*, no math in grade 12, and *where students stop*, highest-level course. Distributions for the CC Freshmen subset and by ethnicity illustrate that, in this sample, disproportionately, Black and Latino students and students who went on to enroll as community college freshmen *started* grade 9 in a lower-level of mathematics, were more likely to have *stopped* taking mathematics before grade

12, and *finished* high school having taken a lower level of highest-level mathematics. These markers identify key points of interest, turning points or forks in the road that define different high school mathematics pathways. Pathways, however, do not appear to be predetermined or set in concrete. Rather, groups of students followed every route possible through high school mathematics. Students' high school mathematics experience appeared more like a network of trails than a pipeline.

Findings for Research Question 2 – From High School to Community College

Research Question 2 (RQ2) asks: Controlling for demographic factors and other background characteristics, how do different high school mathematics course-taking patterns and achievement predict student placement into community college mathematics? Building upon my descriptive analyses of key mathematics pathway markers, I used statistical tests to examine the effectiveness of high school variables as measured by results from the community college placement exams.

Overview of Sample for RQ2

Nine hundred and fifty-three students from the full high school sample matriculated to the community college as freshmen. These students are the CC Freshmen subset and comprise the sample for RQ2. As mentioned before, almost half took no mathematics in grade 12, and almost half received a "D" or an "F" in at least one high school mathematics course. Table 18 summarizes the distribution of demographic and academic characteristics for the CC Freshmen sample.

Table 18.
Distribution of Demographic and Academic Characteristics of the CC Freshmen sample

Variable		Valid Percent
Gender, *n=963*	Male	52%
	Female	48%
Ethnicity, n=950	Black	9%
	Latino	35%
	API	7%
	White	48%
Not an English Only speaker, n=871		28%
Parent Education, n=874	Some High School	12%
	High School Graduate	13%
	Some College	27%
	College Graduate	27%
	Graduate School	21%
Indication of Low SES[a], n=953		40%
High School Class, n=953	2006	25%
	2007	24%
	2008	27%
	2009	24%
Special Education, n=953		8%
Grade 8 Mathematics, n=643	Below Algebra 1	58%
	Algebra 1	42%
Grade 9 Mathematics, n=779	Below Algebra 1	29%
	Algebra 1	31%
	Geometry and above	40%
Grade 10 Mathematics, n=840	Below Geometry	13%
	Geometry	48%
	Algebra 2 and above	40%
Grade 11 Mathematics, n=847	Geometry and below	19%
	Algebra 2	48%
	Above Algebra 2	33%
Grade 12 Mathematics, n=504	Geometry and below	9%
	Algebra 2	26%
	Above Algebra 2	65%
No Mathematics in Grade 12, n=953		47%
Highest-Level Mathematics[b], n=890	Below Algebra 2	11%
	Algebra 2	39%
	Above Algebra 2	49%
Repeated Course in Grade 10, 11, or 12, n=953		
	Algebra 1	6%
	Geometry	3%
	Algebra 2	6%
Unsatisfactory Math Completion[c], n=953		47%

Note. Due to rounding, percentages may not add up to 100%. Percentages are valid for n. [a]Indication of low SES is defined by participation in the NSLP and/or received any financial aid in the first academic year at the community college. Financial aid included BOG waivers, Pell Grants, Cal Grants and/or federal loans. [b]Highest-Level Mathematics is highest-level mathematics course taken in grade 12, or if no math was taken in grade 12, then highest-level is grade 11 mathematics. [c]Unsatisfactory Math Completion means a student received a D or an F in at least one high school mathematics course in grades 9 through 12.

Multinomial Logistic Regression Predicts Placement in 1-, 2-, 3-, or 4-Levels Below College-Level Mathematics.

A multinomial logistic regression tested which variables were significant predictors of placement in below college-level mathematics. Community college placement levels, as determined by the ACT COMPASS assessment test, were the dependent variable for research question 2.

Based on my evaluations (described in Chapter 3) regarding the different possible variables, I selected demographic and high school academic variables to test in a predictive model. Multinomial logistic regression was used with an ordered dependent variable: placement 1-, 2-, 3-, or 4-levels below college-level mathematics as determined by the ACT COMPASS assessment test taken by 903 of the 953 high school students who matriculated to the community college as freshmen. Table 19 presents the 11 independent and predictor variables tested in the model.

Table 19.
Variables for Multinomial Logistic Regression Model Predicting Placement in Mathematics at the Community College

Independent and Predictor Variables
1. Gender
2. Ethnicity: Black, Latino, Asian/Pacific Islander, White
3. Highest-Level of Parent Education
4. Indication of Low Socio-Economic-Status
5. Grade 9 Mathematics Course
6. Grade 9 Mathematics Grade Point
7. Grade 10 Mathematics Grade Point
8. Grade 11 Mathematics Grade Point
9. California High School Exit Exam Mathematics Scores
10. Highest-Level High School Mathematics Course
11. No Mathematics in Grade 12
Ordered Dependent Variable
1. Community College Assessment into 1-, 2-, 3-, or 4-Levels Below College-Level Mathematics

Running the model for the CC Freshmen subset, there were 606 students with valid records for every variable included. Each student had a unique constellation of variable values[53]. Of the 606 students in the final model, 68% assessed below college-level mathematics[54]. Forty-two percent assessed 3- or 4-levels below college-level mathematics, at the level of basic mathematics. Table 20 presents the Case Processing Summary for the regression.

Table 20.
Case Processing Summary for Multinomial Logistic Regression Predicting Placement into 4-, 3-, 2-, or 1-Level Below College-Level Mathematics (n=606)

		N	Marginal Percentage
Community College Placement Level	4-levels below college math	124	20.5%
	3-levels below college math	131	21.6%
	2-levels below college math	75	12.4%
	1-level below college math	80	13.2%
	College-level math	196	32.3%

When run, the final model fit was significant *(x^2 = 573.3, p < .001)* indicating that at least one of the variables in the model was a significant predictor for placement (see Appendix P).

Significant predictor variables. The multinomial logistic regression found the CAHSEE Math and Grade 9 Mathematics course were significant predictors of placement at all four levels below college-level mathematics (see Table 21). Coefficients for both CAHSEE Math and Grade 9 Math were negative, meaning that lower scores predict lower placement relative to the reference placement, college-level mathematics. Although the coefficients were small, the magnitude of the coefficients increased for each level, from 1-level below to 4-levels below, for both

[53] The only continuous variable in the model was the CAHSEE Math score.

[54] In comparison, of the full sample of 857 CC Freshmen who took both the CAHSEE Math and the community college placement exam, 70.8% placed below college-level mathematics with 45% placing 3- or 4-levels below college-level mathematics.

the CAHSEE Math and Grade 9 Math Course, indicating that the effect was stronger at each additional level below college-level math.

Not taking mathematics in grade 12 was also a significant predictor at 2-, 3-, and 4-levels below college-level and had the greatest percentage impact. Grade 11 Math GPA was a significant predictor at 2- and 3-levels below college-level mathematics, and Grade 9 and Grade 10 Math GPA were significant predictors at 4-levels below college-level mathematics. In other words, students who did not take mathematics in grade 12 tended to place in the lowest levels, while students who had lower GPAs in grades 9 through 11 mathematics also tended to place lower than other students, all other characteristics held constant.

Based on Adelman's research (1999, 2006),[55] I was surprised that Highest-Level Mathematics course was not a significant predictor at any of the levels. Demographic variables, including ethnicity, gender, parent education, and low socioeconomic status, also were not significant predictors in the model at any level. Full results of the logistic regression model are presented in Table 21.

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[55] This may be explained by differences in sample, variables, and/or methodology between Adelman's (1999, 2005, 2006) studies and my own. Although, my study was inspired by Adelman's, and both use logistic regression, we have different samples and examine different variables. Specifically, Adelman's (1999, 2006) samples consist of students who enrolled in a four-year college whereas the students in my sample matriculated directly from high school to enroll as freshmen in a community college. Adelman's dependent variable is completion of a bachelor's degree whereas my dependent variable is placement level in mathematics at community college. In a preliminary logistic regression to test the impact for each level of highest-level mathematics on bachelor's degree completion, Adelman (2006) used only SES as a control. Adelman's core regression used composites as high school predictor variables and did not specifically include Grade 9 Mathematics, Highest-Level Mathematics, or No Mathematics in Grade 12. In my study, the inclusion of these specific high school mathematics variables, along with CAHSEE Math, may have subsumed Highest-Level Mathematics so that it does not appear independently as a significant predictor of placement. Although I expected Highest-Level Mathematics to be a significant predictor and it was not, my findings are consistent with Adelman's. Later in this chapter, I report on further analysis for Highest-Level Mathematics that comports with Adelman's research.

Table 21.

Summary of Multinomial Logistic Regression Analysis Predicting Community College Placement in 1-, 2-, 3-, or 4-Levels Below College-Level Mathematics

	1-level below				2-levels below				3-levels below				4-levels below			
	B	Std. Error	Sig.	Delta-p	B	Std. Error	Sig.	Delta-p	B	Std. Error	Sig.	Delta-p	B	Std. Error	Sig.	Delta-p
Intercept	21.963	3.747	***		22.938	3.873	***		39.631	4.152	***		54.593	4.875	***	
Gender (Female)	.340	.329			-.525	.355			.528	.340			.289	.383		
Black	-.289	.569			-.933	.677			-.650	.606			.214	.645		
Latino	-.033	.139			-.126	.144			-.038	.142			.123	.163		
Asian	-.439	.354			-.584	.413			-.089	.349			-.082	.472		
Parent Education	-.030	.109			-.078	.112			-.029	.112			-.145	.131		
Low SES	-.491	.358			-.179	.360			-.013	.357			-.315	.401		
Grade 9 Math Course	-.076	.026	**	21.99%	-.071	.028	*	22.27%	-.089	.026	**	22.39%	-.127	.031	***	21.38%
Grade 9 Math GPA	-.172	.167			-.268	.172			-.252	.169			-.541	.187	**	14.42%
Grade 10 Math GPA	-.102	.160			-.048	.166			-.148	.160			-.387	.183	*	16.74%
Grade 11 Math GPA	-.283	.146			-.450	.151	**	14.96%	-.394	.147	**	16.69%	-.323	.169		
CAHSEE Math	-.048	.009	***	22.64%	-.052	.009	***	22.72%	-.082	.010	***	22.53%	-.118	.012	***	21.54%
Highest Math Course	.013	.036			.033	.040			-.052	.030			-.043	.034		
Grade 12 – No Math	.527	.347			1.049	.366	**	57.64%	.825	.344	*	45.66%	1.095	.391	**	49.20%

The reference category is college-level math.

** p < .05, ** p < .01, *** p < .001*

How the significant variables predict placement. The multinomial logistic regression found significant predictor variables at all four levels below college-level placement (see Table 21). Bear in mind that these predictors are each relative to college-level mathematics placement, not to placement in one level compared to another. In the following sections, I present the significant predictors for each placement level.

One-level below college-level math. Two variables were significant predictors of placement 1-level below college-level mathematics: Grade 9 Math Course and CAHSEE Math.[56] Compared to students who took Geometry in ninth grade, students in a lower mathematics course (Algebra 1 or below) were 22% more likely to place 1-level below college-level mathematics than into college-level mathematics, holding everything else constant. Likewise, students with a lower CAHSEE Math score, everything else being equal, were 23% more likely to place 1-level below college-level mathematics.

Two-levels below college-level math. For placement 2-levels below college-level mathematics, there were four significant predictors. Grade 9 Math Course and CAHSEE Math were significant predictors at this level similar to their effect at 1-level below. As was true for 1-level below, students with a Grade 9 Math Course of Algebra 1 or below were 22% more likely to place 2-levels below college-level mathematics than into college-level mathematics, holding everything else constant. Again, similarly to 1-level below, students with a lower CAHSEE Math score, everything else being equal, were 23% more likely to place 2-levels below

[56] As discussed in Chapter Three, there is moderate correlation between CAHSEE Math and Grade 9 Math, (*r=.512, p <.01*); both reflect content mastery of seventh and eighth grade mathematics.

college-level mathematics. At 2-levels below, however, not taking mathematics in grade 12 is a significant predictor with a large effect. Students who took no mathematics in grade 12 were 58% more likely to place 2-levels below college-level math, holding everything constant. Finally, Grade 11 Math GPA is also significant at this level. Students with a lower 11th grade mathematics GPA were 15% more likely to place 2-levels below.

Three-levels below college-level math. At 3-levels below college-level mathematics, the same four variables that were significant predictors for 2-levels below were significant here: Grade 9 Math, CAHSEE Math, No Math in Grade 12, and Grade 11 Math GPA. Students with a Grade 9 Math Course of Algebra 1 or below were 22% more likely to place 3-levels below college-level mathematics than into college-level mathematics, holding everything else constant. Again, and still similar to the effect for 1- and 2-levels below, students with a lower CAHSEE Math score, everything else being equal, were 23% more likely to place 3-levels below college-level mathematics. However, students who took no mathematics in grade 12 were 46% more likely to place 3-levels below college-level math, holding everything constant. And lastly, for the model at this level, students with a lower 11th grade math GPA were 17% more likely to place 3-levels below.

Four-levels below college-level math. Finally, at 4-levels below college-level mathematics, the lowest placement possible, the model has the most significant predictors. Five predictor variables were significant at this level: Grade 9 Math, CAHSEE Math, No Math in Grade 12, Grade 9 Math GPA, and Grade 10 Math GPA.

Similar to 1-, 2- and 3-levels below college-level, students with Grade 9 Math of Algebra 1 or lower were 21% more likely to place 4-levels below college-level mathematics than into college-level mathematics, holding everything else constant. Likewise, students with a lower CAHSEE Math score, everything else being equal, were 22% more likely to place 4-levels below college-level mathematics. Students who took no mathematics in grade 12 were 49% more likely to place 4-levels below college-level math, holding everything constant.

Finally, grade 9 and grade 10 math GPA variables' significance was unique to this lowest level of placement. Students with a lower Grade 9 Math GPA were 14% more likely to place 4-levels below, and having a lower Grade 10 Math GPA increased the likelihood of placing 4-levels below by 17%.

Further Examination of Variables: Cross-tabulation and ANOVA

Further examination of CAHSEE Math, Grade 9 Math, and No Math in Grade 12. To better understand the relationships of the variables that were significant across multiple levels of below-college-level placement, I used cross-tabulation to see the actual distribution of students at the different levels, and also ANOVA to examine the differences between levels. Cross-checking the cross-tabulation and ANOVA results with the logistic regression model yielded interesting and useful observations.

Examining cross-tabulation for the significant predictor CAHSEE Math as an ordered variable[57] by placement level provided a very clear picture of what this

[57] As described in Chapter 3, I created an ordered variable from the CAHSEE Math Scale Scores. These ordered levels were used to cross-tabulate. The full range of scale scores were used in the regression.

relationship looks like. Eighty-three percent of students who scored above 430 on the CAHSEE Math placed in college-level mathematics. At the low end of both the placement and the CAHSEE math achievement variables, 82% of students who scored below 350[58] on the CAHSEE placed in the lowest level (4-levels below college-level mathematics) into basic arithmetic. Both of these findings are unremarkable. More noteworthy, of students with CAHSEE scale scores ranging from 350-379, 46% placed 4-levels below college-level mathematics, and another 33% placed 3-levels below. These students celebrated passing the CAHSEE, reaching the 350 threshhold, yet four out of five placed into pre-algebra or basic arithmetic, far below college-level; only 2% placed into college-level mathematics. Table 22 presents cross-tabulation[59] for CAHSEE Math scores with college placement levels.

Table 22.
Summary of Cross-tabulation of CAHSEE Math, a Significant Predictor for Community College Placement, at All Four Levels Below College-Level Mathematics

		College-Level	1-level below	2-levels below	3-levels below	4-levels below
CAHSEE Math			***	***	***	***
Scale Score	431-450, *n= 77*	83.1%	9.1%	5.2%	1.3%	1.3%
n = 857	401-430, *n=201*	59.2%	16.4%	16.4%	6.0%	2.0%
	380-400, *n=206*	28.2%	18.4%	19.9%	24.8%	8.7%
	350-379, *n=340*	2.4%	10.3%	8.8%	32.6%	45.9%
	297-349, *n= 33*	3.0%	.0%	.0%	15.2%	81.8%

Note. Significance, as indicated by the asterisks, references significance for predictor variables as determined by a multinomial logistic regression model for placement in mathematics at a specified level below college-level. The reference category is college-level math. *** $p < .001$

[58] 350 is the minimum scale score for passing the CAHSEE, a requirement for graduation from high school. 380 is considered proficient. In this sample, only 33 students scored below 350.

[59] Appendix Q1 provides further detail, presenting distributions by both percent placement level and percent of CAHSEE grouping. Appendix Q2 and Q3 present cross-tabulations disaggregated by ethnicity.

A similar cross-tabulation, disaggregated by ethnicity, illustrates that this situation describes many Black and Latino students. In my sample, 45% of Black students and 57% of Latino students passed the CAHSEE but were not proficient.[60] More than two thirds of these Black students and one half of these Latino students placed into basic arithmetic, 4-levels below college-level mathematics. By comparison, when Black and Latino students scored just one tier higher on the CAHSEE Math, in the low proficient range of 380-400, assessment at the lowest college placement level was greatly reduced, down to 24% of the Black students and 11% of the Latino students. Table 23 presents this cross-tabulation of CAHSEE Math scores with community college placement level for the Black and Latino community college freshmen[61] in this sample.

Table 23.
Summary of Cross-tabulation of CAHSEE Math, a Significant Predictor for Community College Placement, at All Four Levels Below College-Level Mathematics for Black and Latino students

Ethnicity	CAHSEE Math Scale Score	Community College Placement Results in Mathematics				
		College-Level	1-level below	2-levels below	3-levels below	4-levels below
	431-450, *n < 5* *(5%)*	75%	0%	0%	25%	0%
Black,	401-430, *n=13* *(16%)*	39%	8%	23%	15%	15%
n=82	380-400, *n=17* *(21%)*	29%	18%	12%	18%	24%
	350-379, *n=37* *(45%)*	0%	8%	3%	22%	68%
	297-349, *n=11* *(13%)*	0%	0%	0%	27%	64%
Latino,	431-450, *n= 8* *(3%)*	75%	13%	13%	0%	0%
n=308	401-430, *n= 41* *(13%)*	59%	22%	17%	2%	0%
	380-400, *n= 70* *(23%)*	29%	16%	20%	24%	11%
	350-379, *n=174* *(57%)*	2%	7%	8%	32%	51%
	297-349, *n= 15* *(5%)*	0%	0%	0%	0%	100%

Note. The sample size is quite small for some of these disaggregated distributions.

The CAHSEE Math was a significant predictor of community college placement at all four levels below college-level mathematics, however, an

[60] This compares to 24% of API students and 28% of White students (see Appendix Q2).

[61] Appendix Q3 provides a detailed presentation of these cross-tabulations, disaggregated for Black, Latino, API, and White students.

examination of the cross-tabulation (see Table 22) reveals that the percentages of students placing 1-level below and 2-levels below seem very similar. To better understand the differences between groups, I ran a Tukey post-hoc one-way ANOVA and found that, for all of the community college freshmen, there were significant differences *(F=231.7, p <.001)* (see Appendix Q4). The mean CAHSEE Math scale scores are significantly different between all levels of college placement except one; they are not significantly different between 1- and 2-levels below college-level mathematics. Appendix Q5 presents the significant differences in CAHSEE Math scale scores, as well as the mean and standard deviation, by college mathematics placement level.

Along with CAHSEE Math scores, Grade 9 Mathematics course was also a significant predictor in the multinomial logistic regression model at all levels below college-level mathematics. Cross-tabulation reveals that 54% of students who began grade 9 in Algebra 1 and 68% of students who began grade 9 below Algebra 1 placed 3- or 4-levels below college-level, in to pre-algebra or basic arithmetic. Table 24 presents these cross-tabulation results, illustrating the relationship between Grade 9 Mathematics course and community college assessment results for placement in mathematics.

