THE RELATIONSHIP OF HIGH SCHOOL PREPARATION IN MATHEMATICS TO THE ENROLLMENT OF COLLEGE FRESHMAN IN POSTSECONDARY DEVELOPMENTAL MATHEMATICS COURSES

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Submitted to the

Faculty of the College of Arts and Sciences

of American University

in Partial Fulfillment of

the Requirements for the Degree

of Doctor of Philosophy

In

Education

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June 1, 2012

Date

2012

American University

Washington, D.C. 20016

DEDICATION

This work is dedicated to my wife Staci and to my children, Megan and Jordan. Staci, Megan, and Jordan have supported and encouraged me to continue my education. I also dedicate this work to my parents, Henry and June, who encouraged me to enter education and give to others by serving and supporting children and young adults in their educational pursuits.

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ABSTRACT

A student's mathematical preparation is important in readiness for postsecondary study and ultimately success in a global job market. Nationally, a significant number of students are leaving high school unprepared for college-level course work in mathematics. A 2008 National Center for Educational Statistics report on Community Colleges indicates that 15.5 percent of first-year postsecondary students reported taking developmental courses in mathematics during the 2003–2004 academic year (Provasnik & Planty, 2008, p. 39). Data at the state level, and specifically for community colleges, are more unsettling. For example, a Maryland Higher Education Commission (2011) study found that 61 percent of students who entered community colleges, after having completed a high school core curriculum, required remediation in mathematics. The remediation rate in mathematics for graduates who did not complete a core curriculum was 69 percent (p. 13).

With national data showing the United States lagging behind other countries in mathematics achievement, and significant numbers of students annually enrolling in developmental course work, it is important to increase the number of students entering postsecondary study ready for college-level course work. Decreasing the need for remedial course work in mathematics will lead to a higher postsecondary retention rate, an increase in the number of degree confirmations, and potentially a stronger workforce.

This study investigates the articulation of students from Montgomery County Public Schools, Maryland to Montgomery College, the school district's feeder community college. Montgomery County, a suburb of Washington, D.C., has the 16th largest public school district in the nation. Approximately 33 percent of each year's graduating class attends Montgomery College and more than half of these enrollees require developmental course work in mathematics.

Utilizing data from the Montgomery County Public Schools 2009 graduating class, this study employs logistic regression to analyze the records of 2,821 students who entered Montgomery College in the 2009–2010 academic year. The study identifies specific factors, including high school mathematics course attainment and final course grades that predict placement in developmental mathematics courses.

ACKNOWLEDGMENTS

This work would not have been possible without the unwavering support, guidance, and encouragement Dr. Frederic Jacobs, Dr. Vasuki Rethinam, and Dr. Kaye Williams. Dr. Jacobs did not give up on me when the going got tough and Dr. Rethinam and Dr. Williams helped to support, guide, and shape my thinking in the final year of work on this manuscript. I am forever grateful for their patience and scholarly counsel.

I would also like to thank Montgomery County Public Schools and Montgomery College for giving permission to utilize their names and data in this study. Leadership staff at both institutions were tremendously supportive as I worked to navigate the policies and processes which ultimately allowed me to ascertain and analyze the data and implement a survey of high school principals.

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CHAPTER 1

THE RESEARCH PROBLEM

Introduction and Context

Business leaders, politicians, educators, and the general public have deemed mathematics achievement in the United States of America a priority for educational improvement for more than half a century. The launch of Sputnik in 1957 initiated an intense international education race that is still underway as we embark on the second decade of the 21st century. There have been many national initiatives and calls for action to improve mathematics education. The National Defense Education Act (NDEA) of 1958 was one of the first responses to Sputnik by the U.S. government. This legislation appropriated federal funds to support the improvement of mathematics and science education (NDEA, 1958).

The NDEA was followed by a myriad of legislation and commissioned reports designed to improve K–12 education including the *Elementary and Secondary Act of 1965* and its most recent reauthorization as the *No Child Left Behind Act of 2001*, A Nation at Risk (1983), America 2000 (1990), Goals 2000 (1994), Before It's Too Late: A Report to the Nation from the National Commission on Mathematics and Science Teaching for the 21st Century (2000), Trends in International Mathematics and Science Study (TIMSS) 2007, and Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future (2007). These legislative measures and commissioned reports outlined the failures of mathematics education and advocated for higher content standards for American students and improved mathematics achievement.

At the national level, recent TIMMS and National Assessment of Educational Progress (NAEP) data confirm the concerns regarding mathematics achievement. "Although the average mathematics score of U.S. fourth-graders was 518 in both 1995 and 2003, the data suggests that the standing of U.S. fourth-graders relative to their peers in 14 other countries was lower in 2003 than in 1995 in mathematics" (Gonzales, et al., 2004, p. 8). TIMMS scores do show some improvement; however, the gains have been gradual. "In 2007, the U.S. fourth-grade average mathematics score of 529 was 11 scale score points higher than the 1995 average of 518" (Gonzales, et al., 2008, p. 8). The 2007 TIMMS report data also show some improvement in eighth-grade student performance between 1995 and 2007, yet U.S. eighth-grade students still lag behind their peers in several other countries. In 2007, "seven countries had higher percentages of students performing at or above the advanced mathematics benchmark than the United States: Chinese Taipei, Korea, Singapore, Hong Kong SAR, Japan, Hungary, and the Russian Federation" (Gonzales, et. al, 2008, p. iii). Following gains in mean NAEP scores for 17 years, scores for fourth graders remained the same, and the scores for eighth graders saw a sluggish two-point rise between 2007 and 2009 (NAEP, 2009, p. 1).

A student's mathematical preparation is important in readiness for postsecondary study and ultimate success in the job market. Colleges and universities place significant value in SAT, ACT, and Accuplacer scores, which are the most commonly used standardized measures for college admission. Scores from these examinations, as well as placement tests developed and administered at the local university level, determine whether or not a student enters postsecondary study enrolled in college-level course work or is assigned to remedial courses to hone skills that should have been mastered in high

school. A student's high school mathematics course work lays the foundation for success on high-stakes college entry exams. "Educators express concerns that student failure to take college preparatory courses, grade inflation, and a lack of academic rigor in high school courses all contribute to the need for remediation in college" (Hoyt & Sorensen, 2001, p. 26). A student's placement in developmental course work may be a determining factor between earning a college degree or dropping out. It is not uncommon for students' to become so mired in remedial classes that they lose interest and motivation, resulting in the discontinuation of their postsecondary studies (Deil-Amen & Rosenbaum, 2002).

The 2007 Digest of Educational Statistics reports that during the 2006-2007 school year, 72.8 percent of all degree-granting institutions offered remedial services (Snyder, et al., 2008, p. 462). A 2008 National Center for Educational Statistics report on Community Colleges indicates that 15.5 percent of first-year postsecondary students reported taking remedial courses in mathematics during the 2003–2004 academic year. In public two-year institutions, 22.3 percent of students reported enrolling in remedial courses while in four-year public institutions, 13.9 percent of students self-reported enrollment in developmental courses (Provasnik & Planty, 2008, p. 39).

With national data showing the United States lagging behind other countries in mathematics achievement, and significant numbers of students annually enrolling in developmental course work, it is important to identify solutions to increase the number of students entering postsecondary study ready for college-level course work in mathematics. Decreasing the need for remedial course work in mathematics will lead to

a higher postsecondary retention rate, an increased in the number of degree confirmations, and a stronger workforce.

The purpose of this study is to determine whether specific factors, including highest-level mathematics course attained and/or grades in high school mathematics courses predict the need for enrollment in developmental mathematics courses at the postsecondary level. Identification of these factors may provide educators with concrete information that they can use in their efforts to decrease the number of students forced to enroll in remedial courses. If this study identifies a correlation among these elements, it may be possible to alter the high school mathematics pathway of some students, thus benefiting graduates as they enter postsecondary study prepared for college-level mathematics.

Statement of the Problem

Montgomery County Public Schools (MCPS) is located in the Maryland suburb of Washington D.C. As a highly educated community with high-tech governmental and business interests, there are lofty expectations for students who graduate from this school district. Montgomery County is home to approximately 350 biotechnology companies and 19 federal research and regulatory agencies. To support the vast array of high-tech companies and governmental agencies, there are more than 100,000 advanced technology workers (Business Innovation Network, 2011, para 1). Table 1 shows that, among the five most populated jurisdictions in Maryland, Montgomery County ranks number one in the population of citizens 25 years old or older who hold bachelor's or advanced degrees.