Table 24.
Cross-tabulation of Grade 9 Math Course, a Significant Predictor for Community College Placement, at All Four Levels Below College-Level Mathematics (n=740)

Grade 9 Mathematics Course	College-Level	1-level below	2-levels below	3-levels below	4-levels below
		**	*	**	***
Geometry and above, *n=297*	52.2%	13.8%	14.8%	12.1%	7.1%
Algebra 1, *n=233*	18.5%	15.0%	12.0%	29.2%	25.3%
Below Algebra 1, *n=210*	7.6%	11.0%	13.3%	27.1%	41.0%

Note. Asterisks reference significance as determined by a multinomial logistic regression model for placement in mathematics. The reference category is college-level math.
* p< .05, ** p < .01, *** p < .001

An ANOVA examining differences between Grade 9 Mathematics course at the different placement levels found significant differences (*F= 61.129, p< .001*) between college-level and all levels of placement below college-level mathematics. However, there were no statistically significant differences between groups 1-level below and 2-levels below, or between 3-levels below and 4-levels below college-level mathematics. Appendix R presents this information.

The final predictor that was significant at three or more levels of placement below college-level was No Mathematics in Grade 12. The previous finding regarding the lack of difference for CAHSEE Math scores and Grade 9 Mathematics course between 1- and 2-levels below college-level mathematics draws attention to the other predictor variables that are significant. Of these, the largest effect by far is attributed to not taking mathematics in grade 12 (see Table 22). Examination of ANOVA and cross-tabulation of No Math in Grade 12, a dichotomous variable, with the placement levels reveals that 32% of students who took no mathematics in grade 12 placed into college-level mathematics. This group is significantly different than all of the below-college-level groups where not taking mathematics in grade 12 was more common. At 1-level below college-level mathematics, 47% of the students did not take mathematics in grade 12. Notably, more than half of the students who placed 2-, 3-, or 4- levels below college-level mathematics did not take mathematics in grade 12. As noted earlier, in the full sample of high school students, 44% of Black students and 41% of Latino students took no 12th grade mathematics (See Table 14). Table 25 summarizes the descriptive and ANOVA[62]

[62] Appendix R3 presents the ANOVA Summary Table for Mo Math in Grade 12.

findings for No Mathematics in Grade 12 for the full sample of assessed community college freshmen.

Table 25.
Descriptives and One-Way Analysis of Variance Summary for the Significance of No Math in Grade 12 on Placement in Mathematics at College-level, or 1-, 2-, 3-, or 4-Levels Below College-Level. (n=903)

	N	*M as %*	*SD*	College-Level
College-Level	265	32.1	.47	---
1-level below	116	47.4	.50	*
2-levels below	117	54.7	.50	***
3-levels below	190	55.3	.50	***
4-levels below	215	55.4	.50	***

* $p < .05$, *** $p < .001$

Appendix S presents cross-tabulation for all of the predictors that were found to be significant at one or more levels in the multinomial logistic regression model.

Further examination of Highest-Level Mathematics. The inspiration and foundation for this study was Adelman's research and assertion that coursework beyond Algebra 2 is a tipping point for college completion. Accordingly, and in keeping with the step-by-step conceit of a pathway, I expected Highest-Level Mathematics to be a significant predictor for placement into college-level (or below) mathematics. In this logistic regression model, it was not (see Footnote 55). The finding that highest-level mathematics was not a significant predictor baffled me and spurred me on to additional analysis.

To better understand how highest-level mathematics, specifically in relation to Algebra 2,[63] related to college-readiness, I examined cross-tabulations for Highest-Level Mathematics, when taken in grade 12 or in grade 11, with community college placements. Students who took Algebra 2 as their highest-level of

[63] I clustered Highest-Level Math courses to reflect above Algebra 2, Algebra 2, and below Algebra 2.

mathematics in grade 11 had more academic momentum at that point than did students who took Algebra 2 in grade 12. For both groups of students, college-level placement results were the same: 11% placed into college-level mathematics. However, for placement into below-college-levels of mathematics, students who reached Algebra 2 in grade 11 placed higher, proportionately, than did students who took Algebra 2 in grade 12. For example, 72% of students who took Algebra 2 in grade 12 as their highest-level of mathematics placed 3- or 4-levels below college-level mathematics into pre-algebra or basic arithmetic, compared to 59% of students who took Algebra 2 in grade 11. Table 26 presents these findings.

Table 26.
Cross-tabulation of Highest-Level High School Mathematics with Community College Mathematics Placement (N= 842)

Highest-level math	Grade taken	College-level	1-level below	2-levels below	3-levels below	4-levels below	Gr 11 Totals	Gr 12 Totals
Above Algebra 2	Grade 12	54%	16%	13%	11%	6%		307 (65%)
	Grade 11	48%	16%	15%	12.5%	8%	104 (28%)	
Algebra 2	Grade 12	11%	8%	9.5%	32%	40%		126 (26.5%)
	Grade 11	11%	14%	16%	28%	31%	210 (57%)	
Below Algebra 2	Grade 12	2%	2%	5%	24%	67%		42 (9%)
	Grade 11	1.9%	3.8%	5.7%	34%	55%	53 (14%)	
Total							367 (44%)	475 (56%)

Note. Highest-Level Mathematics has been sub-divided into above Algebra 2, Algebra 2, and below Algebra 2. Grade 12 mathematics is highest-level mathematics for those students who took mathematics in grade 12; for students who took no mathematics in grade 12, highest-level mathematics was grade 11 math.

Appendix T presents the results of Tukey post-hoc one-way ANOVA confirming that there were significant differences between groups in Highest-Level Mathematics at different college placement levels.

Knowing that No Math in Grade 12 was a significant predictor, I also cross-tabulated Highest-Level Math for those students who took mathematics in grade 12 (essentially Grade 12 Math[64]) with placement levels. Very few students in this sample, less than 10%, took below-Algebra 2 coursework in grade 12. However, more than 25% of the 12th graders who took mathematics took Algebra 2 as their highest-level course. Seventy-two percent of these students placed 3- or 4-levels below college-level mathematics, into pre-algebra or basic arithmetic. Students who took above-Algebra 2 coursework as 12th graders, fared markedly better. Ninety-five percent of students who took Calculus placed into college-level mathematics. Of the students who took any coursework above Algebra 2 - Calculus, Statistics, or Pre-Calculus/Trigonometry - 54% placed into college-level mathematics. In contrast, only 11% of students who took Algebra 2 in grade 12 placed into college-level mathematics. Table 27 presents this cross-tabulation, illustrating the advantages, for students in this sample, of advancing beyond Algebra 2 by grade 12.

[64] Grade 12 Mathematics was not included as a variable in the logistic regression model although it was part of the variable Highest-Level Mathematics. See Chapter 3 for discussion on variables.

Table 27.
Highest-Level Math in Grade 12 to Community College Placement (N=475)

Grade 12 Mathematics		Community College Assessment Results for Placement in Mathematics											
		College-level		1-level below		2-levels below		3-levels below		4-levels below		TOTAL	
		N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
Above Algebra 2	Calculus[a]	58	95%	<5	3%	0	0%	<5	2%	0	0%	61	13%
	Statistics[b]	63	42%	25	17%	29	19%	23	15%	10	7%	150	32%
	Precalc/Trig	44	46%	23	24%	10	10%	11	11%	8	8%	96	20%
Algebra 2	Algebra 2[c]	14	11%	10	8%	12	10%	40	32%	50	40%	126	27%
Below Algebra 2	Below Alg 2[d]	<5	5%	<5	5%	<5	10%	6	29%	11	52%	21	4%
	Special Ed[e]	0	0%	0	0%	0	0%	<5	19%	17	81%	21	4%
	TOTAL	180	38%	61	13%	53	11%	85	18%	96	20%	475	100%

Note. Algebra 2 is shaded to draw attention to its role in the literature as the dividing line for tipping toward college completion (Adelman, 1999, 2005, 2006).[a] Calculus includes Advanced Placement Calculus BC, Advanced Placement Calculus AB, and Honors PreCalculus/Calculus A. [b] Statistics includes both Advanced Placement Statistics and less rigorous college preparatory statistics coursework. [c] Algebra 2 includes Honors Algebra 2, Spanish Immersion Algebra 2, Algebra 2, and first semester Algebra 2. [d] Below Algebra 2 includes Geometry, and Algebra 1. [e]Special Ed includes Algebra 1 RSP, Special Day Class Algebra 1, Special Day Class Essentials for Algebra 1, Special Day Class Essentials for Algebra 2, and Essentials 2 for Algebra 2.

Further examination of mathematics pathways. Using the high school markers that were significant predictors in my study, I attempted to retrospectively identify mathematics pathways from high school to community college placement. I used concatenation to plot the history of each student at each of my key high school markers – Grade 9 Mathematics, CAHSEE Math scores, Highest-Level Mathematics, and taking math in grade 12 – with each student's respective college placement level. Monitoring only these four markers among high school mathematics variables plus the community college placement level, I observed 86 distinct pathways[65] tread by 696 students.[66] Notably, none of the pathways were commonly travelled. Rather, students took different paths through high school mathematics to their destination, community college placement. Multiple paths, or trails, led to the same placement. Some students took direct routes that were expected, but others meandered and reached the same destination, for better and for worse. Table 28 presents the most common patterns of student progress through high school to placement at the community college for students with no missing values, and including CAHSEE Math.[67] It takes 12 different trails to describe the progress of less than half of the sample. Most trails were used by fewer than 2% of the students.

[65] Grade 9 Math is broadly subdivided into 2 levels (Algebra 1 and below/above Algebra 1), Highest-Level Math has 3 levels (below Algebra 2/Algebra 2/above Algebra 2), Grade 12 Math has 2 levels (yes/no), CAHSEE Math has 3 levels (fails: < 350; passes but not proficient: 350-379: proficient; 380+) and there are 5 levels of community college placement. Therefore 180 different combinations were possible.

[66] Nine hundred and three students in the study matriculated to the community college as freshmen and took the placement examination in mathematics. Of these students, 77% (696) had no data missing for any of the observed variables.

[67] Appendix U presents the ten most frequent patterns using just the landmarks Grade 9 Math, Grade 12 Math, and Highest-Level Math, cross-tabulated with the end of the trail, community college placement level. Among students with no missing data, 701 students followed 47 different combinations, or trails, and for 29% (262 students), fewer than 3% followed the same trail.

Table 28.
Most Common Patterns of Student Progress from High School to Placement at the Community College (N=903)

High School Mathematics				Community College Placement Level	N	%
Grade 9 Math Class*	CAHSEE Math Score*	Math in Grade 12*	Highest-level Math			
Geometry	380+	Yes	Above Algebra 2	College-level	103	11%
Geometry	380+	No	Above Algebra 2	College-level	43	5%
Algebra 1 or less	380+	Yes	Above Algebra 2	College-level	33	4%
Algebra 1 or less	380+	No	Algebra 2	2-levels below	20	2%
Algebra 1 or less	380+	No	Algebra 2	3-levels below	19	2%
Algebra 1 or less	350-379	No	Algebra 2	College-level	17	2%
Algebra 1 or less	350-379	No	Algebra 2	1-level below	17	2%
Algebra 1 or less	350-379	Yes	Above Algebra 2	1-level below	17	2%
Algebra 1 or less	350-379	No	Algebra 2	3-levels below	34	4%
Algebra 1 or less	350-379	Yes	Algebra 2	3-levels below	20	2%
Algebra 1 or less	350-379	No	Algebra 2	4-levels below	48	5%
Algebra 1 or less	350-379	Yes	Algebra 2	4-levels below	36	4%
					407	45%

Note. This table presents the most frequent patterns for students who attended the community college as freshmen, and had no missing data for any of the four high school variables.
* Grade 9 Math course, and CAHSEE Math score were significant predictors at all levels of below college-level placement, and No Math in Grade 12 was a significant predictor for placement at 2-, 3-, and 4-levels below college-level mathematics.

Summary of findings for Research Question 2

In summary, although students with different high school mathematics histories arrived at like community college placement levels, the multinomial logistic regression identified key markers that are statistically significant predictors for placement in below-college-level mathematics. Gender, ethnicity, parent-education, socioeconomic status, and highest-level of mathematics were not significant in the model. The three most significant predictors – in terms of applying to the most levels of placement and also the largest effects – were Grade 9 Mathematics, CAHSEE Math scale score, and No Mathematics in Grade 12. These findings have immediate applicability to policy and practice.

CHAPTER 5: RECOMMENDATIONS, DISCUSSION, IMPLICATIONS, AND CONCLUSIONS

Chapter 5 synthesizes my research findings. I present seven specific recommendations applicable for both policy-makers and practitioners, discuss the implications and limitations of the study, identify directions for future research, and conclude with a reflection.

Since mathematics is a well-documented gatekeeper, and roadblock, to college completion (Adelman, 2006; Berry, 2003; Brown & Niemi, 2007; Lee, 2012; Moore & Shulock, 2010; Offenstein, Moore, & Shulock, 2010; Stigler, et al., 2010; Venezia & Kirst, 2005), I focused my study on high school mathematics experiences, and the effectiveness of different high school mathematics pathways in preparing students for college-level mathematics. Accordingly, this research linked the high school mathematics experiences of community college freshmen with their community college placement results.

In scrutinizing the actual experiences of a diverse group of students in a single comprehensive and relatively affluent high school in California, I was looking to find reliable and well-traveled routes to college-readiness. Instead, I stumbled upon significant and useful predictors of college *un*-readiness. This study suggests that California already has in place a fully implemented high stakes test for 10^{th} graders that predicts placement into below-college-level mathematics. The California High School Exit Exam in Mathematics was a significant predictor of placement in 1-, 2-, 3-, and 4-levels below college-level placement. Furthermore, not taking mathematics in grade 12 was also a significant predictor of placement in below-college-level mathematics. The combination of these two findings suggests that California schools may already have both a diagnostic tool for early identification of students who are not on-track to college-readiness and the time to help them get on-track.

Recommendations

The following recommendations are applicable for educators at both the state and local level. I identify actionable and strategic shifts in practice that my research indicates will be effective in improving college-readiness in mathematics, especially relevant for many community college-bound Black and Latino students.

In this study, gender, ethnicity, parent education level, and indications of lower socioeconomic status were not significant predictors of community college placement in mathematics. However, looking at distribution by ethnicity, more than half of the Black and Latino students who matriculated to the community college as freshmen were severely under-prepared. Sixty-six percent of the Black students placed 3- or 4-levels below college-level mathematics into pre-algebra or basic arithmetic, as did 60% of Latino students (see Appendix Q2). The following recommendations directly affect these students.

Recommendation 1: Utilize the CAHSEE Math to Improve College-Readiness

In grade 10, all California students take the CAHSEE Math, a high-stakes test that is required for high school graduation. My research finds that lower scores on the CAHSEE Math, which tests mastery of Algebra 1 and general mathematics, were significant predictors of placing into below-college-level mathematics. Researchers contend that low standards for passing high school exit exams, reflecting minimal graduation requirements, mislead students into thinking they are ready for college when they are not (Venezia & Perry, 2007). However, my research demonstrates that, while the CAHSEE may not measure college-readiness, it *is* measuring something important: college *un*-readiness.

CAHSEE scores are scaled from 275-450 and provide diagnostic information to schools and individual students about which strands of basic mathematics have not been mastered. However, currently, students and educators only look at CAHSEE Math scores for pass/fail status.[68] Educators are not fully utilizing the information the CAHSEE provides to address assessed weaknesses in mathematics. It is significant that four out of five students who passed the CAHSEE but scored lower than proficient,[69] placed 3- or 4-levels below college-level in community college mathematics (see Table 22). Because of these findings, to improve college-readiness, I recommend that mathematics departments and teachers use CAHSEE Math scores and diagnostic information to tailor interventions in high school that strengthen basic mathematics skills.

Recommendation 2: Stop Wasting 12th Grade

Not taking math in grade 12 was a significant predictor with a large effect for students placing 2-, 3-, or 4-levels below college-level mathematics. Fifty-five percent of students who placed at these levels took no math in grade 12. This finding reveals that there is under-utilized time in high school to improve student

[68] This is both illustrated and incentivized by the fact that only whether or not a student passed the CAHSEE is factored into a school's Academic Performance Index (CA Department of Ed, 2012).

[69] 350 is a passing score on the CAHSEE and 380 is considered proficient. Here I am discussing students with scores from 350-379.

readiness for college-level mathematics. Given the role that mathematics plays as a roadblock to college completion, students who have weak math skills cannot afford to sit out in grade 12. This is not to say that the currently available 12th grade curriculum is appropriate for all students: districts may need to develop new curriculum options to better serve these students and better prepare them to be successful in college. However, at the very least, students, especially those who scored less than proficient on the CAHSEE, should be urged to take mathematics in their final year of high school.

Furthermore, even though highest-level mathematics was not a significant predictor in this model for placement in below-college-level mathematics, students should be supported and encouraged to progress beyond Algebra 2. Fifteen percent of all students and 23% of the CC Freshmen subset took Algebra 2 in the 11th grade and then took no mathematics in their senior year. Of these CC Freshmen, only 11% placed into college-level mathematics.

This recommendation perceives not taking mathematics in grade 12 as a missed opportunity for two groups of students: 1) those students, identified by less than proficient and low proficient scores on the CAHSEE who need remediation; and 2) those students who were making reasonably good progress in mathematics through eleventh grade but opted out of taking above Algebra 2 coursework in grade 12.

Recommendation 3: Post Clear Signs to College-Readiness

Students and their families need to understand college-readiness standards. California's high school graduation requirements, which include passing the CAHSEE, just two years of high school mathematics, and passing Algebra 1, do not communicate college standards. In fact, they mislead students into believing that they will be ready for college when they are not (Venezia & Kirst, 2005; Venezia & Perry, 2007). At the very least, these minimal graduation requirements need to be re-messaged.

The CAHSEE Math can and should be a potent signal to students and their teachers when students are not on-track to college-readiness. Students with weak mathematics skills also need to understand the implications of not taking mathematics in grade 12 and the likelihood that they may have years of remedial mathematics ahead of them in community college if they are not able to address their deficits while still in high school.

Consistent with literature documenting unfamiliarity with "college knowledge" (McDonough, 2005; UCLA/IDEA, 2007; Venezia & Kirst, 2005), my findings documented that a smaller percentage of Black and Latino than White or API students took mathematics in grade 12. In my sample, 44% of Black students and 41% of Latino students did not take any mathematics in their senior year compared to 32.5% of White students and 28% of API students. Policy-makers on the state and local level should consider the message sent to these students when mathematics is optional for high school seniors. Independent of immediate changes to state or district policy, I recommend that counselors and teachers urge students to take mathematics in grade 12 (and that school districts and teachers develop additional curriculum options to address the demonstrated needs of students.)

Lastly, although highest-level mathematics was not a significant predictor in this model for placement in below-college-level mathematics, students should be supported and encouraged to progress beyond Algebra 2. Among students at this single high school, just 40% of Black students and 46% of Latino students took coursework above Algebra 2, compared to 73% of White students and 86% of API students (see Table 14). Of the CC Freshmen who took Algebra 2 in grade 12, only 11% placed into college-level mathematics. These findings accentuate the need for schools – teachers, counselors, and administrators – to aggressively provide students and their parents with the information they need to make decisions that will serve them well.

Recommendation 4: Respond to the Data

Clearly, it is not in the best interests of students, or the state, to wait until students are assessed in community college to remediate missed basic math concepts and skills. Multiple warning flags alert high schools when students are struggling with fundamental mathematics skills. Grade 9 mathematics placement, based on middle school achievement including grade 7 CST results,[70] identifies students with weaker math skills at the very beginning of high school. Grade 9 and 10 math GPA were significant predictors, along with CAHSEE Math, Grade 9 Math

[70] Casella High uses seventh grade CST scores to initially place new to the district students in grade 9 math because the eighth grade CST scores are not available in time to make placement decisions.