Table 1. Percentage of Degrees in the Five Largest Jurisdictions in Maryland

Rank	Jurisdiction	Bachelors Degree and Above	Advanced Degrees	Estimated Population 2009
	Maryland	35.2	15.6	5,699,478
1	Montgomery County	56.1	29.2	971,600
2	Anne Arundel County	35.3	14.6	521,209
3	Baltimore County	34.3	14.2	789,814
4	Prince George's County	30.0	12.2	834,560
5	Baltimore City	24.9	11.7	637,418

Data Source: *U.S. Census Bureau, American Fact Finder, 2009 Data Profiles, Population 25 Years and Over*

As the most populated jurisdiction in Maryland, there has been substantial growth and sizable changes in demographics among the county's population. The student demographics in Montgomery County Public Schools also have changed significantly over the past 30 years. In the 1968–1969 school year, the student population comprised 4 percent African American, 1 percent Asian American, 1.4 percent Hispanic, and 93.6 percent white. In the 2008–2009 school year, the enrollment demographics had changed to 23.2 percent African American, 15.5 percent Asian, 22.1 percent Hispanic, and 39.1 percent white (Montgomery County Public Schools, Capital Improvements Budget, 2009, p. A-3). The enrollment figures for special populations in 2008–2009 included 11.2 percent special education, 11.2 percent English Speakers of Other Languages (ESOL), and 27.1 percent Free and Reduced-priced Meals Systems (FARMS). The total enrollment for Montgomery County Public Schools in the 2008–2009 school year was 139,276 students. Table 2 on page 6 shows the Montgomery County Public Schools demographic enrollment and the total district enrollment from 1968 through 2009.

Table 2. District Enrollment by Race/Ethnic Groups: 1968–2009

School	African American		American Indian		Asian American		Hispanic		White		Total
Year	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Enrollment
1968–69	4,872	4.0%	75	0.1%	1,208	1.0%	1,673	1.4%	113,621	93.6%	121,449
1969–70	5,716	4.6%	123	0.1%	1,401	1.1%	1,832	1.5%	115,899	92.7%	124,971
1970–71	6,454	5.1%	131	0.1%	1,476	1.2%	2,438	1.9%	114,845	91.6%	125,344
1971–72	7,292	5.8%	113	0.1%	1,640	1.3%	2,475	2.0%	114,687	90.9%	126,207
1972–73	8,013	6.3%	194	0.2%	1,904	1.5%	2,688	2.1%	114,113	89.9%	126,912
1973–74	9,264	7.3%	77	0.1%	1,849	1.5%	1,996	1.6%	112,990	89.5%	126,176
1974–75	9,928	8.0%	113	0.1%	1,929	1.6%	2,050	1.6%	110,299	88.7%	124,319
1975–76	10,578	8.7%	122	0.1%	2,438	2.0%	2,234	1.8%	106,900	87.4%	122,272
1976–77	11,012	9.4%	822	0.7%	3,758	3.2%	3,668	3.1%	98,370	83.6%	117,630
1977–78	11,201	9.9%	545	0.5%	4,084	3.6%	3,517	3.1%	93,278	82.8%	112,625
1978–79	11,192	10.4%	334	0.3%	4,360	4.1%	3,486	3.2%	88,058	82.0%	107,430
1979–80	11,648	11.4%	209	0.2%	4,774	4.7%	3,442	3.4%	82,446	80.4%	102,519
1980–81	11,912	12.1%	187	0.2%	5,598	5.7%	3,760	3.8%	77,386	78.3%	98,843
1981–82	12,175	12.7%	161	0.2%	6,291	6.6%	4,122	4.3%	72,838	76.2%	95,587
1982–83	12,345	13.3%	156	0.2%	6,791	7.3%	4,231	4.6%	68,994	74.6%	92,517
1983–84	12,714	14.0%	166	0.2%	7,266	8.0%	4,388	4.8%	66,496	73.0%	91,030
1984–85	13,327	14.5%	136	0.1%	8,024	8.7%	4,807	5.2%	65,410	71.3%	91,704
1985–86	13,765	14.8%	140	0.2%	8,759	9.4%	5,273	5.7%	64,934	69.9%	92,871
1986–87	14,342	15.2%	142	0.2%	9,471	10.0%	5,845	6.2%	64,660	68.5%	94,460
1987–88	14,984	15.6%	194	0.2%	10,229	10.6%	6,376	6.6%	64,488	67.0%	96,271
1988–89	15,900	16.1%	223	0.2%	10,960	11.1%	7,208	7.3%	64,228	65.2%	98,519
1989–90	16,612	16.6%	294	0.3%	11,565	11.5%	8,199	8.2%	63,589	63.4%	100,259
1990–91	17,721	17.1%	268	0.3%	12,352	11.9%	9,202	8.9%	64,189	61.9%	103,732
1991–92	18,867	17.6%	293	0.3%	12,983	12.1%	10,189	9.5%	65,067	60.6%	107,399
1992–93	19,938	18.1%	323	0.3%	13,521	12.3%	11,071	10.1%	65,184	59.2%	110,037
1993–94	21,009	18.5%	397	0.3%	14,014	12.4%	12,260	10.8%	65,749	58.0%	113,429
1994–95	22,170	18.9%	464	0.4%	14,440	12.3%	13,439	11.5%	66,569	56.9%	117,082
1995–96	23,265	19.3%	400	0.3%	15,016	12.5%	14,437	12.0%	67,173	55.8%	120,291
1996–97	24,281	19.8%	440	0.4%	15,384	12.6%	15,348	12.5%	67,052	54.7%	122,505
1997–98	25,420	20.4%	442	0.4%	15,904	12.7%	16,502	13.2%	66,767	53.3%	125,035
1998–99	26,820	21.0%	428	0.3%	16,380	12.8%	17,815	13.9%	66,409	52.0%	127,852
1999–00	27,490	21.0%	385	0.3%	17,093	13.1%	19,485	14.9%	66,236	50.7%	130,689
2000–01	28,426	21.2%	407	0.3%	17,895	13.3%	21,731	16.2%	65,849	49.0%	134,308
2001–02	28,928	21.1%	414	0.3%	19,042	13.9%	23,517	17.2%	64,931	47.5%	136,832
2002–03	29,755	21.4%	428	0.3%	19,765	14.2%	24,915	17.9%	64,028	46.1%	138,891
2003–04	30,736	22.1%	429	0.3%	19,908	14.3%	26,058	18.7%	62,072	44.6%	139,203
2004–05	31,446	22.6%	396	0.3%	20,118	14.4%	27,011	19.4%	60,366	43.3%	139,337
2005–06	31,816	22.8%	402	0.3%	20,458	14.7%	27,931	20.0%	58,780	42.2%	139,387
2006–07	31,620	22.9%	418	0.3%	20,452	14.8%	28,582	20.7%	56,726	41.2%	137,798
2007–08	31,597	22.9%	403	0.3%	20,931	15.2%	29,602	21.5%	55,212	40.1%	137,745
2008–09	32,173	23.1%	399	0.3%	21,551	15.5%	30,738	22.1%	54,415	39.1%	139,276

Source: Montgomery County Public Schools, Department of Reporting and Regulatory Accountability, November 2, 2009.
Note: Montgomery County Public Schools uses a combined method for collecting and reporting racial/ethnic data.
All Hispanic students regardless of their race are included in Hispanic enrollment.

As a well-educated high-technology business community, Montgomery County invests a significant amount of funding in public education. Among the 24 Maryland school districts, Montgomery County has the second highest per-pupil expenditure. The Maryland State Department of Education Fact Book 2009-2010 (pp. 24-25) enumerates the Montgomery County cost per student at $14,969. Worcester County has the highest cost per student at $15,496 and Caroline County has the lowest per-pupil expenditure at $11,154. The average per-student expenditure across all 24 Maryland school districts is $13,013. In the most recent data reported by the U.S. Department of Education, the average cost per student across the United States in the 2006–2007 school year is $10,182 (Aud, et al., 2010, p. 279). By all measures, Montgomery County Public Schools is a well-funded school district.

The Maryland State Department of Education requires that students who earn a Maryland high school diploma complete 3 credits in mathematics with 1 credit required in algebra and 1 credit required in Geometry. The third credit may be satisfied by taking any course that is identified as a mathematics credit (Code of Maryland, 2011). In Montgomery County Public Schools, a fourth credit of mathematics is required to graduate. The school district instituted the graduation requirement for an additional credit in mathematics for students entering Grade 9 during the 1994–1995 school year (Montgomery County Public Schools, Regulation ISA-RA, p. 3). The additional required credit was added in an effort to strengthen students' mathematics knowledge upon graduation and better prepare them for postsecondary study.

Montgomery County Public Schools offers a number of high school mathematics courses, beginning with Algebra I through Advanced Placement Statistics and Calculus.

College math courses are also offered in some high schools. With the exception of Algebra I, on-level and honors courses are offered in Geometry, Algebra II, and Precalculus. Additional math courses include options such as Calculus with Applications, Statistics and Mathematical Modeling, and Quantitative Literacy. MCPS does not offer remedial courses in math; however, an Algebra I support course called Related Math is available to students who need additional time to master the Algebra I content. For English Language Learners, Mathematical Approach to Problem Solving is offered as an introductory mathematics course. Montgomery County Public Schools has a "no gate-keeping" policy for entry into honors and Advanced Placement courses. Students who have the motivation and persistence to enroll in and undertake the challenges of honors-level work, may elect to register for these courses.

Montgomery College, the state- and county-funded community college, offers a range of two-year degree and certificate programs to MCPS graduates and to local residents seeking postsecondary educational opportunities. With $10,000 contributions from both the state and the county, the Montgomery Junior College was established in 1946 in an effort to ensure that returning World War II veterans ascertained skills needed for a burgeoning job market. The college, located at Bethesda-Chevy Chase High School, began offering classes on September 16, 1947. Classes were offered on weeknights and Saturdays. As enrollment grew, campuses were opened in Takoma Park/Silver Spring in 1950 and in Rockville in 1965. The Montgomery County Board of Education served as the governing board of the Montgomery Junior College until 1969, when a Board of Trustees was established and the name was changed to Montgomery College. By 1970, the college employed 500 part- and full-time faculty and enrolled

8,000 students. In 1978, the Germantown campus opened, joining existing campuses in Takoma Park and in Rockville. Montgomery College experienced significant growth in the 1980s. By 1986, the faculty had grown to more than 900 and enrollment expanded to 18,000 students (Montgomery College, 2009).

Modern-day Montgomery College had its roots as a division within Montgomery County Public Schools, creating a unique relationship between the two institutions. In recognition of their exceptional relationship, the two institutions formed a partnership in 1999. With funding and support from the Montgomery County Council, the elected governing body of Montgomery County, Montgomery College and Montgomery County Public Schools established a plan to formally connect the Pre-kindergarten through Grade 12 educational programs of Montgomery County Public Schools with the postsecondary programs at Montgomery College. The partnership work included college and career planning, curricular alignment, literacy support for struggling students, collaboration in offering after-school enrichment programs, college planning workshops for parents, and college courses for high school students. The school district and the college also collaborated on the implementation of a Gateway to College program, designed to offer high school dropouts the opportunity to complete their high school credits on the community college campus and graduate with an associate's degree. This program, initiated in 2004 with start-up funding provided by the Bill and Melinda Gates Foundation, is a replication of the Portland Community College Gateway to College Program (Montgomery College, 2011).

The college experienced gradual growth from 2006 through 2010. In the fall of 2002, enrollment was 22,893 and by the fall of 2010, enrollment had grown to 26,015

(Student Enrollment Profile, Montgomery College, 2010, p. 2). There were 10,158 Montgomery County Public Schools graduates in June 2009. Of these graduates, 3,515 (34.6%) enrolled at Montgomery College in the fall of 2009 (Montgomery College, Student Enrollment Profile, 2010, p. 18). Only students enrolled in the 25 comprehensive high schools are included in the data set for this study which creates a difference between the actual number of Montgomery College enrollees in the fall of 2009 and the number of enrollees used in this study. Students enrolled in alternative programs or in external placements are not captured in the data.

At Montgomery College, the graduation and transfer rate is significantly higher for students who enter college ready. College ready is defined as students who enroll at Montgomery College who do not require developmental or remedial course work. During a four-year period (fall 2001 through fall 2004), the average graduation/transfer rate for students' classified as college ready was 61.8 percent. The mean graduation/transfer rate for students classified as developmental completers was 49.0 percent. Those students who did not complete their developmental course work, yet managed to graduate or transfer did so at an average rate of 28.5 percent (Montgomery College, Performance Accountability Report, 2009, p. 15). These data confirm that students who enter Montgomery College, and directly enter credit-bearing courses, are more likely to graduate with an associate's degree and transfer to a four-year institution than those students who are required to enroll in developmental courses.

Hoyt and Sorensen (2001) states, "There is a widespread need for remedial education at colleges and universities across the country, increasing costs to students and the public for education that students should have successfully completed in high school"

(p. 26). The 2009–2010 student expenditure for a remedial course at Montgomery College was $297.00. State and local funds underwrite the cost for those students who are enrolled in remedial courses. Reducing or eliminating the need for remedial mathematics courses will save students' money, taxpayer funding, and could potentially increase the graduation rate. To achieve progress, students must graduate from high school with increased mathematical skills and knowledge to ensure successful scores on the ACT, SAT, and Accuplacer exams.

The Purpose of the Study

The purpose of this study is to determine if the level of high school mathematics course attainment and final grades in mathematics courses are predictors of placement in developmental math courses. Race/ethnicity and socioeconomic status will be considered as variables. Montgomery College student cohort data will be analyzed and compared with high school course enrollment, final grade, demographic data, and feeder high school articulation information from Montgomery County Public Schools to determine what impact these factors have on the enrollment of students in developmental course work. If Montgomery County Public Schools and other school districts across the nation can reduce the number of students who require remediation, postsecondary graduation rates will increase and the cost of a college education will be reduced for individual students and for the community colleges and universities that offer remedial courses.

Research Questions

Annually, Montgomery County Public Schools sends between one-quarter and one-third of graduating seniors to Montgomery College. More than half of the enrollees need remedial mathematics instruction. Utilizing data from the 2009 MCPS graduating

class, this study will analyze high school course-taking patterns, student grades, and course enrollment demographics to answer the following questions:

1. To what extent does the enrollment in high school Geometry, Algebra II, Precalculus, or Calculus predict a student's enrollment in a developmental mathematics course?
2. Is the final course grade in Geometry, Algebra II, Precalculus, or Calculus a factor in determining enrollment in a developmental mathematics course?
3. Do demographic factors such as student race/ethnicity, Free and Reduced-priced Meals System identification, English Speakers of Other Languages status, and special education services predict student enrollment in developmental mathematics courses?
4. Are students' who graduated from some high schools more likely than students' who graduated from other high schools to be required to enroll in a developmental mathematics course? What are the patterns when data are disaggregated by race/ethnicity, Free and Reduced-priced Meals System, English Speakers of Other Languages status, and special education services?

Definition of Terms

Carnegie Unit: A time-based reference to secondary or postsecondary course work. In secondary schools, specifically in mathematics courses, one Carnegie unit represents a year of work in a given course usually representing approximately 120 hours of instruction.

Capstone Course: A culminating course, at the end of a sequence of courses, that allows a student to apply and demonstrate the accumulated knowledge acquired through the course pathway. Capstone courses are generally offered during the senior year of secondary or postsecondary study.

Developmental course: See remedial course (postsecondary).

English Speakers of Other Languages (ESOL): A designation for students whose primary language is not English and who require services to help them attain English, reading, writing, and listening skills.

Entrance exams: Externally administered and scored standardized assessments used by college admissions officers as a factor in college acceptance. Some college and universities use entrance exams to place students in remedial courses.

Free and Reduced-priced Meals System (FARMS): Breakfast and lunch program offered at schools by the federal government to income-eligible families. Qualified students receive free or reduced-price meals. Students identified with an Ever FARMS designation are not documented as FARMS students for data-gathering purposes; however, these students qualified and received free or reduced-price meals at some point during their enrollment in the Montgomery County Public Schools. In this study, FARMS is a proxy for low-socioeconomic status.

Placement tests: Assessments used by colleges and universities to determine college readiness and course placement. Placement tests are standardized, such as the College Board's Accuplacer assessment, or they are developed locally by a college or university. Montgomery College administers the Accuplacer to students who have not taken the SAT or the ACT.

Postsecondary remedial course: Courses provided in reading, writing, mathematics, or other subjects for college students who lack those skills necessary to perform college-level work at the level required by the attended institution; thus, what constitutes remedial courses varies from institution to institution (National Center for Educational Statistics, 2003, pp. iii-v). In this study, the terms remedial course and developmental course are used interchangeably.

Special Education Services: In order to meet specific learning needs, modifications are made to the curriculum, assessments, and instruction for identified students. Students who receive special education services are specifically identified by the school district through an established process and are provided with an Individualized Education Program. The Individualized Education Program documents the manner in which a student's instructional program will be modified.

Successful completion: For the purpose of this study, successful completion is defined as earning credit in a course with a grade of a C or higher. In most school districts, a student can earn a grade of "D" and attain credit for the course; however, a grade of C or

higher indicates that a student has ascertained enough content knowledge to be successful in subsequent courses.

Remedial education: Instruction for a student lacking the reading, writing, mathematics, or other skills necessary to perform college-level work at the level required by the attended institution (Snyder, et al., 2011 p. 685).

Organization of the Study

This study consists of five chapters. The first chapter provides an introduction to the problem and the rationale for the study. Chapter 2 consists of a literature review that analyzes related studies and explores research associated with the need for, and the implementation of postsecondary remedial mathematics instruction. Chapter 3 outlines the research design methodology employed for this study, including data collection, and the analysis procedures. Chapter 4 offers an analysis of the data and the study's findings, and chapter 5 reveals conclusions and implications and offers recommendations for further inquiry.