Course, and No Math in Grade 12, for students who placed 4-levels below college-level[71] into basic arithmetic. Students placed at this level are very unlikely to complete college (Brown & Niemi, 2007; Perry, et al., 2010). To improve their odds of becoming college-ready, such students require early, strong, innovative interventions. School district leaders, site principals, teachers, and counselors, as well as students and parents, need to understand the data they receive, consider its implications, and develop educational plans that are responsive to identified weaknesses.

Recommendation 5: Focus on Mastering Pre-Algebra Content – Do It Until it's Done.

Although my study focused on high school mathematics, the findings emphatically point back to weaknesses in mathematics that precede high school. Grade 9 Math, determined by the district's assessment of the students' prior content mastery,[72] was a significant predictor of placement into below-college-level mathematics. Grade 7 CST scores, a measure of pre-algebra content mastery, was second only to the CAHSEE Math in correlating with community college placement results. And, as discussed above, the CAHSEE Math also was a significant predictor at all levels of assessment below college-level mathematics.

There is a great deal of literature focusing on the importance of beginning Algebra 1 in middle school (Burris, et al., 2008; Gamoran & Hannigan, 2000; Silva

[71] For students placing 2- and 3-levels below college-level mathematics, Grade 11 math GPA was a significant predictor, along with CAHSEE Math, Grade 9 Course, and No Math in Grade 12.

[72] Whether students were placed in below-Algebra 1, Algebra 1, or Geometry in ninth grade reflects the school district's assessment of the students' mastery of general mathematics coursework.

& Moses, 1990; Spielhagen, 2006). My findings are consistent with and generally support this research: Grade 9 Math was a significant predictor for community college placement. The students in this sample who did not take Algebra 1 until grade 9 did not fare as well as those who had completed Algebra 1 prior to grade 9.[73] However, my findings indicate that it may not be Algebra 1 *per se* that is so important; rather, my findings emphasize the importance of mastering pre-algebra mathematics.

The lesson I take from these findings is that Algebra 1 is not a stand-alone issue. Rather, it seems that students need to master pre-algebra fundamentals to be college-ready. Students are more likely to complete college if they complete coursework above Algebra 2 in high school (Adelman, 1999, 2006). But, they are unlikely to successfully complete coursework above Algebra 2 if they are not competent in general mathematics. In a recent issue brief, EdSource identified grade 7 mathematics as a "pivot point," "the point where students' math course-taking paths clearly begin to diverge" (Terry & Rosin, 2011, p. 1). Adding to this research, I document that students who demonstrate weak basic mathematics skills as early as seventh grade[74] are progressing through high school on to community college; however, when they get to community college, they do not assess as college-ready. This finding that mastery of pre-Algebra 1 content is essential for college-readiness, also supports and is supported by research that describes developmental math students in community college as not understanding why,

[73] This, however, was not true for all students. About 8% of the community college freshmen who had taken Algebra 1 or below in grade 9 assessed into college-level mathematics (see Table 24).

[74] I do not have data prior to grade 7, however Lee (2012) traces divergent math achievement back to Pre-K.

when, or how to use basic mathematics operations (Givvin, Thompson, & Stigler, 2011; Stigler et al., 2010). And, of course, the high percentages of students assessing into basic mathematics when they enter community college also attest to this finding that mastery of pre-Algebra 1 content is a pre-requisite for college-readiness that many entering community college students lack. Therefore, this recommendation contends that mastering basic mathematics needs to be an ongoing priority: If students have not mastered these concepts and skills by the time they enter high school, their high school mathematics experience needs to be recalibrated to ensure mastery of pre-algebra content.

Recommendation 6: Be Strategic – Push at Tipping Points

My study suggests that significant gains in college-readiness might be realized by focusing interventions strategically. The finding that the CAHSEE Math predicts college un-readiness provides a roadmap for action. Seventy-nine percent of the CC Freshmen who passed the CAHSEE Math but were not proficient placed 3- or 4-levels below college-level into pre-algebra or basic arithmetic (see Table 22). These community college students have a lot of demoralizing, time-consuming, and costly remediation ahead of them. Very few of them are likely to complete college (Adelman, 2006; Brown & Niemi, 2007; RP/CSS, 2005; Perry, et al., 2010). Interventions that help these students gain skills identified as deficient by the CAHSEE can increase college-readiness by decreasing un-readiness. Effective remediation, while students are still in high school, that enables them to place 1- or 2-levels below college-level mathematics, rather than 3- or 4-levels below, would improve their prospects for college completion.

Strategically, focusing on strengthening the math skills of students who score at the lower levels of proficiency on the CAHSEE might tip these students into a higher bracket. For example, more than twice as many students (59%) with CAHSEE Math scores from 401-430 placed into college-level mathematics as students (28%) who scored from 380-400 (see Table 22). Continuing to build the math skills of students who have passed the CAHSEE with scores in the low range of proficiency may provide the boost these students need to place into college-level mathematics.

This research also identifies grade 12 mathematics and highest-level mathematics as strategic tipping points for increasing college-readiness. Not taking math in grade 12 was a significant predictor for placing 2-, 3-, or 4- levels below college-level mathematics. Students who took no mathematics in grade 12 were 58% more likely to place 2-levels below college-level than into college-level mathematics, all other factors being equal. Not taking mathematics in grade 12 impacts the highest-level of mathematics students attain which is reflected in placement results. For example, only 11% of students who took Algebra 2 as their highest-level high school mathematics course in grade 11 placed into college-level mathematics, compared to 54% of students who took high school mathematics above-Algebra 2 in grade 12 (see Table 26). This suggests that urging students who successfully completed Algebra 2 or above-Algebra 2 coursework in grade 11 to take additional above-Algebra 2 coursework in grade 12 would be an effective strategy for increasing college-readiness for more students. And, per Adelman's research, this would also improve their odds for college-completion.

Recommendation 7: Recognize That There is No Single Pipeline

Community college-bound students in this sample did not travel en masse through high school in a single mathematics pipeline. Rather, the metaphor of different hiking trails is more apt. Students began high school at different trailheads in ninth grade and passed different markers and signposts as they hiked and climbed the High School Mathematics Mountain toward college-readiness. Some students hiked different trails but reached a common destination. Others hiked the same trail but ended up at different places. For example, students who were placed in above Algebra 1 coursework in Grade 9, took mathematics in grade 12, and took highest-level mathematics coursework above Algebra 2, were more likely to place into college-level mathematics than were students who did not follow this direct path, but some of the students who took less optimal paths also attained college-level mathematics placement. This recommendation calls upon educators to envision progress toward college-readiness as a function of student *learning*, particularly for students with demonstrated weaknesses in pre-algebra mathematics. Meeting the needs of individual students by developing alternative pathways may be more effective in increasing student success than continually pushing resistant students along a single trail they are ill prepared to climb.

Further Discussion and Implications

A discussion of curriculum is beyond the scope of this research, but it is worth noting and applauding that California is on the cusp of implementing new Common Core standards. By concentrating on pre-algebra in eighth grade, the Common Core sequence devotes more time for students to master the basic mathematics skills and concepts that form a strong foundation for Algebra 1 (Fensterwald, 2012[75]). My findings support this new approach, especially for the 71% of students in my sample who assessed as below-college-ready. My data indicates that students will be better prepared for community college if the Common Core is successful in improving content mastery of basic mathematics.

Beyond documenting need for a laser focus on pre-algebra mathematics for community college-bound students, my study spotlights the CAHSEE Math as a useful tool for both monitoring and improving student progress toward college-readiness. This appears to be a new finding that adds to the existing research on both college-readiness and the utility of high school exit exams.

This study also documented the prevalence of not taking mathematics in grade 12, especially for Black, Latino, and community college-bound students. My finding, that No Math in Grade 12 is a significant predictor of placement in below-college-level mathematics, raises the question of effectiveness. What is the most effective way to increase the numbers of students taking 12th grade mathematics? Is this just an issue of clearer counseling? The literature on student success for community colleges emphasizes that "students don't do optional" (McClenney, 2010). In my sample, 36% of high school seniors took no mathematics. Observing this high percentage of students who opted out of grade 12 mathematics, it appears that many high school students also don't do optional.

[75] This article reports on the formation of the Mathematics Curriculum Framework and Evaluation Criteria Committee which will determine whether or not the Common Core is amended to maintain California's current emphasis on offering Algebra 1 in grade 8.

The finding that not taking mathematics in grade 12 was a significant predictor of placement in below-college-level mathematics for community college freshmen does not mean that California's high schools have the 12th grade curriculum in place that students need to become college-ready. High schools might look to some of the new approaches for remedial education that are emerging at innovative community colleges. Colleges are implementing accelerated courses, modules, flipped instruction, and contextualized learning for basic skills students in a concentrated effort to improve and accelerate progress toward completion of college level mathematics[76] (Stigler, et al., 2010). High schools also are innovating and adopting new curricula. The Southern Regional Education Board (2010) has prepared a 12th grade transitional curriculum in mathematics to increase college-readiness. And, as mentioned above, the soon-to-be implemented Common Core standards are designed to do a much better job of ensuring more students understand basic mathematics concepts. In addition to these curriculum-based efforts, California's local and state policy-makers may need to weigh the benefits of requiring four years of high school mathematics, requiring that students take mathematics in their senior year, or otherwise moving more students into above Algebra 2 coursework. I discuss the related issues of high school graduation requirements and college-readiness in the Further Research section.

Limitations of the Study

While this research resulted in important findings, it is important to note some of the limitations inherent in the study design. These include restriction to a

[76] Stigler, et al. (2010) note that most reforms fail to address or change actual teaching methods. Their research supports teaching methods for mathematics at all levels that are "reason-focused."

single local context, sample and sample size, the scope of the research, and generalizability. These limitations are discussed below.

This study examined student progress in mathematics from high school to community college. The students in this sample all attended the same relatively resource-rich comprehensive high school. While I deliberately restricted the study to a single high school to control for variables, and consider the restriction to be an asset of the research, it is also a limitation. I chose my study site because it was relatively well-resourced with qualified teachers, sufficient classroom supplies and textbooks for every student, as well as a robust schedule of upper-level coursework. However, many California high schools do not have these same resources. Therefore, generalizability of the findings will need to be confirmed by subsequent researchers.

My study is further limited by the small sample size, particularly the low numbers of very low-achieving students. Only 4% of the community college freshmen in this sample failed the CAHSEE Math. For particular analyses, my study was also limited by the small sample size of Black students assessed as freshmen at the community college.

This research examined college-readiness in mathematics for community college freshmen, as measured by placement on the college-administered placement test ACT COMPASS. The use of ACT COMPASS as the measure of college-readiness, or, more frequently, college un-readiness, is also a limitation of the study since the study's direct generalizability is limited to this single assessment.[77] As I write this, California's community colleges do not have a common assessment tool for college readiness. Furthermore, even among community colleges using ACT COMPASS, each college determines their own cut scores for placement. Appendix I2 provides the cut scores used by the study community college to determine placement levels.

In addition to the limited size of the sample; the limitation to a single high school and community college district; and the limitation of a single college-readiness assessment instrument; my findings are heavily dependent upon the validity of standardized assessments. The importance of the major finding, that the California High School Exit Exam is a significant predictor of placement in below-college-level mathematics for community college freshmen, inherently depends upon the validity of the CAHSEE and ACT COMPASS. Those who question the validity of these standardized assessments as measures of student learning may assert that what is being measured is test-taking ability rather than content mastery or college-readiness.[78]

The scope of the research topic was another limitation. The study examined progress in high school mathematics as a proxy for academic progress toward college-completion. The narrow quantitative focus on high school mathematics as

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[77] Some researchers question the validity of using standardized assessments to determine college-readiness and course placement (Burdman, 2012; Hughes & Scott-Clayton, 2011). As an alternative, Long Beach Community College is piloting a program to use high school transcripts and GPA for deciding placement (Puente, 2012).

[78] However, the fact that the CAHSEE is a high stakes test for students removes a common objection that high school students do not apply themselves to low-stakes standardized tests. Furthermore, research on community college students in developmental mathematics using surveys and one-on-one interviews to assess mastery of pre-algebra content, demonstrated, independent of standardized assessments, that basic skills community college students lack fundamental skills and conceptual understanding of basic arithmetic (Stigler, et al., 2010; Givvin, et al., 2011).

preparation for college-readiness for community college freshmen, is, by design, limited.

Finally, in terms of my finding that mastery of pre-algebra content material is essential for college-readiness, my research is short on answers. It includes no analysis of curriculum, instructional methods or materials, teacher effectiveness, or other school practices that might positively impact student mastery of mathematics. This is a limitation. The study provides no insights into *how* to increase student learning of mathematics; it only points out that it is necessary. Clearly, this is easier said than done.

Further Research

I believe that the most significant finding in this research is the identification of the CAHSEE Math as a significant predictor of college un-readiness for community college-bound freshmen. Because my study was small in size, and limited to a single district, further research is needed to confirm, explore, or dispute this finding. However, if verified, this finding points to additional areas for future research. Firstly, at the student-level, if the CAHSEE Math identifies students who are not on-track to college-readiness and provides diagnostic, student-specific information that can be used immediately, research is needed to design and evaluate effective responses. Secondly, this finding emphasizes a need for more longitudinal research in California, particularly longitudinal research that explicitly studies the experiences of community college-bound students. Thirdly, this finding suggests that identifying, understanding, and reducing community college *un-*

readiness might be a pragmatic approach to articulating a workable definition of college-readiness and improving college completion rates.

My study highlights key markers - lack of mastery of pre-algebra mathematics, not taking mathematics in grade 12, and not completing high school coursework beyond Algebra 2 - as areas for strategic interventions and further research. The finding that not taking grade 12 mathematics is a significant predictor for assessing 2-, 3-, or 4-levels below college-level mathematics seemingly argues for a change in state policy to require four years of high school mathematics. However, in other research, Droogsma Musoba (2011) found that requiring three years of high school mathematics (rather than two) did not increase college-readiness as measured by SAT scores,[79] although taking coursework above Algebra 2 had large positive effects, especially for Black and Latino students.[80] Regarding mathematics in grade 12, additional research or analysis may be needed to identify changes in policy and practice that will increase college-readiness for community college-bound students.

My study design envisioned the community college entry assessment as a research pivot point (See Figure 1) and examined students' mathematics histories leading up to that examination. I also have data for the mathematics history of these students in community college, post placement exam. For me, future research includes observing and analyzing student progress from the placement examination through completion of college-level mathematics.

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[79] Using SAT scores as a measure of college-readiness restricts the sample to students who intended to attended a somewhat selective four-year college or university.

[80] Black students experienced the greatest positive impact followed by Latino students followed by White students. She did not disaggregate her data to include API students (Droogsma Musoba, 2011).

Lastly, I conceived of this research as a study of the educational pipeline from high school to community college. However, observing the actual mathematics experiences of students, I found the pipeline to be a misleading metaphor, particularly for community college-bound students. Perhaps future research can better illuminate how more students who do not follow the beaten trail to a four-year college can also reach college-readiness.

Reflection

I began this study expecting to identify high school mathematics pathways of varying effectiveness in preparing students for college-level mathematics in community college. Many of my findings surprised me. I did not find a pipeline. Rather, it seems that community college-bound students are taking every possible trail through high school mathematics, with varying degrees of success that seem to be somewhat independent of *what* they do. Whether students were in honors mathematics or took an AP mathematics course never rose in my analysis to a level of pertinence. Highest-level mathematics, which I expected to be a significant predictor of college placement, was not significant. The CAHSEE Math, which I requested only because I knew it was available, with absolutely no expectation that it might be a significant predictor relative to college-placement, had the highest correlation with placement results. My study began as a search for effective pathways to college-readiness. Instead, I report on the inverse: markers that are significant predictors of college un-readiness.

Conclusions

Mathematics is a roadblock to college completion, particularly for Black and Latino students, and this phenomenon is particularly evident and acute for students matriculating as freshmen to community colleges. To better understand this problem, I closely observed and documented the high school histories in mathematics of a cohort of diverse students who enrolled as freshmen at a California community college. I used multinomial logistic regression to identify demographic and academic variables that were significant predictors of placement at the community college in college-level mathematics or 1-, 2-, 3-, or 4-levels below college-level mathematics. Rather than finding a pipeline conveying community college-bound students to college-level mathematics, the model identified variables that predict placement into below-college-level mathematics. These include the mathematics course that students are placed into at the beginning of high school, Grade 9 Math; scores on the California High School Exit Exam (CAHSEE Math); not taking any mathematics as a high school senior, and, at some levels of placement, math GPA. Descriptive statistics and the research literature also identify taking high school mathematics beyond Algebra 2 as being positively associated with college readiness.

For high school educators and students, the findings that the CAHSEE Math and No Math in Grade 12 have predictive value are immediately actionable. The CAHSEE Math is a high stakes exit exam administered to all California students when they are in tenth grade, near the beginning of their high school experience. The results of this study strongly argue for moving past the current, narrow interpretation of the CAHSEE as a pass/fail test. Rather, the CAHSEE Math provides a scale score and diagnostic information that educators can, and should, use to inform and help design a recalibrated high school mathematics experience for students who score below 400.[81] The CAHSEE is also ripe for re-messaging, to help teachers and counselors inform students and parents, especially students and parents who are not members of a strong college-going culture, of college-readiness standards and the importance of taking mathematics in grade 12.

This study found that gender, ethnicity, parent education, and lower socioeconomic status were not significant predictors of placement in community college. However, disaggregating by ethnicity documented that Black and Latino students were overrepresented among students who placed in Algebra 1 or lower in grade 9; passed but scored lower on the CAHSEE Math; took no mathematics in grade 12; and did not advance beyond Algebra 2. These variables are markers that represent strategic leverage points for pushing the curve of college-readiness up. Although these markers are not limited to Black and Latino students, Black and Latino students will be greatly affected by implementing the recommendations derived from these findings.

Lastly, I write this as California is preparing to implement the Common Core standards and (perhaps) develop a statewide assessment test for community colleges. My findings strongly support both of these new directions, as well as the opportunity they provide for meaningful longitudinal research that will benefit California's public school children.

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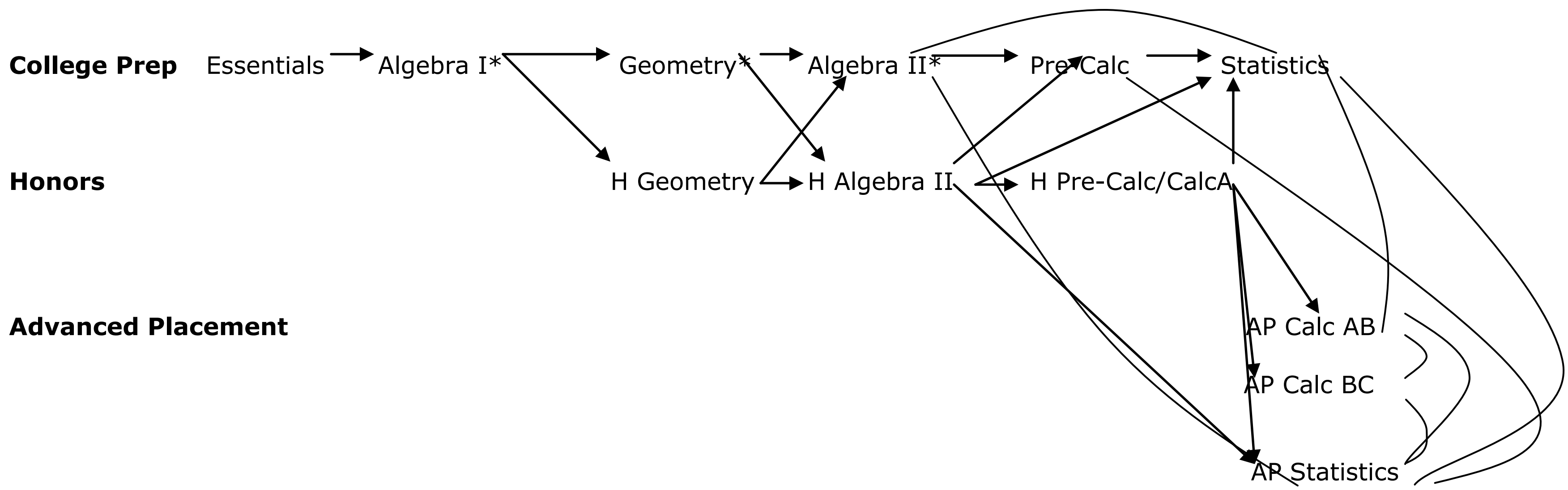
[81] Future research can refine this score. Based on my research scoring below 400 indicates students will benefit from strengthening skills in basic arithmetic.