Significance of the Study

The high number of students exiting secondary education and enrolling in postsecondary remedial mathematics courses is a national issue. The data outlined in this chapter shows that the K–12 educational system is not adequately preparing students for college entrance exams and postsecondary level math instruction. This study is designed to contribute to the literature by identifying key factors that lead to students' success on mathematics entrance exams and placement tests, resulting in direct entry into college-level mathematics course work without the need for remediation. The key factors include

level of mathematics course attainment and grades in the courses. Students, no matter their race/ethnicity or socioeconomic background, who attain the specified level of course completion with a certain grade, are successful in entering postsecondary study without the need for developmental course work in mathematics. This study also analyzes the developmental course enrollment patterns at Montgomery College from the district's 25 high schools to determine if any patterns exist related to race/ethnicity and/or special services.

Limitations

The state of Maryland has played an important role, nationally in the study of postsecondary articulation data through reports such as the Student Outcome and Achievement Report (SOAR), produced by the Maryland Higher Education Commission. The SOAR data primarily centers on a statewide review of secondary and postsecondary data. This study focuses on a student cohort from one public school district and their articulation to the local community college. Enrollment data for students who enrolled at Montgomery College in the fall of 2009, are available for use in the study. The accessibility of a large number of student records, as well as the availability of an existing data set provided by Montgomery County Public Schools, will enhance and strengthen the reliability and validity of this study.

The researcher is an employee of Montgomery County Public Schools. There is the potential for bias in the research, findings, and recommendations. To guard against the potential for bias, and to ensure the accuracy of the data, the Montgomery College Office of Institutional Research and Analysis will furnish the developmental course enrollment data and the Montgomery County Public Schools Office of Shared

Accountability will review the data and provide official data for high school mathematics course enrollment as well as socioeconomic and race/ethnicity information. By utilizing this approach, the probability for errors in the data is reduced and there will be a review of the findings by Montgomery County Public Schools accountability office staff. The generalizability to other settings will safeguard against predispositions in the findings and recommendations.

CHAPTER 2

LITERATURE REVIEW

Remedial course work in college-level mathematics has been a national issue for decades. Despite a significant body of research on remedial course work, substantial numbers of students continue to enroll in these support courses as a condition of college admission. A large portion of the remedial course work research has focused on the students, courses, and faculty of community colleges. There has been less research on students' secondary school pathways to remedial course work. It is important to identify root causes regarding the need for remediation in order reduce the number of students enrolling in developmental courses.

This chapter provides a review of research on remedial and developmental course enrollment, high school requirements and course-taking patterns, student identification processes for enrollment in remedial and developmental courses, postsecondary retention of students enrolled in remedial and developmental courses, and the cost of postsecondary remediation for colleges, universities, as well as students.

Defining Remedial and Developmental Course Work

Provasnik and Planty (2008) states, "Remedial courses, usually in mathematics, English, or writing, provide instruction to shore up the basic fundamentals within the subject and to develop studying and social habits related to academic success" (p. 11). Roueche and Roueche (1999) defines remedial or developmental courses as specialized courses in reading, writing, and mathematics for students who lack certain critical skills

necessary for postsecondary study. Deli-Amen and Rosenbaum (2002) describes the interchangeable use of the terms remedial and developmental:

> The term remedial is rarely used in conversations between staff and students. Instead, the term developmental is usually used. This term accurately reflects the colleges' modes of instruction, yet students do not understand what the word really means. In this institutional context, the term developmental is merely a euphemism for remedial (p. 255).

Kozeracki (2002) states, "While 'remedial education' and 'developmental education' are often used interchangeably by the general public, and even by many scholars, those in the field draw distinctions between these terms and strongly prefer the use of 'developmental education'" (p. 83). The term "remedial" has a negative connotation and may unintentionally reinforce, in a student's mind, his or her inability to understand and master content taught in previous classes. Conversely, the term "developmental" suggests progress in learning or expansion of knowledge, thus reinforcing growth rather than deficits. Although there is merit and a rationale for use of the term "developmental," like much of the research and literature in this area of study, both terms are used interchangeably in this paper.

Under-preparation for Postsecondary Study

The National Center for Educational Statistics in Community Colleges, a supplement to The Conditions of Education 2008, includes a 2003–2004 survey of first-year college and university students. Table 3 displays the self-reported first-year college and university students' enrollment in remedial courses in the 2003–2004 academic year.

Table 3. Enrollment in Remedial Courses 2003–2004

Institution(s)	Percent Enrolled
Community Colleges All Remedial Courses	29
Four-Year Institutions All Remedial Courses	19
Community Colleges Mathematics Courses	22
Four-Year Institutions Mathematics Courses	15

Data Source: Community Colleges, *Special Supplement to The Conditions of Education 2008*

Approximately 29 percent of community college students reported taking remedial courses. The remedial course report rate for four-year institution enrollees was 19 percent. Survey participants reported that the highest remedial course enrollment rate from among mathematics, reading, and English was in mathematics. Fifteen percent of all surveyed students, both community college enrollees and four-year institution enrollees, reported taking remedial course work in mathematics. Twenty-two percent of Community College enrollees indicated that they had enrolled in at least one remedial mathematics course. The authors of the report cautioned that the report rate may be low, due to the narrowness of the survey's first-year student audience and the self-reporting structure of the survey (p. 11).

Curriculum and Courses

The 2011 Student Outcome and Achievement Report by the Maryland Higher Education Commission analyzes students who graduated from a Maryland high school during the 2007–2008 school year and then enrolled in a Maryland college or university in the 2008–2009 academic year. The Maryland Higher Education Commission defines a college-preparatory curriculum or "core" curriculum as 4 or more credits of English, 3 or more credits of mathematics, 3 or more credits of social sciences or history, two or more years of natural sciences, and two or more years of foreign languages. Students who do

not fulfill these minimum numbers of credits in the defined areas are considered to have completed a non-college-preparatory curriculum or "non-core" curriculum (Maryland Higher Education Commission, 2006, pp. 3-4). The specific courses within each content area were not defined in the study, only the number of credits that deemed a student a completer of the "core" or "non-core" curricula. Figure 1 displays the percentage of students who required postsecondary remediation in mathematics, as reported by the Maryland Student Outcome and Achievement Report for the 2008–2009 academic year.

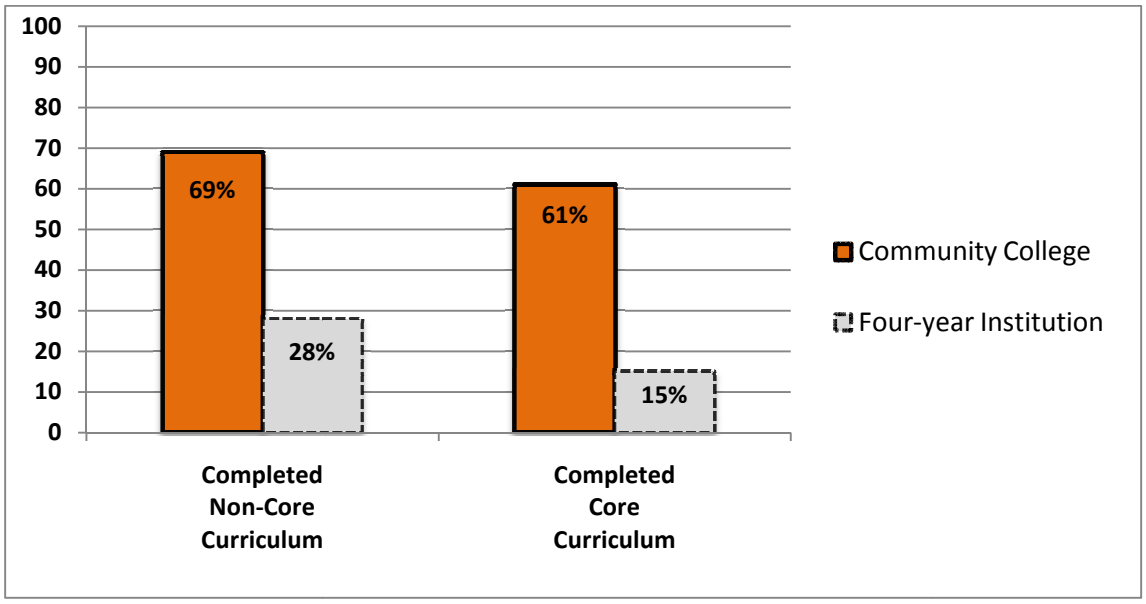

Figure 1. Percentage of Students in Maryland Requiring Remediation in Mathematics During the 2008–2009 Academic Year

Not only do these data show that students who complete the non-core curriculum are required to enroll in remedial courses at a much higher rate than their peers who complete the core curriculum, they also substantiate the elevated entrance requirements for four-year institutions and that a majority of the students who are college ready upon completion of high school attend four-year institutions.