APPENDIX A: Diagram of mathematics pathways

Diagram of possible mathematics pathways at Casella High School



*Immersion options exist for these classes which can include an honors component.

Examples of standard student pathways (these are not suggestions, just possibilities):

Grade	**Student 1:**	**Student 2:**	**Student 3:**	**Student 4:**
9th	Essentials	Algebra I	Honors Geometry	Honors Algebra II
10th	Algebra I	Geometry	Honors Algebra II	Honors Pre-Calc/CalcA
11th	Geometry	Algebra II	Pre-Calculus	AP Calculus BC
12th	Algebra II	Pre-Calc OR Statistics	AP Calc AB OR AP Statistics	AP Statistics

APPENDIX B: Variables, Coding, and Analysis

Table B1.
Variables and coding

Category	**Variable**	**Coding**
Student Demographics	Gender	0=male, 1= female
	Ethnicity	1= Black, 2= API, 3=Latino, 4= White, 5= MultiRace/Other/Unknown
	English first language	0=no, 1=yes
	Father Education Level	1= Some HS, 2=HS Grad, 3= Some College, 4- College Grad, 5= Grad School
	Mother Education Level	1= Some HS, 2=HS Grad, 3= Some College, 4- College Grad, 5= Grad School
	Low Socioeconomic status (determined by participation in Free and Reduced Lunch per K-12 records and/or qualification for financial aid first year of community college)	0=no, 1= yes
	High School Graduating Class	1=2006, 2=2007, 3=2008, 4=2009
Additional Characteristics	Special needs (determined by participation in K-12 Special Education	0=no, 1= yes,
Middle School	Feeder Middle School	1=South, 2=North, 3=Alt, 4=District Elementary but not Middle School, 5= Other/Unknown
	Mathematics Course taken in Grades 7 & 8	*=missing, 1=below algebra or pre-algebra, 2=Pre-Algebra, 3=Algebra 1, 4=Geometry
	Math Grade Point, Grades 7 & 8	*=missing, 0=F, 1=D, 2=C, 3=B, 4=A,
	Math CST Score and Performance Level, Grades 7 & 8	Continuous scores from 200-600 and also performance levels: *=missing, 1=Far Below Basic, 2=Below Basic, 3= Basic, 4=Proficient, 5= Advanced
	GPA – cumulative MS	*=missing, continuous from 0-4
High School	Mathematics Course taken in Grades 9, 10, 11, & 12	*=missing, See USD Math Coding, Appendix F
	Math Grade Point, Grades 9, 10, 11, & 12	*=missing, 0=F, 1=D, 2=C, 3=B, 4=A
	Math CST Score and Performance Level, Grades 9, 10, & 11	Continuous scores from 150-600 and also performance levels: *=missing, 1=Far Below Basic, 2=Below Basic, 3= Basic, 4=Proficient, 5= Advanced
	12th grade – any math	0=no, 1=yes
	A-G completed	0=no, 1=yes,

Table B1. (cont'd)
Variables and coding

Category	Variable	Coding
High School (cont'd)	Participation in AVID	0=no, 1=yes,
	CAHSEE ELA score	Continuous from 275-450
	CAHSEE Math score	Continuous from 275-450
	Dual or Concurrent enrollment while in HS	0=no, 1=yes
	GPA – cumulative HS	Continuous 0-4.0
	Units – total completed in high school	Continuous
Community College	Enrolled at CC as Freshman	0=no, 1=yes
	Math Assessment/Placement	*=missing, 1= 4-levels below college-level, 2= 3- levels below college-level, 3= 2-levels below college-level, 4=1-level below college-level, 5= college-level

APPENDIX B (Cont'd)

Table B2.
Data Analysis Matrix

RESEARCH QUESTION	VARIABLES		ANALYSIS
	Demographic	School-based	
1) What are the high school mathematics course-taking experiences of the high school students and of the subset of students who matriculated to the community college as freshmen? a) How, if at all, do high school mathematics course-taking patterns differ by ethnicity? 2) Controlling for demographic factors and other background characteristics, how do different high school mathematics course-taking patterns and achievement predict placement into community college mathematics? a) How, if at all, does not taking mathematics in grade 12 affect the likelihood of placing into college-level mathematics in community college? b) How, if at all, do characteristics of high school mathematics course-taking that are predictive of placement into college-level mathematics for all students apply to students from different ethnic groups?	Gender Ethnicity Parent Education Indication of low SES English Only Special Needs HS Graduating Class Middle School	7th- 11th grade CST ELA scores 7th- 11th grade CST Math scores 7th – 12th grade math courses 7th - 12th grade math GPA A-G requirements completed AVID participation CAHSEE ELA CAHSEE Math Dual or concurrent enrollment in HS GPA - cumulative MS GPA - cumulative HS Total Units in HS Highest-level HS mathematics No Math in grade 12 Unsatisfactory grade in HS Math Repeated HS Math Matriculated to community college as a freshman OUTCOME VARIABLE: Placement results in mathematics on community college assessment	1) Identify HS Mathematics Pathways or Markers ▪ Descriptive Statistics ▪ Cross-tabulation ▪ Chi-Square ▪ Correlation ▪ Concatenation 2) Stage One: Narrow the list of variables using Chi Square, correlation, and cross-tabulation to examine association and redundancy of variables. Stage Two: Develop a model using multinomial logistic regression for those students who matriculated as freshmen to the community college and took the mathematics placement assessment.

APPENDIX C:

Comparison of Demographic and Academic Characteristics

Table C1.
High School Students' Utilization of Community College (CC) Enrollment Opportunities

	All 12th Graders	CC Enrollment Opportunities			All CC	No CC
		Freshmen	Dual Only	Other		
	n=2920	*n=953*	*n=487*	*n=561*	*n=2001*	*n=919*
	100%	32.6%	16.7%	19.2%	*68.5%*	*31.5%*
Gender						
Male	1452	34%	15%	16%	65%	35%
Female	1468	31%	19%	23%	72%	28%
Race/Ethnicity						
Black	260	36%	9%	18%	63%	37%
API	248	27%	24%	21%	73%	27%
Latino	862	39%	11%	20%	70%	30%
White	1525	30%	20%	6%	55%	31%
Other	25	12%	16%	16%	44%	56%
Parent Education						
High School or Lower	480	46%	9%	17%	72%	28%
Some College	520	46%	10%	22%	78%	22%
College Graduate	696	34%	18%	21%	73%	27%
Grad School	787	23%	23%	25%	71%	29%
Not Indicated	437	18%	18%	5%	41%	59%
Free/Reduced Fee Lunch	651	42%	11%	16%	70%	30%

Note. Dual Only refers to students who take CC classes while they are still in high school only. Students who enroll as freshmen or Other may also have taken dual enrollment classes while in high school. Other students includes students who may have reverse transferred into the community college after their freshmen year or students who pick up additional courses at the community college as part of post-secondary course-taking patterns that include other institutions.

APPENDIX C (cont'd)

Table C2.

Comparison of general academic performance variables for all 12th graders divided into two subsets: those 12th graders who matriculated as community college freshmen (CC Freshmen) and those that did not (NOT CC Freshmen)

		CC Freshmen *n=953*	NOT CC Freshmen n=1967	All 12th Graders n=2920
Grade 8 GPA				
	mean	2.93	3.22	3.13
	SD	.75	.70	.73
	n	660	1432	2092
Grade 12 GPA				
	mean	2.53	3.08	2.90
	SD	.67	.74	.76
	n	929	1909	2838
Total Credits[a]				
	mean	236.48	250.30	245.79
	SD	24.97	34.55	32.40
	n	945	1952	2,897
Met A-G Requirements[b]		56%	77.2%	73.5%

Note. [a]220 semester credits are required to earn a high school diploma. [b]Met A-G Requirements data was available for 94% of all 12th graders and also 94% of the CC Freshmen subset.

Table C3.

Comparison of general academic performance variables by ethnicity

		Black	Latino	White	API
Grade 8 GPA					
	mean	2.91	2.92	3.23	3.35
	SD	.779	.763	.681	.616
	n	154	604	1137	177
Grade 12 GPA					
	mean	2.32	2.50	3.16	3.31
	SD	.682	.741	.640	.587
	n	251	836	1482	244
Total Credits[a]					
	mean	234.08	240.80	248.07	261.82
	SD	31.02	33.519	30.840	30.631
	n	257	858	1510	247
Met A-G Requirements[b]		54.2%	53.9%	79.0%	76.2%

Note. [a]*220 semester credits are required to earn a high school diploma.* [b]Met A-G Requirements data was available for 94% of all 12th graders.

APPENDIX D:

Comparison of CST and CAHSEE Scores

Table D1.
Comparison of performance measures in English language arts (ELA) and mathematics for all 12th graders (All) and the subset of 12th graders who matriculated as community college freshmen (CC Freshmen): California Standardized Tests (CST), and the California High School Exit Exam (CAHSEE)

	English Language Arts		Mathematics	
	All n=2920	CC Freshmen *n=953*	All n=2920	CC Freshmen *n=953*
Grade 7 CST[a]				
mean	371.23	350.95	365.16	341.83
SD	51.287	46.866	61.505	49.784
n	1087	354	1086	357
range	150-569	150-468	175-600	185-495
Proficiency				
Far below basic	2.5%	4.2%	2.1%	3.9%
Below basic	6.9%	10.2%	12.0%	17.4%
Basic	21.5%	30.8%	27.9%	33.9%
Proficient	40.1%	42.4%	37.8%	37.5%
Advanced	29.0%	12.4%	20.2%	7.3%
Grade 8 CST[b]				
mean	367.76	347.85	357.29	336.53
SD	52.072	44.874	58.902	48.633
n	1116	362	1640	522
range	216-564	216-469	165-600	165-495
Proficiency				
Far below basic	3.0%	4.4%	2.30%	3.30%
Below basic	6.6%	8.3%	13.60%	19.50%
Basic	25.0%	37.6%	32.30%	40.20%
Proficient	35.0%	35.4%	39.80%	32.60%
Advanced	30.4%	14.4%	12.00%	4.40%
Grade 9 CST				
mean	365.51	343.75	334.37	309.96
SD	56.518	51.812	63.645	48.979
n	2328	747	2458	794
range	216-564	216-485	150-600	150-506
Proficiency				
Far below basic	4.2%	6.3%	6.60%	9.70%
Below basic	10.2%	15.5%	26.30%	35.80%
Basic	22.9%	31.6%	30.80%	34.40%
Proficient	30.7%	30.7%	25.30%	17.80%
Advanced	32.0%	15.9%	10.90%	2.40%

Table D1. (cont'd)

	English Language Arts		Mathematics	
	All n=2920	CC Freshmen *n=953*	All n=2920	CC Freshmen *n=953*
Grade 10 CST				
mean	361.31	339.29	312.96	291.61
SD	58.186	53.632	60.276	47.369
n	2568	832	2538	807
range	207-541	212-504	176-600	176-552
Proficiency				
Far below basic	6.2%	9.5%	13.00%	18.10%
Below basic	10.3%	16.0%	34.70%	43.70%
Basic	22.6%	29.0%	27.30%	26.00%
Proficient	30.1%	30.0%	19.30%	10.80%
Advanced	30.8%	15.5%	5.70%	1.40%
Grade 11 CST				
mean	358.02	335.07	299.22	275.39
SD	65.203	56.624	65.743	49.213
n	2652	862	2496	796
range	150-600	185-502	158-600	174-516
Proficiency				
Far below basic	8.5%	11.4%	24.30%	36.10%
Below basic	11.2%	16.0%	32.90%	36.60%
Basic	23.6%	31.7%	22.30%	20.10%
Proficient	27.1%	26.9%	15.30%	6.30%
Advanced	29.5%	14.0%	5.20%	1.00%
CAHSEE				
mean	404.12	394.14	400.38	388.08
SD	31.309	28.212	32.608	28.537
n	2774	904	2778	906
range	275-450	275-450	297-450	297-450

Note. [a]Grade 7 CST data is not available for the high school graduating classes of 2006 and 2007. [b] Grade 8 CST data is not available for the class of 2006.

APPENDIX D (cont'd)

Table D2.
Comparison of CST and CAHSEE scores in ELA and Mathematics, grades 7-11, disaggregated by ethnicity

	English Language Arts				Mathematics			
	BLACK	LATINO	API	WHITE	BLACK	LATINO	API	WHITE
Grade 7[a] CST								
mean	338.01	344.33	396.20	387.30	323.35	332.58	410.39	383.22
SD	47.379	49.558	49.448	43.994	47.354	50.501	68.213	56.654
n	74	340	70	593	74	341	71	591
range	238-443	213-489	262-536	150-569	210-430	175-489	256-600	252-600
Performance %								
Far below basic	6.8	5.3	1.4	.5	5.4	4.4	1.4	.5
Below basic	16.2	13.5	2.9	2.5	29.7	23.5	1.4	4.6
Basic	37.8	33.8	11.4	14.0	37.8	38.1	16.9	22.5
Proficient	28.4	35.3	32.9	45.2	23.0	27.9	32.4	45.5
Advanced	10.8	12.1	51.4	37.8	4.1	6.2	47.9	26.9
Grade 8[b] CST								
mean	335.00	340.74	386.96	384.42	321.51	327.14	392.85	373.36
SD	45.474	47.829	49.527	46.908	42.671	47.806	66.266	56.242
n	80	346	73	605	119	486	116	903
range	216-458	218-500	266-500	237-564	207-441	165-476	250-600	225-600
Performance %								
Far below basic	5.0	6.6	0	1.0	5.0	4.5	.9	.9
Below basic	17.5	12.4	2.7	2.5	26.9	25.5	4.3	6.8
Basic	42.5	38.4	16.4	16.5	46.2	40.3	26.7	27.2
Proficient	27.5	29.5	39.7	38.8	21.0	26.7	36.2	49.2
Advanced	7.5	13.0	41.1	41.2	.8	2.9	31.9	15.9

Table D2. (cont'd)

Comparison of CST and CAHSEE scores in ELA and Mathematics, grades 7-11, disaggregated by ethnicity

	English Language Arts				Mathematics			
	BLACK	LATINO	API	WHITE	BLACK	LATINO	API	WHITE
Grade 9 CST								
mean	328.12	334.69	378.54	385.92	299.94	304.04	374.30	350.45
SD	52.254	50.925	52.698	49.730	45.908	48.877	72.350	62.508
n	188	691	182	1248	200	734	201	1302
range	216-466	225-500	248-500	225-564	186-459	180-522	150-575	211-600
Performance %								
Far below basic	10.6	7.2	2.2	1.8	13.0	12.3	2.0	3.1
Below basic	21.8	19.8	4.9	3.9	41.5	40.1	12.4	18.5
Basic	33.0	34.3	23.1	15.3	31.0	30.7	22.4	32.2
Proficient	25.0	25.8	29.1	34.7	13.5	14.9	38.3	31.0
Advanced	9.6	12.9	40.7	44.2	1.0	2.2	24.9	15.3
Grade 10 CST								
mean	323.34	332.73	374.42	381.15	279.89	287.22	351.58	326.27
SD	52.222	53.192	56.044	52.132	39.668	47.908	69.890	59.692
n	217	765	214	1350	217	743	214	1340
range	223-500	213-500	223-541	207-538	203-436	176-528	188-557	191-600
Performance %								
Far below basic	14.7	11.0	1.4	2.8	23.0	21.8	5.1	7.7
Below basic	19.8	17.5	8.4	5.0	48.8	44.1	18.7	29.9
Basic	32.7	32.8	23.8	15.3	24.0	24.2	29.0	29.2
Proficient	24.4	25.2	28.5	34.1	3.7	8.3	32.2	25.8
Advanced	8.3	13.5	37.9	42.8	.5	1.5	15.0	7.4
Grade 11 CST								
mean	319.43	327.37	375.45	379.20	263.17	271.73	342.52	312.67
SD	58.631	57.344	63.345	60.716	43.705	47.813	77.541	66.560
n	239	794	225	1370	213	726	229	1307
range	198-529	150-499	219-574	192-600	176-460	158-600	162-600	174-600
Performance %								
Far below basic	18.0	14.1	3.6	4.5	43.2	35.5	9.2	17.8
Below basic	18.8	18.6	8.4	6.3	36.6	40.8	23.1	29.7
Basic	33.5	32.2	22.7	17.3	16.4	18.3	23.6	25.1
Proficient	18.0	21.9	26.7	31.6	2.8	4.4	30.6	20.7
Advanced	11.7	13.1	38.7	40.4	.9	1.0	13.5	6.8

Table D2. (cont'd)

Comparison of CST and CAHSEE scores in ELA and Mathematics, grades 7-11, disaggregated by ethnicity

	English Language Arts				Mathematics			
	BLACK	LATINO	API	WHITE	BLACK	LATINO	API	WHITE
CAHSEE								
mean	383.64	388.33	411.07	415.29	380.27	382.29	420.35	410.55
SD	30.678	29.609	30.887	26.547	28.449	28.962	28.100	29.264
n	242	824	230	1453	241	836	233	1453
range	275-450	287-450	345-450	305-450	297-450	302-450	346-450	322-450

Note. [a]Grade 7 CST data is not available for the high school graduating classes of 2006 and 2007. [b] Grade 8 CST data is not available for the class of 2006.

APPENDIX D (cont'd)

Table D3.
Snapshot of performance over time in English Language Arts as measured by the California Standards Test (CST) Performance Levels

CST in ELA	Black	Latino	API	White	CC Freshmen	ALL
Grade 7 [a]						
Below "Basic"	23%	19%	4%	3%	14%	9%
"Basic"	38%	34%	11%	14%	31%	22%
Above "Basic"	39%	47%	84%	83%	55%	69%
Grade 9						
Below "Basic"	32%	27%	7%	6%	22%	14%
"Basic"	33%	34%	23%	15%	32%	23%
Above "Basic"	35%	39%	70%	79%	47%	63%
Grade 11						
Below "Basic"	38%	33%	12%	11%	27%	20%
"Basic"	33%	32%	23%	17%	32%	24%
Above "Basic"	30%	35%	65%	72%	41%	57%

Note. Due to rounding, the sum of group percentages may not add up to 100.

Table D4.
Snapshot of performance over time in Mathematics as measured by the California Standards Test (CST) Performance Levels

CST in Mathematics	Black	Latino	API	White	CC Freshmen	ALL
Grade 7 [a]						
Below "Basic"	35%	28%	3%	5%	21%	14%
"Basic"	38%	38%	17%	23%	34%	28%
Above "Basic"	27%	34%	80%	72%	45%	58%
Grade 9						
Below "Basic"	55%	52%	14%	22%	46%	33%
"Basic"	31%	31%	22%	32%	34%	31%
Above "Basic"	15%	17%	63%	46%	20%	36%
Grade 11						
Below "Basic"	80%	76%	32%	48%	73%	57%
"Basic"	16%	18%	24%	25%	20%	22%
Above "Basic"	4%	5%	44%	28%	7%	21%

Note. Students in grades 9 and 11 took End-of-Course CSTs in mathematics. For example, in grade 11, students who took the mathematics CST may have taken an End-of-Course exam in algebra, Geometry, Algebra 2, or the Summative High School Mathematics CST for courses above Algebra 2, depending on which level of mathematics they just completed. Therefore, the proficiency that is being measured for grades 9 and 11 is proficiency in different coursework. Due to rounding, the sum of group percentages may not add up to 100.
[a] In grade 7, all students took a grade-level CST in mathematics for below algebra coursework.

APPENDIX E:

Correlations Between School District Variables

Table E1.

Correlations between achievement in English Language Arts (ELA) and Mathematics (Math) as measured by the California Standards Tests in grades 7 through 11 and by the California High School Exit Exam (KC).

		Gr7 ELA	Gr7 Math	Gr8 ELA	Gr8 Math	Gr9 ELA	Gr9 Math	Gr10 ELA	Gr10 Math	Gr11 ELA	Gr11 Math	KC ELA	KC Math
Gr7 ELA	Pearson Correlation	1											
	N	1087											
Gr7 Math	Pearson Correlation	.757**	1										
	N	1080	1086										
Gr 8 ELA	Pearson Correlation	.833**	.725**	1									
	N	1059	1059	1116									
Gr8 Math	Pearson Correlation	.649**	.807**	.673**	1								
	N	1048	1049	1103	1640								
Gr9 ELA	Pearson Correlation	.820**	.716**	.904**	.656**	1							
	N	1054	1053	1090	1608	2328							
Gr9 Math	Pearson Correlation	.616**	.744**	.620**	.764**	.657**	1						
	N	1038	1036	1066	1578	2250	2458						
Gr10 ELA	Pearson Correlation	.803**	.687**	.829**	.644**	.820**	.655**	1					
	N	1048	1048	1081	1587	2257	2411	2568					
Gr10 Math	Pearson Correlation	.565**	.723**	.583**	.739**	.593**	.771**	.606**	1				
	N	1014	1014	1042	1531	2175	2313	2432	2538				
Gr11 ELA	Pearson Correlation	.765**	.660**	.760**	.624**	.766**	.622**	.805**	.594**	1			
	N	1050	1049	1081	1586	2212	2353	2461	2462	2652			
Gr11 Math	Pearson Correlation	.552**	.723**	.575**	.720**	.568**	.763**	.575**	.764**	.587**	1		
	N	970	971	997	1479	2059	2187	2286	2280	2403	2496		
KC ELA	Pearson Correlation	.776**	.630**	.781**	.589**	.774**	.589**	.761**	.544**	.727**	.509**	1	
	N	1069	1067	1099	1614	2298	2431	2543	2522	2616	2431	2774	
KC Math	Pearson Correlation	.715**	.812**	.699**	.757**	.697**	.772**	.688**	.734**	.639**	.716**	.687**	1
	N	1070	1068	1100	1615	2300	2434	2547	2529	2620	2432	2764	2778

** $p < .000$ (2-tailed)

APPENDIX E (cont'd)

Table E2.
Correlation of high school mathematics variables, grade 12 cumulative GPA, and total high school credits

	Grade 9 Math			Grade 10 Math			Grade 11 Math			Grade 12 Math		KC Math SS	Gr 12 GPA	Total HS Credits
	Course	GPA	CST SS	Course	GPA	CST SS	Course	GPA	CST SS	Course	GPA			
Grade 9 Math Course	1													
Grade 9 Math GPA	.306**	1												
Grade 9 Math CST	.457**	.476**	1											
Grade 10 Math Course	.873**	.449**	.504**	1										
Grade 10 Math GPA	.281**	.533**	.470**	.352**	1									
Grade 10 Math CST	.424**	.436**	.764**	.434**	.492**	1								
Grade 11 Math Course	.847**	.514**	.567**	.899**	.481**	.522**	1							
Grade 11 Math GPA	.275**	.464**	.463**	.335**	.567**	.460**	.364**	1						
Grade 11 Math CST	.474**	.445**	.761**	.494**	.442**	.761**	.533**	.472**	1					
Grade 12 Math Course	.493**	.469**	.468**	.600**	.530**	.445**	.680**	.499**	.443**	1				
Grade 12 Math GPA	.357**	.363**	.446**	.360**	.443**	.447**	.409**	.453**	.461**	.252**	1			
Cahsee Math SS	.632**	.507**	.760**	.657**	.518**	.733**	.717**	.482**	.728**	.573**	.469**	1		
Grade 12 GPA	.514**	.685**	.610**	.595**	.731**	.602**	.682**	.699**	.596**	.644**	.632**	.669**	1	
Total HS Credits	.357**	.374**	.387**	.394**	.342**	.374**	.445**	.333**	.389**	.380**	.310**	.404**	.547**	1

Note. Shaded cells are correlated at close to .600 or above, showing strong correlation and lack of independence. CST is for scaled scores.
** $p < .01$ (two-tailed) Listwise N=1415

APPENDIX F:

Coding for School District Mathematics Courses

Code (8)	Code (10-65)	Mathematics Group	Grade	Course Title
1	11	Below Alg: Spec Ed and Sheltered English	9	Math 9-12 A SE
1	10	Below Alg: Spec Ed	10	Math 9-12
1	10	Below Alg: Spec Ed	10	Math Workshop
1	12	Below Alg : 1: SDC	10	Essentials for Algebra 1 SDC
1	13	Below Alg: 2: SDC	10	Essentials for Algebra 2 SDC
1	19	Alg 1: SDC	10	Algebra SDC
1	22	Alg 1: Sp Ed	10	Algebra RSP
1	10	Below Alg: Spec Ed	11	Math 9-12
1	12	Below Alg: 1: SDC	11	Essentials for Algebra 1 SDC
1	13	Below Alg: 2: SDC	11	Essentials for Algebra 2 SDC
1	19	Alg 1: SDC	11	Algebra SDC
1	22	Alg 1: Sp Ed	11	Algebra RSP
1	10	Below Alg: Spec Ed	12	Math 9-12
1	12	Below Alg: 1: SDC	12	Essentials for Algebra 1 SDC
1	13	Below Alg: 2: SDC	12	Essentials for Algebra 2 SDC
1	19	Alg 1: SDC	12	Algebra SDC
1	22	Alg 1: Sp Ed	12	Algebra RSP
2	14	Below Algebra	7	Math 6
2	15	Below Alg: Accelerated	7	Math 6 Accel
2	16	Below Alg	7	Math 7
2	17	Below Alg: Accelerated	7	Math 7 Accel
2	21	Pre Alg A	7	Intro Algebra A
2	16	Below Alg	8	Math 7
2	18	Below Alg	8	Math 8
2	21	Below Alg	8	Pre-Algebra
2	21	Below Algebra	8	Essentials for Algebra
2	21	Pre Alg A	8	Intro Algebra A
2	21	Below Alg	9	Math 9B
2	20	Below Alg 1: 2	11	Essentials 2 for Algebra
2	20	Below Alg 1: 2	12	Essentials 2 for Algebra
3	29	Alg 1 – A	7	Algebra A/7
3	27	Alg 1 - 2 periods	8	Algebra S
3	29	Alg 1 – A	8	Algebra A
3	29	Alg 1 – A	8	Algebra A P
3	30	Alg 1 – B	8	Algebra B
3	23	Alg 1 - A 1-2	9	Algebra 9A 1-2
3	23	Alg 1 - A 1-2	9	Algebra A ½
3	23	Alg 1 - A 1-2	9	Algebra A1/A2 P
3	24	Alg 1 - A 1-2: SE	9	Algebra A 1/2 SE
3	25	Alg 1 - B 1-2	9	Algebra 9B 1-2P

Appendix F Continued 1

Code (8)	Code (10-65)	Mathematics Group	Grade	Course Title
3	25	Alg 1 - B 1-2	9	Algebra B1/2 P
3	25	Alg 1 - B 1-2	9	Algebra B1/B2P
3	26	Alg 1 - B 1-2: SE	9	Algebra B 1/2 SE
3	27	Alg 1 - 2 periods	9	Algebra P BK
3	28	Alg 1 - B 1-2: IM	9	Algebra B1-2 IMP
3	29	Alg 1 – A	9	Algebra 9A 1
3	29	Alg 1 – A	9	Algebra 9A P
3	29	Alg 1 – A	9	Algebra A P
3	24	Alg 1 - A 1-2: SE	10	Algebra A 1/2 SE
3	25	Alg 1 - B 1-2	10	Algebra 9B 1-2P
3	25	Alg 1 - B 1-2	10	Algebra B 1/2 P
3	26	Alg 1 - B 1-2: SE	10	Algebra B 1/2 SE
3	29	Alg 1 – A	10	Algebra A P
3	26	Alg 1 - B 1-2: SE	11	Algebra B 1/2 SE
3	29	Alg 1 – A	11	Algebra AP
3	26	Alg 1 - B 1-2: SE	12	Algebra B 1/2 SE
4	31	Alg 1	7	Algebra
4	31	Alg 1	8	Algebra
4	31	Alg 1	8	Algebra 8
4	31	Alg 1	9	Algebra 9 P
4	31	Alg 1	9	Algebra P
4	32	Alg 1: SE	9	Algebra P SE
4	32	Alg 1:SE	9	Algebra SE P
4	33	Alg 1 – im	9	Algebra 1m P
4	33	Alg 1: IM	9	Algebra P IM
4	31	Alg 1	10	Algebra P
4	32	Alg 1: SE	10	Algebra SEP
4	32	Alg 1:SE	10	Algebra P SE
4	33	Agl 1: IM	10	Algebra IM P
4	31	Alg 1	11	Algebra P
4	32	Alg 1:SE	11	Algebra P SE
4	31	Alg 1	12	Algebra P
5	34	Alg 1 – accelerated	7	Accelerated Algebra 1
5	34	Alg 1 – accelerated	7	Accelerated Algebra 7th grade
5	34	Alg 1 – accelerated	8	Accelerated Alg 1
6	43	Geom	8	Geometry
6	44	Geom: HP	8	Geom HP
6	40	Geom A	9	Geometry A P
6	41	Geom: SE	9	Geometry SE
6	42	Geom: IM	9	Geometry P IM
6	43	Geom	9	Geometry
6	43	Geom	9	Geometry 9P
6	43	Geom	9	Geometry P
6	44	Geom HP	9	Geometry HP

Appendix F Continued 2

Code (8)	Code (10-65)	Mathematics Group	Grade	Course Title
6	45	Geom: IM HP	9	Geometry IM HP
6	40	Geom A	10	Geom A P
6	41	Geom: SE	10	Geometry P SE
6	41	Geom: SE	10	Geometry SE
6	42	Geom: IM	10	Geometry P IM
6	43	Geom	10	Geometry P
6	44	Geom HP	10	Geometry HP
6	40	Geom A	11	Geometry A P
6	41	Geom: SE	11	Geometry P SE
6	41	Geom: SE	11	Geometry SE
6	42	Geom: IM	11	Geometry P IM
6	43	Geom	11	Geometry P
6	40	Geom A	12	Geometry A P
6	41	Geom: SE	12	Geometry P SE
6	42	Geom: IM	12	Geometry P IM
6	43	Geom	12	Geometry P
7	51	Alg 2	9	Algebra II P
7	51	Alg 2	9	Intermediate Algebra P
7	53	Alg 2 – HP	9	Algebra II HP
7	53	Alg 2 – HP	9	Int Algebra HP
7	50	alg 2 – A	10	Algebra II AP
7	50	Alg 2: A	10	Int Algebra A P
7	51	Alg 2	10	Algebra II P
7	51	Alg 2	10	Int Algebra P
7	52	Alg 2: IM	10	Algebra II P IM
7	52	Alg 2: IM	10	Int Algebra IM P
7	53	Alg 2 – HP	10	Algebra II HP
7	53	Alg 2 – HP	10	Int Algebra HP
7	50	alg 2 – A	11	Algebra II A P
7	50	Alg 2: A	11	Int Algebra A P
7	51	Alg 2	11	Algebra II P
7	51	Alg 2	11	Int Algebra P
7	52	Alg 2: IM	11	Algebra II P IM
7	52	Alg 2: IM	11	Int Alebra IM P
7	53	Alg 2 – HP	11	Algebra II HP
7	53	Alg 2 – HP	11	Int Algebra HP
7	51	Alg 2	11	Algebra II P
7	50	alg 2 – A	12	Algeba II A P
7	51	Alg 2	12	Algebra II P
7	52	Alg 2: IM	12	Algebra II P IM
7	53	Alg 2 – HP	12	Algebra II HP
8	60	Pre Calc/Trig	9	Pre Calc P
8	62	Stats AP	9	Statistic AP
8	63	PreCal/Calc A HP	9	PreCalc/Calc A HP

Appendix F Continued 3

Code (8)	Code (10-65)	Mathematics Group	Grade	Course Title
8	64	Calc AB AP	9	Calc AB AP
8	60	Pre Calc/Trig	10	Pre Calc P
8	60	Pre Calc/Trig	10	PreCalculus/Trigonometry P
8	62	Stats AP	10	Statistic AP
8	62	Stats AP	10	Statistic B AP
8	63	PreCal/Calc A HP	10	PreCalc/Calc A HP
8	64	Calc AB AP	10	Calculus AB AP
8	65	Calc BC AP	10	Calculus BC AP
8	60	Pre Calc/Trig	11	PreCalc P
8	60	Pre Calc/Trig	11	Precalculus/Trigonometry P
8	61	Stats	11	Statistics P
8	62	Stats AP	11	Statistic AP
8	63	PreCal/Calc A HP	11	PreCalc/Calc A HP
8	64	Calc AB AP	11	Calculus AB AP
8	65	Calc BC AP	11	Calculus BC AP
8	60	Pre Calc/Trig	12	Precal/Trigonomerty P
8	61	Stats	12	Statistic P
8	62	Stats AP	12	Statistic AP
8	63	PreCal/Calc A HP	12	Precalc/Calc A HP
8	64	Calc AB AP	12	Calculus AB AP
8	65	Calc BC AP	12	Calc BC AP

Note. SDC = Special Day Class for special ed students; A, as in Algebra A is 1st semester of 2; B refers to 2nd semester work only; 1-2 also refers to 1st and 2nd semesters; IM = immersion in Spanish; SE = Sheltered English; P= college prep; HP= Honors; AP=Advanced Placement

APPENDIX G:

Math Enrollment, Grades 7 to 12

Enrollment in mathematics coursework from grades 7 to 12

Math Course	Grade 7	Grade 8	Grade 9	Grade 10	Grade 11	Grade 12
Special Education	0	0	<5	14	36	27
Below Algebra 1	1006	153	<5	0	<5	21
Extended Algebra 1	<5	720	491	82	<5	<5
Algebra 1	<5	610	508	125	36	16
Algebra 1 Accelerated	28	577	0	0	0	0
Geometry	0	29	1362	905	250	34
Algebra 2	0	0	71	1377	914	251
Above Algebra 2	0	0	6	105	1381	1526
Total included	1040	2089	2441	2608	2624	1876
Missing	1880	831	479	312	296	1044
Full Sample	2920	2920	2920	2920	2920	2920

APPENDIX H:

Prior Year Performance to Placement

Table H1.
Correlation of Prior Year Performance Measures – GPA and California Standards Tests Scale Scores - in Mathematics to Subsequent Year Mathematics Placement, by Ethnicity.

	Correlation to Grade 8 Math Course		Correlation to Grade 9 Math Course	
	Grade 7 Math GPA	Grade 7 Math CST SS	Grade 8 Math GPA	Grade 8 Math CST SS
Black	.443**	.640**	.271**	.481**
Latino	.443**	.569**	.325**	.390**
API	.197	.508**	.285**	.438**
White	.443**	.640**	.376**	.437**

** $p < .01$ (two-tailed)

Table H2.
Grade 7 California Standards Tests Scale Scores (CSTSS) and Grade Point Average (GPA) to Placement in Grade 8 Mathematics

Grade 7 Performance	*n*	*M*	*SD*	Grade 8 Mathematics	*N*
CSTSS	59	286.93	29.604	Below Algebra 1	59
GPA	61	1.57	1.056		
CSTSS	228	332.43	33.783	Extended Algebra 1	228
GPA	233	2.64	1.062		
CSTSS	368	364.10	47.455	Algebra 1	368
GPA	371	2.85	1.006		
CSTSS	327	405.04	48.257	Accelerated Algebra 1	327
GPA	328	3.58	.569		

Note. Ninety-seven percent of 7th graders took the same below Algebra 1 coursework.
** $p < .01$

Table H3.
Grade 8 California Standards Tests Scale Scores (CSTSS) and Grade Point Average (GPA) to Placement in Grade 9 Mathematics

Grade 8 Mathematics: Course	Grade 8 Mathematics: Performance	*n*	*M*	*SD*	Placement in Grade 9 Mathematics	*N*
Below Algebra 1 *n=153*	CSTSS	44	302.59	35.56	Extended Algebra 1	44
	GPA	74	1.97	.921		
	CSTSS	43	308.86	25.82	Algebra 1	43
	GPA	64	2.48	1.04		
	CSTSS	<5	337.50	32.15	Geometry	<5
	GPA	<5	2.25	.96		
	CSTSS	<5	580.50	27.58	Algebra 2 and Above	<5
	GPA	<5	4.0	.000		
Extended Algebra 1 *n=720*	CSTSS	173	330.95	39.34	Extended Algebra 1	173
	GPA	327	2.24	1.05		
	CSTSS	171	340.15	41.18	Algebra 1	171
	GPA	179	2.09	1.09		
	CSTSS	117	355.47	36.61	Geometry	117
	GPA	196	2.93	.92		
Algebra 1 n=610	CSTSS	6	292.83	31.71	Extended Algebra 1 (repeat)	6
	GPA	7	1.14	.90		
	CSTSS	86	318.87	38.98	Algebra 1 (repeat)	86
	GPA	95	1.60	.75		
	CSTSS	404	358.60	54.70	Geometry	404
	GPA	491	2.76	.90		
	CSTSS	7	477.71	74.33	Algebra 2 and Above	7
	GPA	7	3.57	7.87		
Accelerated Algebra 1 n=577	CSTSS	9	344.89	38.76	Algebra 1 (repeat)	9
	GPA	10	1.50	.53		
	CSTSS	421	393.58	52.50	Geometry	421
	GPA	539	3.14	.84		
	CSTSS	15	444.53	67.89	Algebra 2 and Above	15
	GPA	15	3.80	.41		
Geometry n=29	CSTSS	30	470.47	49.92	Algebra 2 and Above	30
	GPA	30	3.63	.49		

Note. Students who took Geometry in 8^{th} grade took a different end-of-course CST than students who took Algebra 1.
* p <.05; ** p <.01

APPENDIX I:

Community college mathematics placement levels

Table I1.
Community college mathematics coursework per level of placement relative to college-level mathematics

Levels		Mathematics Course							
Below-College-Level	4-levels below	Math 81: Basic Arithmetic							
	3-levels below	Math 84: Pre-Algebra							
	2-levels below	Math 31: Elementary Algebra							
	1-level below college math	Math 18: Intermediate Algebra for Statistics & Finite Mathematics		Math 20: Intermediate Algebra		Math 32: Plane Geometry			
College-Level (Transfer Courses)		Math 21: Finite Math	Math 52/54: Elementary Statistics	Math 41: Math for Elementary Teachers	Math 26: Functions and Modeling for Business and Social Sciences	Math 2: Pre-Calculus			
				Math 28: Calculus 1 for Business and Social Sciences		Math 7: Calculus 1			
				Math 29: Calculus 2 for Business and Social Sciences		Math 8: Calculus 2			
						Math 10: Discrete Structures	Math 11: Multivariable Calculus	Math 13: Linear Algebra	Math 15: Differential Equations

Note. Students are placed into one of five different levels of mathematics in community college. Transfer or college-level mathematics and four different levels below college-level.

APPENDIX I (cont'd)

Table I2.