The authors of Student Outcome and Achievement Report assert that there was a 23 percent increase in the community college mathematics remediation rates for high school core curriculum students and a 20 percent increase in remedial mathematics course work enrollment for non-core students between the 1997–1998 and 2008–2009 cohorts (p. 13). Consequently, the report asserts that the remediation rates for English and reading during the same period have been stable indicating a greater need for the identification of a solution to Pre-kindergarten through Grade 12 student preparation in mathematics. The continued growth in the number of students who require remediation in mathematics will result in future expansion of postsecondary developmental mathematics courses.

The Ohio Board of Regents (2005) reports, "forty-one percent of Ohio's recent high school graduates enrolling at Ohio public colleges or universities in the fall of 2003 took at least one remedial course in English or math during their first year of college" (p. 1). The mathematics remediation rate for students entering public colleges and universities in Ohio was 33 percent (p. 17). This study also compared the socioeconomic status of school systems in the state classifying the districts with significant numbers of low socioeconomic students as "low," those districts with a middle range of students impacted by poverty as "medium," and districts with the smallest number of low socioeconomic students as "high." Among public colleges and universities, researchers found the lowest rates of remedial course enrollment in school districts with the fewest students impacted by poverty. The remedial course enrollment rate was 53 percent for the "low" districts, 43 percent for the "medium" districts, and 34 percent for the "high"

districts (p. 17). Table 4 shows the Board of Regents classification of school district remedial course enrollment rates by socioeconomic status in the fall of 2003.

Table 4. Ohio Remedial Course Enrollment by Socioeconomic Status, Fall 2003

Institution(s)	Percent
Low-income Public School Districts	53
Medium-income Public School Districts	43
High-income Public School Districts	34

Data Source: *Making the Transition from High School to College in Ohio 2005: A Statewide Perspective*

Based on these findings, students attending schools in districts impacted by poverty are more likely to require postsecondary remediation than students who are in school districts with a majority of students in families in the middle and upper strati of family income.

In addition, the Ohio Board of Regents study examined the connection of high school course enrollment and college outcomes.

> Every outcome measure is better for students who take more rigorous courses in high school. Students attending Ohio colleges who have taken the complete core have average ACT scores of 24, first-term GPAs of 3.0, first-to-second year retention rates of 91 percent and remediation rates of 15 percent. Students taking the minimum core have average ACT scores of 22, first-term GPAs of 2.8, first-to-second year retention rates of 86 percent, and remediation rates of 35 percent. Students taking less than the minimum core have even worse results, with average ACT scores of 20, first-term GPAs of 2.5, first-to-second year retention rates of 77 percent and remediation rates of 53 percent (p. 20).

The researchers define the complete core as student enrollment in a minimum of three years of science, including biology, physics, and chemistry, and four years of English, mathematics, and social studies. The minimum core is defined as three years of mathematics, science, and social studies and four years of English (p. 14). This research indicates that course-taking patterns and grades in those courses may be a contributing factor in determining if a student requires remedial course work when entering postsecondary study.

The Ohio report defines the college-preparatory curriculum as a specific number of years taking courses in English, mathematics, science, and social students and offers data to support that completion of a specific number of course credits is more likely to ensure that students are completely college ready and do not require remediation. With the exception of science, the report does not provide information on which courses and/or content within a multi-year pathway must be taken to achieve college readiness. In addition, the report lacks specificity regarding capstone-level courses, for example Algebra II or Precalculus, which must be completed in a multi-year pathway to avoid enrollment in postsecondary remedial courses.

Grades and Placement Tests

Fong, Huang, and Goel (2008) examined the link between Nevada public high school students' mathematics course completion and the connection to the need for remedial mathematics enrollment in Nevada's public colleges and universities. In their study of 4,653 graduates from the class of 2006, they found that 37.6 percent enrolled in a developmental math course in their first year of college. In addition, students who retained higher grade point averages in their math courses and completed advanced math courses had lower rates of remediation. Interestingly, the authors point out that their research found that students who completed an "Advanced I" math course with a 4.0 grade point average as a senior in high school were less likely to require remediation than a student who completed an "Advanced II" math course as a senior with a 2.0 grade point average (p. iv). This finding suggests that course grades and mastery of content in lower-level courses may be a more important factor in student success than completing a more advanced course without complete mastery of the content. Fong, Huang, and Goel

(2008) notes that there are limitations to their research including the non-random sorting of students and the natural motivation of students who take advanced courses.

The findings in the Fong, Huang, and Goel study are consistent with those offered by other researchers. Hoyt (1999) as well as Hoyt and Sorensen (2001) found that students who completed advanced-level math courses while in high school achieved higher college math placement assessment scores resulting in lower rates of remedial course placement in studies of students attending Utah Valley State College. They recommend that public schools should review prerequisite requirements for math course pathways, raise grading standards among teachers to ensure consistency in the academic meaning of a grade, and foster an increased focus on teaching and learning to ensure that teachers have the content and pedagogical knowledge they need to successfully deliver curricula. As with other research in the area of course taking-patterns, these researchers suggest that faculty review grading and the multi-year course-taking patterns of students; however, they do not provide recommendations on the specific courses students must complete, or grades they must attain, to be college ready.

The Maryland Higher Education Commission (2009) reports that, of all the variables reviewed in the study, high school grade point average is the most reliable predictor of first-year college success. "With only one exception, high school grade point average has been the best predictor of all three measures of college performance (first college math grade, first college English grade, and college grade point average) in each of the 10 years" (p. 10). The authors further report that "in 9 out of 10 years, the average high school math grade variable has been a good predictor of students' performance in their first college math course" (p. 10). The data show that students' attending school

districts with significant numbers of students' in poverty and with large minority populations have lower grade point averages than students' enrolled in school districts with greater overall wealth and sizeable white and Asian American populations. During the 10-year period from 1997–1998 to 2006–2007, expectedly, Maryland public school non-core students received lower grade point averages than core students.

Boylan and Saxon (2001) surveyed community colleges and universities in Texas, for an evaluation of developmental education commissioned by the Texas Higher Education Coordinating Board. Although this study focuses on an evaluation of a standardized college placement test employed by Texas postsecondary institutions, there are data and findings applicable to the research for this paper. At the time of the survey, there were 75 community colleges in the state of Texas and 44 responded to the survey. Of the 44 responding institutions, 33 provided developmental course placement data (p. 2). Based on the responses, the researchers found a 61.8 percent development course placement rate in mathematics. The placement rate was significantly higher than the placement rates of 37.7 percent for reading, and 40.4 percent for English/Writing (p. 3). The authors conclude that "a large number of Texas high school graduates are either relatively unprepared or absolutely unprepared for college-level work" (p. 16). Based on their findings, Boylan and Saxon imply that there is a disconnect between student course grades in high school and low achievement on college entrance exams, suggesting the probability of grade inflation. Grades are a subjective form of measuring student achievement, thus inconsistency in grading practices could potentially lead to a misrepresentation of a student's content knowledge in a given subject area. However, if a school district provides all teachers with standardized end of unit assessments taken by

all students in a given course, as well as guidance on the grading of the assessments, the probability of grade inflation will be reduced. In the case of the Texas study, consistent unit and course assessments were not in place at the high school level. Student grades, and the impact of grades on the potential need for postsecondary remediation, are discussed in Chapters 4 and 5.

High School Requirements and Course-taking Patterns

The National Center for Educational Statistics reports that the average number of Carnegie units that high school students earned in mathematics increased from 1.9 to 3.1 between 1982 and 2004. During the same period, the percentage of high school graduates who completed one year of Geometry rose from 47 to 76 percent. In addition, the percentage of graduates who finished one semester or more of Algebra II improved from 40 to 67 percent, and there was a 22 percent increase in graduates earning a semester or more of credit in Precalculus rising from 6 to 28 percent, respectively (U.S. Department of Education NCES, 2007, pp. 7-9).

Maryland and National Perspective

In the state of Maryland, high school students are required to take Algebra I and Geometry to graduate from high school. A total of 3 math credits are required to earn a Maryland High School Diploma by the Maryland State Department of Education (Maryland State Department of Education, 2010). Montgomery County Public Schools has implemented a more rigorous standard and requires 4 math credits to earn a high school diploma based on their authority as a governing body (Montgomery County Public Schools Regulation, ISB-RA, p. 3). Due to the flexibility of students' course enrollment

options to complete the additional mathematics credits, some students enroll in Algebra II and higher mathematics courses and other students take courses such as Quantitative Literacy. For this reason, not all students take Algebra II, a course that prepares them for college entrance exams such as the ACT and SAT, college placement tests, including the Accuplacer, as well as the rigor of college-level course work. Research on Maryland high school students, national studies, as well as the examination of sub-sets of high school students reveals that students who do not take Algebra II are more likely to be required to enroll in developmental courses (Maryland Higher Education Commission, 2009; Duranczyk and Higbee, 2006; Adelman, 1999; Hoyt, 1999).