Community college determined placement cut scores on ACT COMPASS assessment in mathematics

Test Taken	Cut Score (04/06/04-06/05/07)	Cut Score (Starting 06/06/07)	Cut Score (Starting 05/01/08)	Placement Course	Placement Level	Note on Re-routing into Different Math Test
Pre-Algebra Type: 5 or 15	0-34 35-52 53-100	0-34 35-52 53-100	0-34 35-52 53-100	Math 81 Math 84 Math 31	levels below levels below levels below	1. No re-routing occurs in Pre-Algebra
Algebra Type: 6 or 16 All students start here	0-38 39-49 50-64 65-100 75-100[2]	0-38 39-49 50-100 65-100[2]	0-38 39-49 50-100 75-100[2]	Routed back[1] Math 20, 32 Math 21, 26, 41, 52 Routed up[2]	1-level below	[1] If Algebra test is completed with a score of 38 or less, student is routed back to take the Pre-Algebra test for placement [2] If Algebra test is completed with a score of 75 or higher, student is routed up to take the College Algebra test where a placement may be assigned if a score of 46 or above is obtained; otherwise student will be eligible for Math 21, 26, 41, 52
College Algebra Type: 7 or 17	00-36 37-45 46-100 60-100[1]	00-45 46-100 60-100[1]	00-45 46-100 60-100[1]	Math 21, 26, 41, 52 Math 28 Routed up[1]	College-level	[1] If College Algebra test is completed with a score of 60 or higher, student is routed up to take the Geometry test. If score in Geometry is 1-100, math placement will be based on highest score obtained in College Algebra. If a score of 66 or more is obtained on the Geometry test, student will be routed up to the Trigonometry test.
Geometry Type: 8 or 18	00-65[1] 66-100[2]	00-65[1] 66-100[2]	00-65[1] 66-100[2]	Routed back[1] Routed up[2]		[1] If Geometry test is completed with a score of 65 or less, math placement will be based on highest score obtained in College Algebra test. [2] If Geometry test is completed with a score of 66 or higher, student is routed up to take the Trigonometry test; otherwise placement will be based on College Algebra score.
Trigonometry Type: 9 or 19	00-44 45-65 66-100	00-44 45-65 66-100	01-65 66-100	Math 2 Math 7		No routing back

APPENDIX J:

Variables considered for RQ2 Regression

Table J1.

Descriptives for variables considered for RQ 2 regression model

Category	Independent & Predictor Variables	*n*	*mean*	*s.d.*	Coding
Demographic	Gender	2920	.50	.50	1=female, 0= male
	Ethnicity [a]	2920	3.28	.96	1=Black 2=Asian/Pacific Islander 3=Latino 4=White 5=Other/Unknown
	Parent Education: Highest level [a]	2483	4.23	1.72	1=below high school grad [b] 2= high school graduate 3=some college[c] 5=college graduate 6=grad school experience
	Language Status	2920	.58	.97	0= English Only or Native English speakers 1= students who were classified by the school district as English Language Learners, Fluent English Proficient, and Reclassified Fluent English Proficient
	Special Needs	2920	.06	.23	1= student participated in special education
	Indication of lower SES	2920	.26	.44	0= did not participate in free and/or reduced lunch program and did not receive financial aid as a CC Freshman.1= student qualified for a free or reduced fee lunch while in the school district and/or (if they were a CC Freshman) received financial aid in their first year at the community college (summer, fall, winter, and/or spring).
School-based: Non – Mathematics	Met A-G Requirements	2920	.69	.46	0 = did not complete A-G requirements 1= completed A-G requirements
	Total High School Units	2897	245.79	32.40	continuous, ranges from 15-465
	Class or 2008 or 2009	2920	.51	.50	0= member class of 2006 or 2007 1= member class of 2008 or 2009
	Grade 12 GPA	2838	2.90	.76	continuous, ranges from .15-4.00

APPENDIX J (cont'd)

Table J1 continued 1

Category	Independent & Predictor Variables	n	mean	s.d.	Coding
School-based: Non – Mathematics (cont'd)	CAHSEE ELA	2774	404.12	31.31	continuous, ranges from 275-450
	CST ELA SS:				continuous, ranges from
	grade 9	2328	365.51	56.52	216-564
	grade 10	2568	361.31	58.19	207-541
	grade 11	2652	358.02	65.20	150-600
	CST ELA performance levels				1= far below basic 2= below basic
	grade 9	2328	3.76	1.13	3= basic
	grade 10	2568	3.69	1.19	4=proficient
	grade 11	2652	3.58	1.25	5=advanced
School-based: Mathematics	Grade 9 Mathematics Placement [d]	2441	37.56	8.15	1-3=below algebra 1 4-5=algebra 1 6=geometry 7=algebra 2 8=above algebra 2 see Appendix 3 for details
	Highest-level high school mathematics[e]	2920	53.68	15.88	same coding as grade 9 mathematics placement
	No mathematics in grade 12	2920	.36	.48	0 = took math in grade 12 1= no math in grade 12
	CST Mathematics SS:				continuous, ranges from
	grade 9	2458	334.37	63.65	150-600
	grade 10	2538	312.96	60.28	176-600
	grade 11	2496	299.22	65.74	158-600
	CST Mathematics proficiency levels				1= far below basic 2= below basic
	grade 9	2458	3.08	1.10	3= basic
	grade 10	2538	2.70	1.09	4=proficient
	grade 11	2496	2.44	1.16	5=advanced
	GPA or letter grade in mathematics courses				0=F 1=D
	grade 9	2441	2.80	1.14	2=C
	grade 10	2608	2.69	1.20	3=B
	grade 11	2624	2.44	1.26	4=A
	grade 12	1876	2.45	1.11	
	Repeated one or more mathematics courses (unduplicated students)	2920	.10	.30	0= no mathematics course repetitions 1= Repeated Algebra 1, Geometry, or Algebra 2
	Unsatisfactory completion in any HS mathematics course	2920	.30	.46	1= received less than a C in any high school mathematics course
	CAHSEE Math	2778	400.38	32.61	continuous, ranges from 297-450

APPENDIX J (cont'd)

Table J1 continued 2

Category	Independent & Predictor Variables		*n*	*mean*	*s.d.*	Coding
Prior Knowledge	Feeder Middle School					
		N	2920	.41	.49	1= district middle school N
		S	2920	.34	.47	2= district middle school S
		A	2920	.02	.13	3= district middle school A
		O	2920	.23	.42	4= district middle school O
	Grade 7 Mathematics GPA[f]		1040	2.96	1.05	ordered, ranges from 0-4
	Grade 7 Mathematics CST SS		1086	365.16	61.51	continuous, rantes from 175-600
	Grade 8 Mathematics Placement		2089	30.52	3.67	ordered, see grade 9 math coding
	Grade 8 Mathematics GPA		2089	2.63	1.05	ordered, ranges from 0-4
	Grade 8 Mathematics CST SS[g]		1640	357.29	58.90	continuous, ranges from 165-600
	Grade 8 GPA total		2092	3.13	.73	continuous, ranges from .46-4.0

[a] Ethnicity and highest level of parent education begin with data from the school district but use data from the community college district to fill in where school district values were missing. For the regression, ethnicity was coded dichotomously; 1=Black, 0=Other; 2=API, 0=Other; 3=Latino, 0=Other; 4=White, 0=Other. [b] Below high school graduate includes no high school. [c] Some college, coded 3 here, includes students who completed a 2 year degree (coded as a 4 in the community college dataset) [d] Full coding of school district mathematics offerings are presented in Appendix F [e] Highest-level of mathematics is grade 12 mathematics when mathematics is taken in grade 12. If no mathematics was taken in grade 12, highest-level of mathematics is grade 11 mathematics. [f] Grade 7 data is not available for the class of 2006 or 2007. [g] Grade 8 CST data is not available for the class of 2006

APPENDIX J (cont'd)

Table J2.
Correlation of predictor variables to community college placement assessment in mathematics

Variable Category	Independent & Predictor Variables	*r*	*n*	Coding
Demographic	Gender	-.088**	903	1= female
	Ethnicity			
	Black	-.126**	903	1= Black
	Latino	-.240**	903	1= Latino
	API	.162**	903	1= API
	White	.222**	903	
	Parent Education: Highest level	.244**	825	1= Some HS, 2= HS Grad, 3=Some College, 5=College Grad, 6= Grad School
	Language Status	-.037	903	0=English Only, 1= Fluent English Proficient, (FEP) 2= Reclassified FEP
	Special Needs Program	-.215**	903	1= Yes
	Low SES: Participated in Free or reduced lunch or Year One Financial Aid	-.125**	903	1= Yes
School-based: Non –Mathematics	Met A-G Requirements	.291**	903	1= Yes
	Total High School Units	.174**	896	continuous
	High School Class or 2008 or 2009	.054	903	0 = Class of 2006 or 2007; 1 = Class of 2008 or 2009
	Grade 12 GPA	.489**	882	continuous
	CAHSEE ELA	.406**	855	continuous
	CST ELA scaled scores			continuous
	Grade 9	.473**	707	
	Grade 10	.506**	789	
	Grade 11	.489**	817	
School-based: Mathematics	Grade 9 Mathematics	.466**	740	1= extended algebra or below; 2= algebra 1, 3= geometry or above
	Grade 9 Math GPA	.417**	740	0-4
	Grade 9 Math CST SS	.610**	755	continuous
	Grade 10 Mathematics	.488**	794	ordered, see Appendix F
	Grade 10 Math GPA	.381**	794	0-4
	Grade 10 Math CST SS	.573**	764	continuous
	Grade 11 Mathematics	.499**	800	ordered, see Appendix F
	Grade 11 Math GPA	.312**	800	0-4
	Grade 11 Math CST SS	.577**	755	continuous
	Grade 12 Mathematics	.277**	903	ordered, see Appendix F
	Grade 12 Math GPA	.278**	475	0-4

APPENDIX J (cont'd)

Table J2. Continued

Variable Category	Independent & Predictor Variables	*r*	*n*	Coding
School-based: Mathematics (cont'd)	Highest level mathematics (taken in grade 12, or in grade 11 if no math in grade 12)	.317**	903	1= below algebra 2, 2= algebra 2, 3= above algebra 2
	No Math in Grade 12	-.189**	903	1= No math in Gr 12
	Repeated (at least one) Math course in grades 10 -12 (during regular school semesters)	-.225**	903	1 = Yes
	Unsatisfactory progress (less than a C) in any HS mathematics course	-.302**	903	1 = Yes
	CAHSEE Math	.669**	857	continuous
School-based: Prior Knowledge (maybe)	Feeder Middle School			
	School N	.081*	903	1 = Yes
	School S	-.085*	903	1 = Yes
	School A	.000	903	1 = Yes
	Non-District Middle School	.003	903	1 = Yes
	Grade 7 Mathematics GPA	.301**	327	0-4
	Grade 7 Mathematics CST	.624**	349	continuous
	Grade 8 Mathematics	.000	609	ordered, see Appendix F
	Grade 8 Mathematics GPA	.344**	609	0-4
	Grade 8 Mathematics CST	.608**	505	continuous
	Grade 8 GPA total	.230**	625	continuous

$^{*}p < .05$, $^{**}p < .01$

APPENDIX K:

Math Grade Point Average Over Time

Comparison of grade point averages (GPA) in mathematics over time for grades 7 – 12 by ethnicity and between All Students and those students who matriculated to the community college as freshmen (CC Freshmen).

	N	A = 4	B = 3	C = 2	D = 1	F = 0	*mean*	*SD*
Grade 7								
Black	64	13%	25%	44%	14%	5%	2.27	1.01
Latino	316	24%	34%	25%	12%	6%	2.57	1.16
API	70	59%	31%	8%	1%	1%	3.44	.81
White	580	46%	35%	15%	4%	1%	3.20	.91
All Students	1040	38%	33%	19%	7%	3%	2.96	1.05
CC Freshmen	335	24%	36%	24%	11%	5%	2.62	1.11
Grade 8								
Black	144	8%	22%	35%	28%	6%	1.99	1.04
Latino	603	14%	30%	32%	21%	3%	2.32	1.04
API	158	46%	34%	15%	4%	.6%	3.20	.90
White	1166	28%	37%	24%	10%	1%	2.80	.99
All Students	2089	24%	34%	27%	14%	2%	2.63	1.05
CC Freshmen	643	10%	31%	35%	21%	3%	2.26	.99
Grade 9								
Black	193	17%	31%	32%	11%	9%	2.35	1.17
Latino	725	22%	26%	28%	15%	9%	2.38	1.23
API	201	56%	25%	14%	4%	1%	3.31	.91
White	1300	39%	35%	19%	4%	3%	3.03	1.00
All Students	2441	34%	31%	22%	8%	5%	2.80	1.14
CC Freshmen	779	21%	30%	28%	12%	8%	2.44	1.99
Grade 10								
Black	222	14%	24%	30%	19%	12%	2.09	1.22
Latino	774	18%	25%	28%	17%	11%	2.21	1.25
API	220	52%	29%	13%	4%	2%	3.25	.97
White	1368	39%	34%	17%	7%	4%	2.97	1.07
All Students	2608	31%	30%	21%	10%	7%	2.69	1.20
CC Freshmen	840	18%	26%	30%	18%	9%	2.26	1.20
Grade 11								
Black	230	10%	21%	29%	22%	19%	1.82	1.24
Latino	774	15%	21%	29%	17%	18%	1.98	1.30
API	232	34%	31%	24%	7%	4%	2.83	1.11
White	1366	31%	32%	23%	8%	6%	2.74	1.15
All Students	2624	25%	28%	25%	12%	10%	2.44	1.26
CC Freshmen	847	13%	23%	30%	18%	16%	1.98	1.25
Grade 12								
Black	146	7%	21%	40%	23%	9%	1.95	1.04
Latino	506	13%	21%	33%	22%	11%	2.02	1.18
API	179	25%	34%	31%	7%	3%	2.71	1.03
White	1030	22%	39%	28%	7%	4%	2.68	1.02
All Students	1876	19%	32%	31%	12%	6%	2.45	1.11
CC Freshmen	504	12%	20%	35%	23%	10%	2.00	1.14

Note. Due to rounding, percentages may not add up to 100. The numbers of Black, Latino, API, and White students may not add up to the same number as grade level All Students due to students whose ethnicity was unknown or other.

APPENDIX L:
Correlation Matrix for Math Variables for CC Freshmen

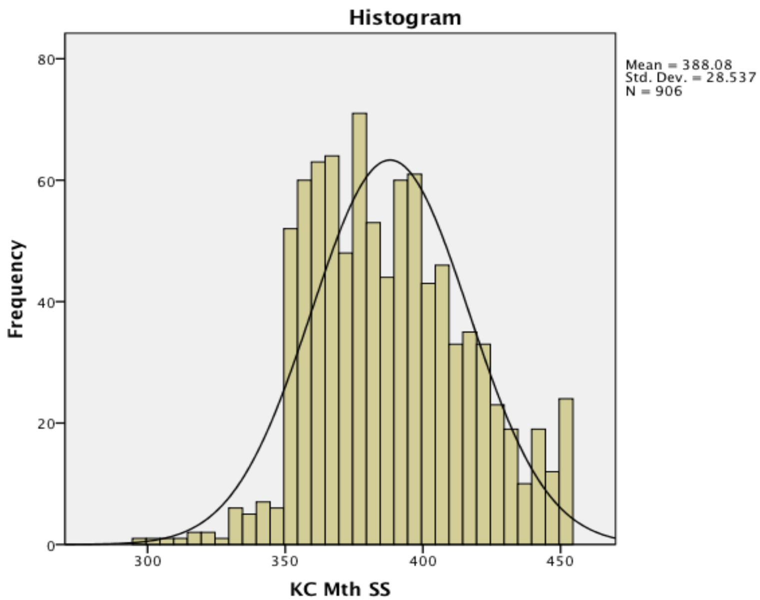
Correlation matrix for mathematics variables for the subset of students who matriculated to the community college as freshmen

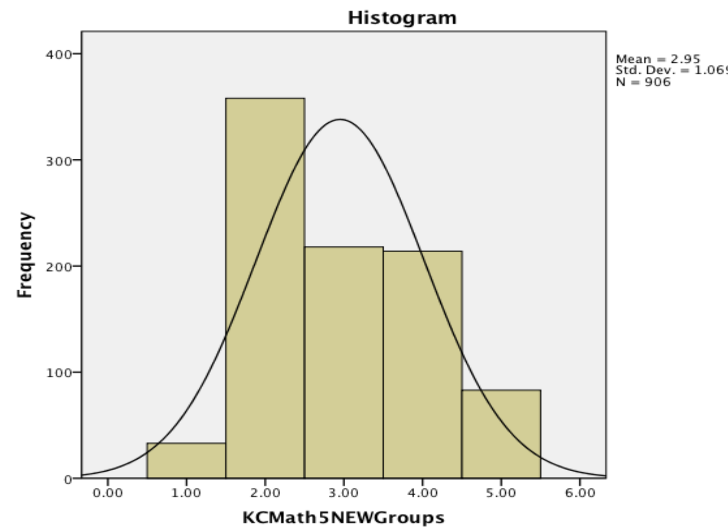
		CC Math Placement	Gr 9 Math Course	Gr 9 Math gpa	Gr 10 Math Course	Gr 10 Math gpa	Gr 11 Math Course	Gr 11 Math gpa	CAHSEE Math	Highest-level Math	No Gr 12 Math
CC Math_ Placement	Pearson Correlation	1									
	N	903									
Gr 9 Math Course	Pearson Correlation	.466**	1								
	N	740	779								
Gr 9 Math gpa	Pearson Correlation	.417**	.221**	1							
	N	740	779	779							
Gr 10 Math Course	Pearson Correlation	.488**	.820**	.392**	1						
	N	794	758	758	840						
Gr 10 Math gpa	Pearson Correlation	.381**	.178**	.435**	.199**	1					
	N	794	758	758	840	840					
Gr 11 Math Course	Pearson Correlation	.499**	.769**	.453**	.858**	.332**	1				
	N	800	709	709	774	774	847				
Gr 11 Math gpa	Pearson Correlation	.312**	.134**	.349**	.143**	.428**	.098**	1			
	N	800	709	709	774	774	847	847			
CAHSEE Math	Pearson Correlation	.669**	.512**	.412**	.603**	.361**	.595**	.278**	1		
	N	857	771	771	833	833	818	818	906		
Highest-level Math	Pearson Correlation	.317**	.220**	.287**	.338**	.267**	.807**	.238**	.286**	1	
	N	903	779	779	840	840	847	847	906	953	
No Gr 12 Math	Pearson Correlation	-.189**	-.075*	-.046	-.009	-.077*	-.040	-.113**	-.069*	-.354**	1
	N	903	779	779	840	840	847	847	906	953	953

Note. Cells are shaded to indicate very strong correlation values.
* $p < .05$, ** $p < .01$ (2-tailed)

APPENDIX M: Histograms of CAHSEE Math Scores

Histograms of CAHSEE Math Scale Scores and of CAHSEE Math subdivided into five performance levels





CAHSEE Mathematics Scaled Scores

N	Valid	906
	Missing	47
Mean		388.08
Std. Deviation		28.537

CAHSEE Math subdivided into five performance levels

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.00 lowest-349	33	3.7	3.9	3.9
	2.00 350-379	340	37.7	39.7	43.5
	3.00 380-400	206	22.8	24.0	67.6
	4.00 401-430	201	22.3	23.5	91.0
	5.00 431-450	77	8.5	9.0	100.0
	Total	857	94.9	100.0	
Missing	System	46	5.1		
Total		903	100.0		

APPENDIX N:

Enrollment in Grade 9 Math

Table N1.

Enrollment in Grade 9 mathematics by high school class. N=2441

Grade 9 Mathematics	High School Graduating Class 2006			2007			2008			2009			Total Students	
	N	Level	Year	*N*	Level	Year	*N*	Level	Year	*N*	Level	Year	*N*	Total
Extended Algebra 1 or less	221	45%	30%	199	40%	28%	43	9%	6%	31	6%	4%	494	17%
Algebra 1	68	13%	9%	82	16%	11%	161	32%	21%	197	39%	27%	508	17%
Geometry	303	22%	42%	324	24%	45%	388	28%	51%	347	25%	48%	1362	47%
Algebra 2 or above	<5	5%	1%	11	14%	2%	18	23%	2%	44	57%	6%	77	3%
Missing math data	129	27%	18%	100	21%	14%	146	30%	19%	104	22%	14%	479	16%
Total year	725	25%	100%	716	25%	100%	756	26%	100%	723	25%	100%	2920	100%

Note. During the course of the study, the high school changed their mathematics offerings in grade 9, reducing the numbers of students enrolled in mathematics below Algebra 1 from 30% of students in the class of 2006 to just 4% of students in the class of 2009.

APPENDIX N (cont'd)

Table N2.
Ethnic group enrollment in Grade 9 mathematics course

	Extended Algebra or below		Algebra 1		Geometry or Above	
	#	%	#	%	#	%
Black	59	(30.6)	67	(34.7)	67	(34.7)
API	16	(8.0)	17	(8.5)	168	(83.6)
Latino	231	(31.9)	190	(26.2)	304	(41.9)
White	185	(14.2)	230	(17.7)	885	(68.1)

Note. Extended Algebra refers to courses that extended the amount of class time, either by offering two periods of algebra in the same year or by offering the first semester of algebra in one year, usually grade 8, and then the second semester of algebra 1 the following year, usually grade 9. Eighty-five percent of students who took extended algebra or lower in grade 9 were from the class of 2006 or 2007 (see Appendix V). The district largely discontinued the use of Extended Algebra for students in the class of 2008 and 2009.

APPENDIX O:

Highest-Level Math in 11th Grade

Letter grade in highest-level mathematics for 11th graders who took no mathematics in grade 12

		A, B, or C	D or F
Ethnicity	Highest Level Math		
Black	Below Algebra 2		
n=98 of 260	n = 24	45%	54%
(38%)	Algebra 2		
	n = 57	60%	41%
	Above Algebra 2		
	n = 17	59%	41%
Latino	Below Algebra 2		
n=305 of 862	n = 60	41%	58%
(35%)	Algebra 2		
	n = 177	59%	41%
	Above Algebra 2		
	n = 68	66%	34%
API	Below Algebra 2		
n=62 of 248	n < 5	-	-
(25%)	Algebra 2		
	n = 18	72%	28%
	Above Algebra 2		
	n = 40	81%	20%
White	Below Algebra 2		
n=405 of 1525	n = 39	41%	59%
(27%)	Algebra 2		
	n = 183	72%	28%
	Above Algebra 2		
	n = 183	90%	11%

Note. Due to rounding, percentages may not add up to 100.

APPENDIX P:

Regression Model Fitting Information

Model fitting information for multinomial logistic regression

	Model Fitting Criteria			Likelihood Ratio Tests		
Model	AIC	BIC	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	1882.639	1900.266	1874.639			
Final	1413.332	1660.117	1301.332	573.307	52	.000

APPENDIX Q:

Further Exploration of CAHSEE Math

Table Q1.
Cross-tabulation of CAHSEE Mathematics scale score groups with assessed mathematics placement level for incoming community college freshmen

Community College Placement		CAHSEE Mathematics Scores – 5 Groupings					Total
		297-349	350-379	380-400	401-430	431-450	
College-level math	*N*	<10	<10	58	119	64	250 (29.2%)
	Placement level	.4%	3.2%	23.2%	47.6%	25.6%	
	CAHSEE group	3.0%	2.4%	28.2%	59.2%	83.1%	
1-level below college math	*N*	0	35	38	33	<10	113 (13.2%)
	Placement level	.0%	31.0%	33.6%	29.2%	6.2%	
	CAHSEE group	.0%	10.3%	18.4%	16.4%	9.1%	
2-levels below college math	*N*	0	30	41	33	<10	108 (12.6%)
	Placement level	.0%	27.8%	38.0%	30.6%	3.7%	
	CAHSEE group	.0%	8.8%	19.9%	16.4%	5.2%	
3-levels below college math	*N*	<10	111	51	12	<10	180 (21.0%)
	Placement level	2.8%	61.7%	28.3%	6.7%	.6%	
	CAHSEE group	15.2%	32.6%	24.8%	6.0%	1.3%	
4-levels below college math	*N*	27	156	18	<10	<10	206 (24.0%)
	Placement level	13.1%	75.7%	8.7%	1.9%	.5%	
	CAHSEE group	81.8%	45.9%	8.7%	2.0%	1.3%	
Total	*N*	33	340	206	201	77	857 (100%)
	CAHSEE group	3.9%	39.7%	24.0%	23.5%	9.0%	

Note. A score of 350 is required to pass the CAHSEE; a score of 380 demonstrates proficiency.

APPENDIX Q (cont'd)

Table Q2.
Summary CAHSEE Mathematics cross-tabulation with community college placement, by ethnicity

Ethnicity	CAHSEE Math Scores	Community College Placement Levels in Mathematics				
		College-Level	1-level below	2-levels below	3-levels below	4-levels below
Black, n=82						
	431-450, (4.9%)					
	401-430, *(15.9%)*					
	380-400, *(20.7%)*					
	350-379, (*45.1%)*					
	297-349, *(13.4%)*					
		17.1%	8.5%	7.3%	20.7%	46.3%
Latino, n=308	431-450, (2.6%)					
	401-430, *(13.3%)*					
	380-400, *(22.7%)*					
	350-379, (*56.5%)*					
	297-349, *(4.9%)*					
		17.5%	10.7%	11.7%	23.7%	36.4%
API, n=54	431-450, (18.5%)					
	401-430, *(35.2%)*					
	380-400, *(22.2%)*					
	350-379, (*24.1%)*					
	297-349, *(0.0%)*					
		57.4%	13.0%	5.6%	13.0%	11.1%
White, n=410	431-450, (13.2%)					
	401-430, *(31.0%)*					
	380-400, *(26.1%)*					
	350-379, (*28.3%)*					
	297-349, *(1.5%)*					
		36.3%	16.1%	15.4%	20.2%	12.0%

Note. A score of 350 is required to pass the CAHSEE; a score of 380 is considered evidence of proficiency. To protect the identity of the students, percentages are not given for each row.

APPENDIX Q (cont'd)

Table Q3.
Detailed cross-tabulation of CAHSEE Mathematics scale scores to placement level in community college for CC Freshmen by ethnicity. N=854

			CAHSEE Mathematics Scores – 5 Groupings					
Ethnicity	Community College Placement		297-349	350-379	380-400	401-430	431-450	Total
Black, n=82	College-level math	*N*	<5	0	5	5	<5	14 (17.1%)
		Placement level	7.1%	.0%	35.7%	35.7%	21.4%	
		CAHSEE group	9.1%	.0%	29.4%	38.5%	75.0%	
	1-level below college math	*N*	0	<5	<5	<5	0	7 (8.5%)
		Placement level	.0%	42.9%	42.9%	14.3%	.0%	
		CAHSEE group	.0%	8.1%	17.6%	7.7%	.0%	
	2-levels below college math	*N*	0	<5	<5	<5	0	6 (7.3%)
		Placement level	.0%	16.7%	33.3%	50.0%	.0%	
		CAHSEE group	.0%	2.7%	11.8%	23.1%	.0%	
	3-levels below college math	*N*	<5	8	<5	<5	<5	17 (20.7%)
		Placement level	17.6%	47.1%	17.6%	11.8%	5.9%	
		CAHSEE group	27.3	21.6	17.6	15.4	25.0	
	4-levels below college math	*N*	7	25	<5	<5	0	38 (46.3%)
		Placement level	18.4%	65.8%	10.5%	5.3%	.0%	
		CAHSEE group	63.6%	67.6%	23.5%	15.4%	.0%	
	Total	*N*	11	37	17	13	<5	82
		CAHSEE group	13.4%	45.1%	20.7%	15.9%	4.9%	
Latino, n=308	College-level math	*N*	0	<5	20	24	6	54 (17.5%)
		Placement level	.0%	7.4%	37.0%	44.4%	11.1%	
		CAHSEE group	.0%	2.3%	28.6%	58.5%	75.0%	
	1-level below college math	*N*	0	12	11	9	<5	33 (10.7%)
		Placement level	.0%	36.4%	33.3%	27.3%	3.0%	
		CAHSEE group	.0%	6.9%	15.7%	22.0%	12.5%	
	2-levels below college math	*N*	0	14	14	7	<5	36 (11.7%)
		Placement level	.0%	38.9%	38.9%	19.4%	2.8%	
		CAHSEE group	.0%	8.0%	20.0%	17.1%	12.5%	
	3-levels below college math	*N*	0	55	17	<5	0	73 (23.7%)
		Placement level	.0%	75.3%	23.3%	1.4%	.0%	
		CAHSEE group	.0%	31.6%	24.3%	2.4%	.0%	
	4-levels below college math	*N*	15	89	8	0	0	112 (36.4%)
		Placement level	13.4%	79.5%	7.1%	.0%	.0%	
		CAHSEE group	100%	51.1%	11.4%	.0%	.0%	
	Total	*N*	15	174	70	41	8	308
		CAHSEE group	4.9%	56.5%	22.7%	13.3%	2.6%	

Table Q3. (cont'd)

Detailed cross-tabulation of CAHSEE Mathematics scale scores to placement level in community college for CC Freshmen by ethnicity. N=854

Ethnicity	Community College Placement		CAHSEE Mathematics Scores – 5 Groupings 297-349	350-379	380-400	401-430	431-450	Total
API, n=54	College-level math	*N*	0	0	7	14	10	31 (57.4%)
		Placement level	.0%	.0%	22.6%	45.2%	32.3%	
		CAHSEE group	.0%	.0%	58.3%	73.7%	100%	
	1-level below college math	*N*	0	<5	<5	0	0	8 (13.0%)
		Placement level	.0%	42.9%	57.1%	.0%	.0%	
		CAHSEE group	.0%	23.1%	33.3%	.0%	.0%	
	2-levels below college math	*N*	0	<5	<5	<5	0	<5 (5.6%)
		Placement level	.0%	33.3%	33.3%	33.3%	.0%	
		CAHSEE group	.0%	7.7%	8.3%	5.3%	.0%	
	3-levels below college math	*N*	0	<5	0	<5	0	7 (13.0%)
		Placement level	.0%	42.9%	.0%	57.1%	.0%	
		CAHSEE group	.0%	23.1%	.0%	21.1%	.0%	
	4-levels below college math	*N*	0	6	0	0	0	6 (11.1%)
		Placement level	.0%	100%	.0%	.0%	.0%	
		CAHSEE group	.0%	46.2%	.0%	.0%	.0%	
	Total	*N*	0	13	12	19	10	54
		CAHSEE group	.0%	24.1%	22.2%	35.2%	18.5%	
White, n=410	College-level math	*N*	0	<5	26	75	44	149 (36.3%)
		Placement level	.0%	2.7%	17.4%	50.3%	29.5%	
		CAHSEE group	.0%	3.4%	24.3%	59.1%	81.5%	
	1-level below college math	*N*	0	17	20	23	6	66 (16.1%)
		Placement level	.0%	25.8%	30.3%	34.8%	9.1%	
		CAHSEE group	.0%	14.7%	18.7%	18.1%	11.1%	
	2-levels below college math	*N*	0	14	24	22	<5	63 (15.4%)
		Placement level	.0%	22.2%	38.1%	34.9%	4.8%	
		CAHSEE group	.0%	12.1%	22.4%	17.3%	5.6%	
	3-levels below college math	*N*	<5	45	31	5	0	83 (20.2%)
		Placement level	2.4%	54.2%	37.3%	6.0%	.0%	
		CAHSEE group	33.3%	38.8%	29.0%	3.9%	.0%	
	4-levels below college math	*N*	<5	36	6	<5	<5	49 (12.0%)
		Placement level	8.2%	73.5%	12.2%	4.1%	2.0%	
		CAHSEE group	66.7%	31.0%	5.6%	1.6%	1.9%	
	Total	*N*	6	116	107	127	54	410
		CAHSEE group	1.5%	28.3%	26.1%	31.0%	13.2%	

Note. A score of 350 is required to pass the CAHSEE; a score of 380 demonstrates proficiency.

APPENDIX Q (cont'd)

Table Q4.
One-Way Analysis of Variance Summary Table for the Effects of CAHSEE Math Scaled Scores on Placement in Mathematics at College-Level or 1-, 2-, 3-, or 4-Levels Below College-Level Mathematics

	CAHSEE Mathematics Scaled Scores				
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	365202.506	4	91300.627	231.700	.000
Within Groups	335727.302	852	394.046		
Total	700929.809	856			

Table Q5.
Descriptives and One-Way Analysis of Variance summary for the significance of CAHSEE Math scale scores on placement in mathematics at college-level, or 1-, 2-, 3-, or 4-levels below college-level. (n=857)

	N	*M*	*SD*	college-level	1-level below	2-levels below	3-levels below	4-levels below
College-level	250	415	22	---				
1-level below	113	392	21	***	---			
2-levels below	108	392	19	***		---		
3-levels below	180	375	18	***	***	***	---	
4-levels below	206	361	18	***	***	***	***	---

Note. As indicated by the lack of significance on the ANOVA test, the mean scores for 1- level below college-level mathematics and 2-levels below college-level mathematics are the same. (The means are rounded in the chart. The mean for 1-level below was 392.48 and the mean for 2-levels below was 392.11).
*** *p <.001*

APPENDIX R:

Further exploration of significant predictors

Table R1.
One-Way Analysis of Variance Summary Table for the Effects of Grade 9 Mathematics on Placement in Mathematics at College-Level or 1-, 2-, 3-, or 4-Levels Below College Level Mathematics

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	11005.141	4	2751.285	61.129	.000
Within Groups	33080.643	735	45.008		
Total	44085.784	739			

Table R2.
One-Way Analysis of Variance summary for the significance of Grade 9 Math Course on placement in mathematics at college-level, or 1-, 2-, 3-, or 4-levels below college-level. (n=740)

	N	College-Level	1-level below	2-levels below	3-levels below	4-levels below
College-Level	214	---				
1-level below	99	***	---			
2-levels below	100	***		---		
3-levels below	161	***	**	**	---	
4-levels below	166	***	***	***		---

Note. Grade 9 Math Courses were Below Algebra 1, Algebra 1, Geometry and above. Mean values are not given for Grade 9 mathematics course. This is because, although ranked numeric values were assigned for different grade 9 math courses, the numeric values are not meaningful independent of my coding.
* $p < .05$, ** $p < .01$, *** $p < .001$

Table R3.
One-Way Analysis of Variance Summary Table for the Effects of No Mathematics in Grade 12 on Placement in Mathematics at College-Level or 1-, 2-, 3-, or 4-Levels Below College Level Mathematics

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	9.380	4	2.345	9.760	.000
Within Groups	215.758	898	.240		
Total	225.138	902			

APPENDIX S:

Cross-Tabulations for All Significant Predictors

Cross-tabulation of significant predictors for community college placement below college-level math

		College-Level	1-level below	2-levels below	3-levels below	4-levels below
Grade 9 Math Course *n=740*			**	*	**	***
	Geometry and above, *n=297*	52.2%	13.8%	14.8%	12.1%	7.1%
	Algebra 1, *n=233*	18.5%	15.0%	12.0%	29.2%	25.3%
	Below Algebra 1, *n=210*	7.6%	11.0%	13.3%	27.1%	41.0%
Grade 9 Math Letter Grade *n=740*						**
	A, *n= 158*	53.8%	15.8%	13.3%	12.0%	5.1%
	B, *n=218*	37.2%	15.1%	12.8%	21.6%	13.3%
	C, *n= 213*	17.4%	14.1%	13.6%	26.3%	28.6%
	D, *n=91*	9.9%	8.8%	16.5%	22.0%	42.9%
	F, n *=60*	3.3%	5.0%	11.7%	31.7%	48.3%
Grade 10 Math Letter Grade *n = 794*						*
	A, *n = 135*	59.3%	12.6%	12.6%	10.4%	5.2%
	B, *n= 204*	38.2%	18.1%	11.8%	17.6%	14.2%
	C, *n = 237*	19.0%	13.9%	16.9%	26.2%	24.1%
	D, *n= 145*	16.6%	7.6%	11.0%	26.9%	37.9%
	F, n *=73*	8.2%	15.1%	8.2%	20.5%	47.9%
Grade 11 Math Letter Grade *n = 800*				**	**	
	A, *n= 98*	59.2%	14.3%	6.1%	10.2%	10.2%
	B, *n= 183*	43.7%	12.6%	13.7%	16.4%	13.7%
	C, *n = 243*	26.3%	12.8%	14.0%	22.6%	24.3%
	D, *n= 147*	19.0%	13.6%	9.5%	22.4%	35.4%
	F, *n = 129*	12.4%	11.6%	14.7%	30.2%	31.0%
Cahsee Math Scale Score *n = 857*			***	***	***	***
	431-450, *n=77*	83.1%	9.1%	5.2%	1.3%	1.3%
	401-430, *n=201*	59.2%	16.4%	16.4%	6.0%	2.0%
	380-400, *n=206*	28.2%	18.4%	19.9%	24.8%	8.7%
	350-379, *n=340*	2.4%	10.3%	8.8%	32.6%	45.9%
	297-349, *n=33*	3.0%	.0%	.0%	15.2%	81.8%
Grade 12 n=903				**	*	**
	No Math	32.1%	47.4%	54.7%	55.3%	55.4%

Note. Significance, as indicated by the asterisks, references significance for predictor variables as determined by a multinomial logistic regression model for placement in mathematics at a specified level below college-level. The reference category is college level math.
* *p< .05, ** p < .01, *** p < .001*

APPENDIX T:

ANOVA for Highest-Level Mathematics

Table T1.
One-Way Analysis of Variance Summary Table for the Effects of Highest-Level Mathematics on Placement in Mathematics at College-Level or 1-, 2-, 3-, or 4-Levels Below College Level Mathematics

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	128.326	4	32.082	103.645	.000
Within Groups	259.080	837	.310		
Total	387.406	841			

Table T2.
One-Way Analysis of Variance summary for differences between groups of Highest-Level Mathematics and placement in mathematics at college-level, or 1-, 2-, 3-, or 4-levels below college-level. (n=842)

	N	College-level	1-level below	2-levels below	3-levels below	4-levels below
College-level	254	---				
1-level below	109	**	---			
2-levels below	106	***		---		
3-levels below	175	***	***	***	---	
4-levels below	198	***	***	***	***	---

Note. Highest-Level Mathematics was coded as *coursework below Algebra 2, Algebra 2, and above Algebra 2, taken in grade 12 unless no mathematics was taken in grade 12 in which case highest-level mathematics refers to* 11^{th} *grade mathematics.*
**** p <.001, ** p <.01*

APPENDIX U:

Ten Most Frequent High School Mathematics Paths

Ten most frequent combinations from high school to community college for CC Freshmen (N=903)

High School Mathematics			Community College Assessment	N	%
Grade 9 Math Class[a]	Math in Grade 12 [a]	Highest-level Math			
Above Algebra 1	Yes	Above Algebra 2	College-level	105	12%
Algebra 1 or below	No	Algebra 2	3-levels below	54	6%
Algebra 1 or below	No	Algebra 2	4-levels below	53	6%
Algebra 1 or below	Yes	Algebra 2	4-levels below	45	5%
Above Algebra 1	No	Above Algebra 2	College-level	43	5%
Algebra 1 or below	Yes	Above Algebra 2	College-level	33	4%
Algebra 1 or below	No	Algebra 2	2-levels below	29	3%
Algebra 1 or below	Yes	Algebra 2	3-levels below	28	3%
Algebra 1 or below	Yes	Above Algebra 2	1-level below	25	3%
Algebra 1 or below	No	Algebra 2	1-level below	24	3%
				439	49%

Note. Among students with no missing data, 701 students followed 47 different combinations. Fewer than 3% of 262 students (29%) had the same combination. The remaining 202 students, 22%, had data missing for one of the variables.
[a] Grade 9 Math and No Math in Grade 12 were significant predictors for community college placement.