Mathematics graduation requirements and course pathways vary from school to school and district to district, not only in Maryland, but also in other states. Generally, course requirements in mathematics vary from 3 to 4 credits to earn a graduation diploma. In some districts, Algebra I is the on-grade-level mathematics course for grade 9, while in recent years, many school districts have made Algebra I the on-grade-level course for grade 8 (Cogan, Schmidt, Wiley, 2001, p. 324). Roth et al. (2001), in a research project implemented with Florida students states, "The explanation most commonly given by community college officials for the high failure rate on the Computerized Placement Test (CPT) is that students' course-taking choices in high school did not equip them with the skills needed to do college-level work" (p. 73).

Achieve, Inc., an organization formed in 1996 by the National Governors' Association and national business leaders in collaboration with 15 states, has created an Algebra II end-of-course assessment. The assessment is designed to measure a student's mastery of mathematics through Algebra II content (National Mathematics Advisory

Panel, 2008, p. 3-26). Achieve, Inc. has branded Algebra II as the "gateway" course to postsecondary study and identified three major purposes for the development of the assessment: to improve high school Algebra II curriculum and instruction, including consistency of content and rigor within and across the states; to serve as an indicator of readiness for first-year college credit-bearing courses; and to provide a common measure of student performance within and across the states over time (Achieve, 2010). The 15 participating states are in the process of piloting this assessment. It is possible that some states will adopt this assessment as a graduation requirement as a means to increase the number of mathematics courses required to graduate and to ensure the mathematics literacy of their students with the goal of reducing the number of students who require postsecondary developmental courses in mathematics.

Tracking

How students are placed or enroll in courses can take different forms, depending on the school district or local school policies. Spade, Columba, and Vanfossen (1997) defines tracking as "the placement of students in courses of similar levels across disciplines" (p. 109). Cogan, Schmidt, and Wiley (2001) states, "In the United States, 'tracking' typically refers to within-school curriculum differentiation that varies the curriculum from course to course" (p. 324). School districts and individual schools determine which courses are offered at each grade level. For example, a grade 11 student may have the opportunity to enroll in either Algebra II, Business Math, Consumer Math, or a statistics course. The choice of math, and the guidance and advice provided by teachers, counselors, and parents are important. Algebra II is part of the mathematics course pathway that leads to enrollment in Precalculus and Calculus courses. Enrollment

in Business Math or Consumer Math is not part of the course trajectory to college-level math. "Depending on the school and the size of the student enrollment, schools may decide to offer two, three, or more types of mathematics courses to as many different groups of students" (Cogan, Schmidt, and Wiley, 2001, p. 324). This array of course offerings, with some courses on a college-preparatory pathway and other courses available to ensure that students' only meet high school graduation requirements, leaves future college-going students vulnerable to the need for postsecondary remedial course work.

Spade, Columba, and Vanfossen (1997) found "that schools can influence the achievement of students, even when the social-class origins of the students they serve may not be conductive to achievement, by restructuring the patterning of classes and facilitating the placement of students in more challenging courses" (p. 125). The authors also found that advanced-level and honors courses on the college-preparatory pathway often "cover more material, in more depth, and with more assigned homework and laboratory work" than on-level or non-college-preparatory courses (p. 114). Spade, Columba, and Vanfossen (1997) concludes that "course-taking is the most powerful factor affecting student's achievement that is under the school's control" (p. 125). Although the research concludes that course taking patterns play a significant role in student outcomes, specific course attainment recommendations or conclusions in mathematics were not identified.

Advanced-course Completion

Roth, Crans, et al. (1997) studied 19,736 Florida high school transcripts to determine the effect of high school grades and course taking on passing college

placement exams. The researchers contend that community college staff report high school course taking as the most important factor in performance on a standardized computerized placement test (CPT) that was administered throughout the state. The authors found that, although "49 percent of the students who enrolled in Florida community college in the fall of 1994 had taken Algebra 2 in high school, those who did far exceeded the average Math CPT pass rate of 50 percent achieved that year by all test takers" (p. 80). In addition, the researchers found that students who completed the course with a grade of a "D," passed the entrance exam at a rate of 75 percent. Based on their research findings, Roth, Crans, et al. concluded that exposure to the more challenging content of Algebra II was more important than the grades students' received in the course.

Adelman (1999) completed a longitudinal study initiated with a group of 10th graders in 1980, following their education progress through 1993. As a result of his research, the author asserts that socioeconomic status does have an impact on "life-course events"; however, a high-quality and rigorous education provides students with the opportunity to overcome the negative effects of poverty (p. 83). Adelman compares the influence of curriculum, test scores and class rank/GPA on bachelor's degree completion rates and found that, among his research cohort, those students who took the college-preparatory pathway, including Algebra II or beyond, had higher bachelor's degree completion rates than students who were in the highest 40 percent of the standardized test scorers or class rank/GPA in the cohort (p. 85). Adelman repeated his research study, reporting his findings in The Toolbox Revisited (2006). With a different cohort of students, Adelman replicated his 1999 study. His data and findings aligned with the 1999

report and reaffirmed the initial conclusion that a rigorous high school curriculum is the most predictive element of bachelor's degree attainment. Adelman claims that course enrollment and exposure to a rigorous curriculum are more predictive of bachelor's degree attainment than test scores or class rank/GPA and found that this was true across all racial and ethnic groups.

Adelman's conclusion regarding bachelor's degree attainment is consistent with the research on course-level completion and the need, or lack of need, for postsecondary remedial course work. His findings indicate that the level of rigorous course work completed in high school matters, but also states that GPA and class rank are less predictive of postsecondary success. Adelman's research specifically points to Algebra II as a key level of mathematics completion for students to finish a bachelor's degree. This claim aligns with other research highlighted in this paper related to mastery of specific levels of content and course work; however, Adelman goes beyond other research and specifically names Algebra II as a course students should complete in order to be successful at the postsecondary level. In addition, Adelman's findings go beyond the other research related to postsecondary success by stating that race/ethnicity and socioeconomic status were not factors for students successfully completing advanced-level course work in high school.

Sawyer (2008) studied actions that school districts could take to improve the college readiness of high school students. Sawyer found that enrollment in advanced courses and producing higher grades would "modestly" increase student preparation for postsecondary credit-bearing course work (p. 57). The author notes that grading, teacher

expectations, and curricula can differ from district to district, differentiating the levels of impact advanced courses have on a student's preparation.

Defining the Trajectory

Most school districts have not clearly defined which course students need to complete to be successful in college. Rosenbaum 2001 states, "High schools offer vague promises of open opportunity for college without specifying the requirements for degree completion" (p. 56). He further states,

> Failure in community college may stem not from any overt barrier in those institutions but from seeds planted much earlier—when youths are still in high school. Because students do not usually realize that their expectations were mistaken until long after they have left high school, high schools are rarely blamed for their graduates' failures in community college (p. 56).

High school staff have a responsibility to specify the trajectory to college success and clearly articulate the pathway to students and parents. This trajectory includes completing particular levels of courses and attaining certain grades in order to ensure a reliable level of preparedness for postsecondary study. The paradigm of college-for-all dissuades high schools from identifying clear course pathways for their students. "So as not to discourage students, the college-for-all norm avoids focusing on requirements, but in the process it fails to tell students what steps they should take to be successful in college, and it does not warn them when their low achievements make their college plans unlikely to be attained" (Rosenbaum 2001, p. 57). In order to reduce the number of students entering developmental courses and increase graduation rates, it is incumbent upon school districts to identify the highest level of mathematics courses required, and the minimum grade in those courses, to ensure entry into college-level mathematics without remediation.

Postsecondary Enrollment Requirements and Remedial Course Criteria

Community colleges have been given major responsibility in the developmental education of students who have not mastered key content that would allow them to enroll in credit bearing mathematics courses upon entry into postsecondary study. Over time, open admissions policies, increased enrollment by minority and non-traditional students at community colleges, and increased entrance standards by four-year institutions, have reduced the number of four-year institutions offering remedial course work (Provasnik & Planty, 2008, p. 11). The authors of Condition of Education (2004) contend that remedial course enrollment at two-year public postsecondary institutions is significantly higher than at four-year institutions. "Postsecondary transcripts of 1992 12th-graders who enrolled in postsecondary education between 1992 and 2000 show that 61 percent of students who first attended a public 2-year and 25 percent who first attend a 4-year institution complete at least one remedial course at the postsecondary level" (p. 63). Ignash (1997) states, "Because community colleges are more accessible to students in terms of cost, location, and admissions policies, they will always provide more remediation than four-year institutions" (p. 15). Community colleges also have an extensive breadth of offerings, which make them attractive to many students. Ignash asserts that community colleges have more support staff and faculty capable of teaching reading, which places them in a more favorable position than four-year institutions to support students requiring remediation.

The Maryland Higher Education Commission (2009) states, "Policies regarding the identification and placement of remedial students at Maryland community colleges was standardized in fall 1998" (p. I-4). Since that time, community colleges have used

uniform assessments and cut-scores to place students in developmental courses. For example, all community colleges in Maryland use an SAT math cut score of 550 as the minimum score to avoid enrollment in developmental math. The cut score for ACT is 24 and the Accuplacer mathematics cut score is 75. This uniform approach not only provides consistent student enrollment criteria across the state, it also ensures a standardized method for tracking and monitoring enrollment in developmental courses at each community college. Unlike the placement policies of two-year colleges in Maryland, practices regarding placement in remedial courses at public four-year institutions vary significantly, and there is no uniform assessment used in the placement of students into developmental courses.

The University System of Maryland, which includes all state-funded and governed colleges and universities, has raised the bar for the state-wide student admissions process. The mathematics admission requirements have been amplified to go beyond the previous standard of Algebra I and Geometry to include Algebra II. The requirement also asserts that students who successfully complete Algebra II before their senior year in high school must enroll in, and complete, additional mathematics courses that include "non-trivial" algebra. The "non-trivial" algebra courses include Trigonometry, Precalculus, Calculus and courses that include content beyond Calculus. Maryland high school graduation requirements currently obligate students to complete 3 credits of mathematics, including algebra and Geometry. Although students must take 1 additional credit in mathematics, there is no specifically required content beyond Geometry. The goal of the University System of Maryland is to ensure that students continue to build their mathematics knowledge and skills to prepare for college-level

mathematics throughout their high school career and do not enroll in courses that are non-college-preparatory if they plan to attend a state four-year public college or university. This requirement will first impact students who graduate from high school in 2015 (University of Maryland Board of Regents, 2009).

Postsecondary Retention

The Condition of Education (2004) reports that students enrolled in remedial courses are less inclined to earn a degree or certificate.

> Despite assistance offered through remediation, students enrolled in remediation are less likely to earn a degree or certificate. Regardless of the combination of remedial coursework, students who completed any remedial courses were less likely to earn a degree or certificate than students who had no remediation (p. 63).

The amount of time spent in remedial courses and the non-credit-bearing characteristics of those courses may serve as contributing factors to the lack of degree attainment among remedial course enrollees. "Among institutions that offered remedial courses, 63 percent of public 2-year institutions reported that their students averaged a year or more of remedial course taking, compared with 38 percent of public 4-year institutions" (U.S. Department of Education NCES, 2004, p. 84). The Condition of Education 2004 maintains that postsecondary institutions reported an increase in the percentage of students participating in a year or more of remediation between 1995 and 2000 from 33 to 40 percent, respectively. In addition, approximately 76 percent of remedial courses were non-credit-bearing among institutions that offered remedial courses in the fall of 2000. Specifically, 77 percent of remedial courses in mathematics did not provide college credit to participating students (p. 84).

Adelman (1999) asserts that participation in remedial course work has an impact on bachelor's degree attainment among students who attended four-year institutions. He found that, of the students who participated in remedial reading, 39.3 percent earned a bachelor's degree. Forty-seven percent of those students who took no remedial reading but enrolled in two other remedial courses earned a bachelor's degree, and 68.9 percent of students who took no remedial course work earned a four-year degree (p. 74). The author concludes that students who enter college with a low degree of academic preparation do not earn postsecondary degrees.

Hoyt (1999) studied the relationship between remediation rates and community college retention. Hoyt concluded that two-thirds of students who required developmental course work in multiple areas dropped out and remedial course participants had lower grade point averages than their non-remedial course peers. Hoyt extrapolates from his findings that "a lack of preparation for college substantially reduces a student's chances of college success by decreasing his or her ability to perform academically" (p. 61).

Through staff and student interviews, Deil-Amen and Rosenbaum (2002) studied remedial education at two community colleges. They found that "Students often go for several months, a full semester, or even a full year without knowing that their remedial courses are not counting toward a degree or their transfer goals" (p. 260). The authors point out that students' lack of a clear understanding vis-à-vis the purpose of remedial courses, and the "delayed recognition" in earning credits toward a degree, "may be contributing to students dropping out of college altogether and hence accumulating no credentials rather than a lesser degree" (p. 264).

The Cost of Remediation

The cost of college remediation must also be considered as a motivating factor in the goal of significantly reducing student remediation not only in math, but in all areas. At Montgomery College, a two-year community college, students who require developmental course work enroll in a non-credit-bearing course with an assessed fee of $297.00. The University of Maryland College Park, a four-year state institution, assesses a "special fee" of $280.00 for students who require developmental course work. The fee pays for a support class that is taken concurrently with the freshman-level mathematics course. Breneman and Haarlow (1998) states,

> The additional financial data we have gathered do not alter the earlier estimate that remedial education costs the nation's public colleges and universities about $1 billion annually—roughly one percent of the institution's current fund revenues of $115 billion. It is important to note that this figure includes not only the costs associated with remediation for traditional age freshmen, but also costs associated with remedial education for returning adult students (p. 2).

Breneman and Haarlow note that this estimate does not include data from private institutions. Merisotis and Phipps (2000) claims that the cost of remediation is underreported, primarily due to "the perceived damage to the 'reputation' of a college or university." They estimate remediation costs at closer to $2 billion (p. 77). The economic impact of college remediation goes beyond the cost of the tuition. A delayed college graduation due to the need for remediation, or dropping out due to the inability to accumulate college credits results in lost wages, reduced income tax collection, and the potential for lower lifetime annual income (Breneman & Haarlow, 1998, p. 2).

Conclusion

Despite decades of significant postsecondary student enrollment in remedial courses, and research that has attempted to find solutions to this educational conundrum,

the United States educational system has not found an approach to appreciably improve the college readiness of high school students. In fact, this researcher would argue that, based on the data assembled in this literature review, the number of students requiring postsecondary remediation in mathematics is gradually rising. If the United States is to maintain an educational edge and financial security in an increasingly global economy, we must unlock the key to ensuring that all students have the educational foundation to enter postsecondary institutions with the knowledge and skills needed to enroll directly into credit-bearing courses.

The research studies analyzed for this paper confirm that mathematics remedial course enrollment for two- and four-year institutions range from 19 to 69 percent (Maryland Higher Education Commission, 2011, p. 13). A number of the studies indicate that the percentage of students who enroll in remedial courses is increasing. This increase may be caused in part by an expansion in the number of students attending college. Many researchers point to the lack of student preparation as a key factor in students' college preparation. Students who attain certain academic skills in their elementary and secondary school years are not required to enroll in remedial courses. Those students who are forced to enroll in developmental course work earn fewer credits in their freshman year, tend to have lower college GPAs, and are less likely to graduate with a four-year degree. This trend appears to be exacerbated for those students who take more remedial courses. Moreover, the opportunity cost as well as the fiscal expenditure for students who require remediation also leads to lower postsecondary graduation rates.

Educating high school students and their parents on the importance of attaining a certain level of mathematics with satisfactory grades is a key to reducing the number of

students enrolling in postsecondary remedial courses. It is essential that high schools and colleges work together to identify key milestones that students must reach in order to decrease their chances of requiring remedial course work. Deil-Amen and Rosenbaum 2002 states, "Colleges must manage information if feeder institutions allow students to have unrealistic college plans and do not provide key information about the demands of college." The authors further assert that "these practices may provide the conditions for students' misperceptions about their position within the structure of higher education and their prospect for success" (p. 250). The responsibility for ensuring that students' understand how their high school academic plan will impact their ability to succeed in college should not fall solely to postsecondary institutions. If we as a society are to improve postsecondary graduation rates, Prekindergarten through Grade 12 institutions must take a substantial role in providing the educational guidance and academic supports to make certain students participate in the secondary math courses essential to direct enrollment into postsecondary credit-bearing courses. "In four-year colleges, the graduation rate for students who took remedial course work was about two thirds of the graduation rate of students who took no remediation. As was the case for two-year college students, these lower graduation rates faced by students in four-year colleges predominately reflected skill problems students brought from high school, rather than a negative consequence of taking remedial courses" (Attewell, et. al, 2006, p. 916).

"It is evident that a piece-meal approach to addressing the problem of remediation in higher education has not worked. Intermittent schemes to 'correct' remedial education are stop-gap solutions at best. Only a systemic design at the state level comprised of a set of interrelated strategies will succeed" (Merisotis and Phipps, 2000, p. 80). The

University Maryland System has taken a first step to creating a state-level systematic approach to raise the bar for mathematics education at the Prekindergarten through Grade 12 levels. As a result, public and private Prekindergarten through Grade 12 institutions will need to identify strategies to increase enrollment in higher level math courses and, at the same time, ensure that students are successfully completing the courses. One state-level strategy is to increase the number of mathematics courses required for graduation, thus forcing students to take additional mathematics courses. However, if the course pathway a student selects does not contain "rigorous" content, or the student does not successfully master the content there by increasing the mathematical knowledge needed for college-level mathematics study, enrollment in remedial courses is a probable result.