REFERENCES

Adelman, C. (1999). *Answers in the tool box: Academic intensity, attendance patterns, and bachelor's degree attainment.* Washington, DC: U.S. Government Printing Office.

Adelman, C. (2005). *Moving into town - and moving on: The community college in the lives of traditional-age students*. Washington, DC: Office of Vocational and Adult Education, U.S. Dept. of Education.

Adelman, C. (2006). *The toolbox revisited: Paths to degree completion from high school through college.* ED Pubs, P.O. Box 1398, Jessup, MD 20794-1398. Tel: 877-433-7827 (Toll Free).

Almy, S., & Theokas, C. (2010). *Not prepared for class: High-poverty schools continue to have fewer in-field teachers.* (November 18). Washington, DC: The Education Trust. Retrieved from http://www.edtrust.org/dc/publication/not-prepared-for-class-high-poverty-schools-continue-to-have-fewer-in-field-teachers

American Association of Community Colleges. (2010). *Fast facts 2010.* Retrieved March 7, 2011, from http://www.aacc.nche.edu/AboutCC/Documents/factsheet2010.pdf

Associated Press. (2008, July 11). California to require algebra taught in 8th grade. *USA Today,* Retrieved from http://www.usatoday.com/cleanprint/?1270428249653

Association of American Colleges and Universities (AAC&U). (2002). *Greater expectations: A new vision for learning as a nation goes to college.* (National Panel Report). Washington, DC.: Author. http://www.greaterexpectations.org.

Atkinson, R. C., & Geiser, S. (2009). Reflections on a century of college admissions tests. *Educational Researcher, Research & Occasional Paper Series: CSHE.4.09, 38*(9), 665-676. doi: 10.3102/0013189X09351981

Belfield, C. R., & Bailey, T. (2011). The benefits of attending community college: A review of the evidence. *Community College Review, 39*(1), 46-68.

Berry, L. (2003). Bridging the gap: A community college and area high schools collaborate to improve student success in college. *Community College Journal of Research and Practice, 27*(5), 393-408.

Bound, J., & Turner, S. (2010). Collegiate attainment: Understand degree completion. *NBER Reporter, 4*(Research Summary), 1-5. Retrieved from http://www.nber.org/reporter/2010number4/bound.html

Brown, R. S., & Conley, D. T. (2007). Comparing state high school assessments to standards for success in entry-level university courses. *Educational Assessment, 12*(2), 137-160.

Brown, R. S., & Niemi, D. N. (2007). *Investigating the alignment of high school and community college assessments in California.* (National Center Report #07-3). San Jose, CA: National Center for Public Policy and Higher Education.

Bueschel, A. C. (2003). *The missing link: The role of the community colleges in the transition between high school and college.* Stanford University: The Bridge Project.

Burdman, P. (2012). Where to begin? The evolving role of placement exams for students starting college. Community College Research Center, Institute on Education and the Economy, Teachers College, Columbia University. New York, NY. (August), 1-29. Retrieved from http://www.jff.org/publications/education/where-begin-evolving-role-placement-exam/1452

Burris, C. C., Wiley, Welner, K. G., & Murphy, J. (2008). Accountability, rigor, and detracking: Achievement effects of embracing a challenging curriculum as a universal good for all students. *Teachers College Record, 110*(3), 571-607.

California Community Colleges Chancellor's Office (CCCCO). (2009a). *Basic skills accountability report.* (). Sacramento, CA: Author. Retrieved from http://www.cccco.edu/Portals/4/TRIS/research/Basic_Skills/system.pdf

California Community Colleges Chancellor's Office (CCCCO). (2009b). *Focus on results: Accountability reporting for the community colleges.* Retrieved November 30, 2009b, from http://www.cccco.edu/Portals/4/TRIS/research/ARCC/arcc_2009_final.pdf

California Department of Education. (2009a). *Graduation requirements - high school.* Retrieved November 30, 2009, from http://www.cde.ca.gov/ci/gs/hs/hsgrtable.asp

California Department of Education. (2009b). *Overview of the California high school exit examination (CAHSEE).* Retrieved November 30, 2009, from http://www.cde.ca.gov/ta/tg/hs/overview.asp

California Department of Education. (2012). *2011-12 Academic Performance Index Reports Information Guide.* Retrieved October 18, 2012 from http://www.cde.ca.gov/ta/ac/ap/documents/infoguide12.pdf

California Liaison Committee of the Regents of the University of California and the State Board of Education. (1960). *A master plan for higher education in California, 1960-1975.* Sacramento, CA: Assembly of the State of California.

California Postsecondary Education Commission (CPEC). *Ethnicity snapshots.* Retrieved March 7, 2011, from http://www.cpec.ca.gov/StudentData/EthSnapshotMenu.asp

California Postsecondary Education Commission (CPEC). (2010). *2008 College-going rates to public colleges and universities: College-going rates by ethnicity and gender.* Retrieved November 29, 2010, from http://www.cpec.ca.gov/StudentData/CACGREthnicity.asp

California State University. (2011). *Freshman admission requirements overview.* Retrieved March 7, 2011, from http://www.csumentor.edu/planning/high_school/

Carnevale, A. P., Smith, N., & Strohl, J. (2010). *Help wanted: Projections of jobs and education requirements through 2018.* Georgetown University Center on Education and the Workforce.

Center for the Future of Teaching and Learning. (2008). *California's approach to math instruction still doesn't add up.* (CenterView). Santa Cruz, CA: Author.

College Entrance Examination Board. (2008a). *Fulfilling the commitment recommendations for reforming federal student aid: The report from the rethinking student aid study group.* New York, N.Y.: Author.

College Entrance Examination Board. (2008b). *Coming to our senses: Education and the American future.* New York. N.Y.: Author. Retrieved from http://professionals.collegeboard.com/profdownload/coming-to-our-senses-colege-board-2008.pdf

Community College League of California (CCLC). (2010). *Fast facts 2010.* Sacramento, CA: Author. Retrieved from http://www.ccleague.org/i4a/pages/index.cfm?pageid=3285

Community College League of California (CCLC). (2011). *Fast facts 2011.* Sacramento, CA: Author. Retrieved March 7, 2011,

Department of Education, Washington, DC. (2006). *A test of leadership: Charting the future of U.S. higher education.* Jessup, MD: ED Pubs.

Douglass, J. A. (2010a). *From chaos to order and back? A revisionist reflection on the California master plan for higher education @ 50 and thoughts about its* *future.* Research & Occasional Paper Series: CSHE.7.10. Center for Studies in Higher Education. University of California, Berkeley, CA.: Web site: http://cshe.berkeley.edu/.

Douglass, J. A. (2010b). *Re-imagining California higher education.* Research & Occasional Papers Series: CSHE.14.10. Center for Studies in Higher Education. University of California, Berkeley, CA.: Web site: http://cshe.berkeley.edu/.

Doyle, W. R. (2009). The effect of community college enrollment on bachelor's degree completion. *Economics of Education Review, 28*(2), 199-206. DOI: 10.1016/j.econedurev.2008.01.006

Droogsma Musoba, G. (2011). Accountability policies and readiness for college for diverse students. *Educational Policy, 25*(3), 451-487.

EdSource. (2003). *The California high school exit exam.* Palo Alto, CA: Author.

EdSource. (2010). Something's got to give: California can't improve college completions without rethinking developmental education at its community colleges. (October), 1-28. Author.

Fensterwald, J. (2012, September 5). State board now can wade back into eighth grade math debate. *Edsource.*

Gamoran, A., & Hannigan, E. C. (2000). Algebra for everyone? Benefits of college-preparatory mathematics for students with diverse abilities in early secondary school. *Educational Evaluation and Policy Analysis, 22*(3), 241-254.

Geiser, S., & Atkinson, R. C. (2010). *Beyond the master plan: The case for restructuring baccalaureate education in California.* (Research & Occassional Paper Series: CSHE. 16.10). University of California, Berkeley: Center for Studies in Higher Education. Retrieved from http://74.125.155.132/scholar?q=cache:Xl7u4MU45KwJ:scholar.google.com/+Beyond+the+Master+Plan+author:Geiser&hl=en&as_sdt=0,5

Givvin, K. B., Thompson, B. J., & Stigler, J. W. (2011). What community college developmental mathematics students understand about mathematics, Part 2: The interviews. *Math*AMATYC *Educator,* 2(3), 4-18.

Greene, T. G., Marti, C. N., & McClenney, K. (2008). The effort-outcome gap: Differences for African American and Hispanic community college students in student engagement and academic achievement. *Journal of Higher Education, 79*(5), 513-539.

Grimm, L. G., & Yarnold, P. R. (1995). *Reading and understanding multivariate statistics*. Washington, D.C.: American Psychological Association.

Hartley, M. (2009). *Looking beyond the numbers: Implications of shifting demographics.* [S.l.]: American Council On Education.

Hughes, K. L., & Scott-Clayton, J. (2010). *Assessing developmental assessment in community colleges: A review of the literature. CCRC working paper no. 19.* Community College Research Center. Teachers College, Columbia University, New York, NY.

Jellison Holme, J., Richards, M., Jimerson, J., & Cohen, R. (2010). Assessing the effects of high school exit examinations. *Review of Educational Research, 80*(4), 476-526.

Kelly, P. J. (2010). *Closing the college attainment gap between the U.S. and most educated countries, and the contributions to be made by the states.* 2011 National Center for Higher Education Management Systems (NCHEMS). Boulder, Colorado 80301-2251: Retrieved from http://www.nchems.org/pubs/detail.php?id=129

Kirst, M., Bracco, K. (2004). Bridging the great divide: How the K-12 and postsecondary split hurts students, and what can be done about it. In Kirst, M. and Venezia, A. (Ed.), *From high school to college* (pp. 1-30). San Francisco: Jossey Bass.

Kisker, C. B. (2006). Integrating high school and the community college: Previous efforts and current possibilities. *Community College Review, 34*(1), 68-86. doi: 10.1177/0091552106289821

Lay, S. (2010). In Jaffe L. (Ed.), *Email to members of the CCLC* Community College League of California.

Lee, J. (2012). College for all: Gaps between desirable and actual P-12 math achievement trajectories for college readiness. *American Educational Research Journal, 41*(2), 43-55.

Legislative Analyst's Office (LAO). (2011). *The 2011–12 budget: Prioritizing course enrollment at the community colleges.* Sacramento, California. Author. Retrieved from http://www.lao.ca.gov/analysis/2011/highered/ccc_course_enrollment.aspx

Loveless, T. (2008). *The misplaced math student: Lost in eighth-grade algebra.* (Special Release No. The 2008 Brown Center Report on American Education). Washington, DC: Brookings Institution Press.

Lumina Foundation for Education. (2009). *A stronger nation through higher education: How and why Americans must meet a "big goal" for college attainment.* (Special Report) Author.

Matthews, D. (2011). The big goal. *CCLC Annual Legislation Conference,* Sacramento, CA.

Maxwell, J. A. (2005). *Qualitative research design: An interactive approach* (Second ed.). Thousand Oaks, CA: Sage Publications, Inc.

McClenney, K. M. (2006). Benchmarking effective educational practice. *New Directions for Community Colleges,* (134), 47-55.

McClenney, K. M. (2007). The community college survey of student engagement. *Community College Review, 35*(2), 137-146.

McClenney, K. M. (2010). Leadership for student success. Powerpoint presented at the *California Community College Trustees Annual Convention,* Long Beach, California.

McClenney, K. M., McClenney, B. N., & Peterson, G. F. (2007). A culture of evidence: What is it? Do we have one? *Planning for Higher Education, 35*(3), 26-33.

McDonough, P. M. (2005). *Counseling and college counseling in America's high schools.* National Association for College Admission Counseling.

Miller, R. (2001). *Lesser and greater expectations: The wasted senior year and college-level study in high school.* (Briefing Papers). http://www.aacu-edu.org/gex/briefingpapers/.

Mirowsky, J., & Ross, C. E. (2003). *Education, social status, and health*. New York: A. de Gruyter.

Moore, C., & Shulock, N. (2010). *Divided we fail: Improving completion and closing racial gaps in California's community colleges.* (October). Sacramento, CA: Institute for Higher Education Leadership & Policy. Retrieved from http://www.csus.edu/ihelp/PDFs/R_Div_We_Fail_1010.pdf

National Center for Education Statistics. (2005). *Beginning postsecondary students: Data analysis system.* (Technical report). Washington, DC: Author. United States Department of Education.

Oakes, J. (2003). Critical conditions for equity and diversity in college access: Informing policy and monitoring results. Retrieved from http://escholarship.org/uc/item/427737xt

Oakes, J. (2004). Investigating the claims in Williams v. state of California: An unconstituional denial of education's basic tools? *Teachers College Record, 106*(10, October), 1889-1906.

Oakes, J. (2008). Keeping track: Structuring equality and inequality in an era of accountability. *Teachers College Record, 110*(3), 700-712.

Offenstein, J., Moore, C., & Shulock, N. (2010). *Advancing by degrees: A framework for increasing college completion.* Washington, DC: Institute for Higher Education Policy.

Organization for Economic Cooperation and Development (OECD). (2010). *Education at a Glance: 2010.* Author. Paris.

Panel of the Center for Student Success of the Research and Planning Group for California Community Colleges (RP/CSS). (2005). *Environmental scan: A summary of key issues facing California community colleges pertinent to the strategic planning process.* Retrieved November 30, 2009, from http://www.rpgroup.org/documents/projects/CCC-StrategicPlan/EvScanCCC-StrategicPln-RPCSS-07-05.pdf

Payne, J. L. (1989). The high school/college interface: A new challenge for the community college. *Community College Review, 16*(4), 22-27. doi: 10.1177/009155218901600403

Perry, M. (2011, September 8). Seventh grade is key to balancing California's math equation. *Edsource*

Perry, P. (2010). *End of year (2009-2010) analysis of changes in CCC system: Students, courses, and FTES.* (Report from Patrick Perry, Chancellor's Office to Board of Governors at their September 14, 2010 meeting). Sacramento, CA: California Community College Chancellor's Office.

Perry, M., Bahr, P. R., Rosin, M., & Woodward, K. M. (2010). *Course-taking patterns, policies, and practices in developmental education in the California community colleges. A report to the California Community Colleges Chancellor's Office.* Mountain View, CA: EdSource.

Puente, K. (2012, July 21). LBCC's promise of better placement. *Long Beach Press Telegram*

Ramirez, E. (2008, December 29). 8th-grade algebra requirement in California gets sidelined. *U.S. News & World Report,* Retrieved from http://www.usnews.com/blogs/on-education/2008/12/29/8th-grade-algebra-requirement-in-California-gets-sidelined.html

Ready, D. D., Lee, V. E., & Welner, K. G. (2004). Educational equity and school structure: School size, overcrowding, and schools-within-schools. *Teachers College Record, 106*(10), 1989-2014.

Riegle-Crumb, C., & King, B. (2010). Questioning a white male advantage in STEM: Examining disparities in college major by gender and Race/Ethnicity. *Educational Researcher, 39*(9), 656-664.

Rivas, M. A., Perez, J., Alvarez, C. R., & Solorzano, D. G. (2007). *An examination of Latina/o transfer students in California's postsecondary institutions.* (No. 16). UCLA Chicano Studies Research Center.

Rosenbaum, J. (1998). *Unrealistic plans and misdirected efforts: Are community colleges getting the right message to high school students?* (Occasional Paper). New York, NY: Community College Research Center, Teachers College, Columbia University.

Rosenbaum, J. E., & Person, A. E. (2003). Beyond college for all: Policies and practices to improve transitions into college and jobs. *Professional School Counseling, 6*(4), 252-260.

Rosin, M., & Wilson, K. (2008). *High school to community college: New efforts to build shared expectations.* Mountain View, CA: EdSource.

Rouse, C. E., & Princeton University. Industrial Relations Section. (1995). *Democratization or diversion?: The effect of community colleges on educational attainment*. Princeton, N.J.: Industrial Relations Section, Dept. of Economics, Princeton University.

Sandy, J., Gonzalez, A., & Hilmer, M. J. (2006). Alternative paths to college completion: Effect of attending a 2-year school on the probability of completing a 4-year degree. *Economics of Education Review, 25*(5), 463-471.

Shulock, N., & Moore, C. (2007). *Rules of the game: How state policy creates barriers to degree completion and impedes student success in the California* *community colleges*. Sacramento, CA: California State University Sacramento, Institute for Higher Education Leadership & Policy.

Shulock, N., Moore, C., Ceja, M., Lang, D. M. (2007). *Beyond the open door: Increasing student success in the California community colleges*. Sacramento, CA: California State University Sacramento, Institute for Higher Education Leadership & Policy.

Silva, C. M., & Moses, R. P. (1990). The algebra project: Making middle school mathematics count. *Journal of Negro Education, 59*(3), 375-391.

Southern Regional Education Board. (2010). *Getting students ready for college and careers: Transitional senior mathematics.* (No. 10V26). Atlanta, Georgia: Southern Regional Education Board.

Spielhagen, F. R. (2006). Closing the achievement gap in math: The long-term effects of eighth-grade algebra. *Journal of Advanced Academics, 18*(1), 34-59.

Stern, B. (2009a). *Community college math transitions - DRAFT.* (No. 2009027a). Cal-PASS Research Department. California Partnership for Achieving Student Success. http://www.cal-pass.org/

Stern, B. (2009b). *Community college math transitions - DRAFT.* (No. 2009027b). Cal-PASS Research Department. California Partnership for Achieving Student Success. http://www.cal-pass.org/

Stern, B. (2009c). *University math transitions.* (No. 2009034a). Cal-PASS Research Department. California Partnership for Achieving Student Success. http://www.cal-pass.org/

Stigler, J. W., Givvin, K. B., & Thompson, B. J. (2010). What community college developmental mathematics students understand about mathematics. *MathAMATYC Educator, 1*(3), 4-16.

Terry, L., & Rosin, M. (2011). California's math pipeline: The grade 7 pivot point. (September). *Edsource.*

UCLA/IDEA, & UC/ACCORD. (2007). *California educational opportunity report 2007.* (No. November). UCLA Institute for Democracy, Education, and Access and University of California All Campus Consortium on Research for Diversity. Retrieved from http://idea.gseis.ucla.edu/publications/eor-07/StateEOR2007.pdf

United States Department of Labor Bureau of Labor Statistics. (January 7, 2011). *Table A-4. employment status of the civilian population 25 years and over by educational attainment.* Retrieved January 18, 2011,

University of California. (2007). *Admissions.* Retrieved October 19, 2009, from http://www.universityofcalifornia.edu/admissions/undergrad_adm/paths_to_adm/freshman/subject_reqs.html

Venezia, A., & Perry, M. (2007). *Levers for change: Opportunities to strengthen California's high school curriculum.* (May). Mountain View, CA: EdSource.

Venezia, A., & Kirst, M. W. (2005). Inequitable opportunities: How current education systems and policies undermine the chances for student persistence and success in college. *Educational Policy, 19*(2), 283-307.

Wellman, J. V., Desrochers, D. M., & Lenihan, C. M. (2008). *The growing imbalance: Recent trends in US post-secondary education.* P.O. Box 1806, Indianapolis, IN 46206-1806. Tel: 800-834-5756; Fax: 317-951-5063; Lumina Foundation for Education. Retrieved from http://eric.ed.gov/PDFS/ED501221.pdf

Williams, T., Haertel, E., Kirst, M. W., Rosin, M., & Perry, M. (2011). *Preparation, placement, proficiency: Improving middle grades math performance. Policy and Practice Brief.* Mountain View, CA : EdSource.

Woodrow Wilson National Fellowship Foundation, Princeton, NJ. (2001). *Raising our sights: No high school senior left behind.* (Senior Year Report. Final Report, National Commission on the High School Senior Year). Princeton, NJ: Author.

Yosso, T. J., & Solorzano, D. G. (2006). *Leaks in the Chicana and Chicano educational pipeline.* (Latino Policy & Issues Brief. Number 13.) Los Angeles, CA: UCLA Chicano Studies Research Center.