The research found and utilized in this literature review show that large numbers of students are not prepared to complete and pass credit-bearing college-level math courses upon completion of high school. Through additional study of mathematics course attainment and course grades, this study will identify key strategies designed to assist school districts as they work to reduce the number of students who require postsecondary remediation in mathematics.

CHAPTER 3

RESEARCH METHODOLOGY

The purpose of this study is to examine what factors (level of high school mathematics course attainment, final grades in mathematics courses, and demographic variables) are predictors of placement in developmental mathematics courses at Montgomery College. Each year, between one-quarter and one-third of the seniors graduating from Montgomery County Public Schools enroll at Montgomery College and more than half of the enrollees require remedial mathematics instruction. Using data from the fall 2009 Montgomery College freshman class, this study will analyze high school mathematics course-taking patterns, student grades, and course enrollment demographic variables to answer the following questions:

1. To what extent does the enrollment in high school Geometry, Algebra II, Precalculus, or Calculus predict a student's enrollment in a developmental mathematics course?
2. Is the final course grade in Geometry, Algebra II, Precalculus, or Calculus a factor in determining enrollment in a developmental mathematics course?
3. Do demographic factors such as student race/ethnicity, Free and Reduced-priced Meals System identification, English Speakers of Other Languages status, and special education services predict student enrollment in developmental mathematics courses?

4. Are students' who graduated from some high schools more likely than students' who graduated from other high schools to be required to enroll in a developmental mathematics course? What are the patterns when data are disaggregated by race/ethnicity, Free and Reduced-priced Meals System, English Speakers of Other Languages status, and special education services?

Data Source

This research study is a secondary analysis of data provided by Montgomery College and Montgomery County Public Schools. Through a 2009 Memorandum of Understanding between Montgomery College and Montgomery County Public Schools, enrollment and performance data is shared between the two institutions. Montgomery County Public Schools receives data on developmental mathematics course enrollment and student performance in the developmental courses from Montgomery College.

Staff from the Montgomery County Public Schools Office of Shared Accountability, the research unit for Montgomery County Public Schools, aggregated the fall 2009 Montgomery College cohort data with the students' high school course enrollment, grade, race/ethnicity, Free and Reduced-priced Meals System identification, English Speakers of Other Languages status, special education services, and high school articulation information to provide a data set for this research project. The data source from Montgomery County Public Schools is student demographic data, student transcript data, and course history electronic files. The data source from Montgomery College is mathematics developmental course enrollment records on students who graduated from Montgomery County Public Schools in the summer of 2009 and enrolled at Montgomery

College in the fall of 2009. No student names are accessible to this researcher. All individual student data will be sorted and studied using unique student identification numbers assigned to each student by Montgomery County Public Schools.

Study Population

The students in this study are 2009 Montgomery County Public Schools high school graduates. Montgomery County Public Schools graduated 10,158 students in the class of 2009. This study analyzes the 2,821 graduates from 25 high schools who enrolled at Montgomery College in the 2009–2010 academic year. Of the 2,821 graduates enrolled at Montgomery College, 1,014 (35.9%) of students were not enrolled in a developmental mathematics course and 1,807 students (64.1%) required developmental mathematics (MC Data, 2009). All students who enter Montgomery College without taking the SAT or achieving a score less than 550 on the mathematics section of the SAT are required to take the Accuplacer, a computer-adapted college placement test produced by the College Board. A student's score on the Accuplacer is designed to ascertain college readiness and, at Montgomery College, the Accuplacer is administered to determine whether or not a student should be placed in a developmental mathematics course. Students who earn a score of 550 or higher on the mathematics section of the SAT are not required to take the Accuplacer or a developmental mathematics course.

This study will examine the 1,014 students enrolled in the 2009–2010 freshman class at Montgomery College who did not require developmental course work and the 1,807 students who were required to enroll in developmental mathematics. Students' race/ethnicity, socioeconomic status as indicated by participation in Free and Reduced-

priced Meals System, English Speakers of Other Languages status, and special education services designations are based on Montgomery County Public School records, as reported as a senior (Grade 12). Table 5 displays the race/ethnicity of the 2009 Montgomery County Public Schools cohort graduates who attended Montgomery College, in 2009–2010.

Table 5. 2009 Cohort Graduates Who Attended Montgomery College, by Race/Ethnicity

Student Groups by Race/Ethnicity*	Number of MCPS Graduates	Did Not Require Development Mathematics		Required Developmental Mathematics	
		Number	Percent	Number	Percent
Asian American	421	196	46.6	225	53.4
African American	651	215	33.0	436	67.0
White	940	356	37.9	584	62.1
Hispanic	800	246	30.7	554	69.3
TOTAL	2821	1014	35.9	1807	64.1

*American Indian students are included with all students but not reported separately due to small group size

Table 6 shows the Montgomery County Public Schools cohort graduates who attended Montgomery College in 2009–2010 by participation in Free and Reduced-priced Meals System, English Speakers of Other Languages status, and special education services. Table 6 lists the 2009 Montgomery County Public School cohort graduates by special populations attending Montgomery College in 2009–2010. Table 6 does not include a total since some students are counted in more than one special population category.

Table 6. 2009 Cohort Graduates Who Attended Montgomery College, by Special Population

Student Groups by Special Population	Number of MCPS Graduates	Did Not Require Development Mathematics		Required Developmental Mathematics	
		Number	Percent	Number	Percent
FARMS	711	282	39.7	429	60.3
ESOL	156	115	73.7	41	26.3
Special Education	287	111	38.7	176	61.3

Variables Used in the Study

This study involves the analysis of factors that could predict placement in developmental mathematics courses at Montgomery College. Predicting factors include level of high school mathematics course attainment, final grades in mathematics courses, and several student demographic variables. The variables were selected from among data collected and maintained by Montgomery County Public Schools and Montgomery College for students who graduated from Montgomery County Public Schools in 2009 and enrolled at Montgomery College in the 2009–2010 academic year. Table 7 displays the dependent variable and a description and Table 8 lists the independent variables and corresponding descriptions.

Table 7. Dependent Variable and Description

Variable	**Description**
Enrollment in Developmental Mathematics	A binary variable produced by Montgomery College: 1 = students required to enroll in a developmental mathematics course 0 = students not required to enroll in a developmental mathematics course

Table 8. Independent Variables and Descriptions

Variable	Description
Asian American	A binary variable indicating if a student is Asian American*: 1 = Asian American 0 = not Asian American
African American	A binary variable indicating if a student is African American*: 1 = African American 0 = not African American
Hispanic	A binary variable indicating if a student is Hispanic*: 1 = Hispanic 0 = not Hispanic
Free and Reduced-priced Meals System (FARMS)	A binary variable indicating if a student was FARMS at the time of graduation from Montgomery County Public Schools^: 1 = classified as FARMS 0 = classified as not FARMS or prior FARMS
Special Education (SPED)	A binary variable indicating if a student was SPED at the time of graduation from Montgomery County Public Schools: 1 = classified as SPED 0 = classified as not SPED or prior SPED
English Speakers of Other Languages (ESOL)	A binary variable indicating if a student was ESOL at the time of graduation from Montgomery County Public Schools: 1 = classified as ESOL 0 = classified as not ESOL or prior ESOL

Table 8. Independent Variables and Descriptions (continued)

Variable	Description
Enrollment in Geometry	A binary variable created using the course history of a student: 1 = student enrolled in Geometry 0 = student did not enroll in Geometry
Enrollment in Algebra II	A binary variable created using the course history of a student: 1 = student enrolled in Algebra II 0 = student did not enroll in Algebra II
Enrollment in Precalculus	A binary variable created using the course history of a student: 1 = student enrolled in Precalculus 0 = student did not enroll in Precalculus
Enrollment in Calculus	A binary variable created using the course history of a student: 1 = student enrolled in Calculus 0 = student did not enroll in Calculus
Successful Completion of Geometry	A binary variable created using the course history of a student†: 1 = student enrolled and completed with a grade of C or higher 0 = student enrolled with a grade of D
Successful Completion of Algebra II	A binary variable created using student transcript data: 1 = Grade of C or higher 0 = Grade of D or E
Successful Completion of Precalculus	A binary variable created using student transcript data: 1 = Grade of C or higher 0 = Grade of D or E
Successful Completion of Calculus	A binary variable created using student transcript data: 1 = Grade of C or higher 0 = Grade of D or E

*White reference group
^FARMS is used as a proxy for socioeconomic status in this study
†Enrollment in Geometry is required to earn a diploma from the state of Maryland

For the purposes of this study, the final grade of C or higher variable represents mastery of the content contained in the course. If a student earns a final grade of D, the student is considered to have passed the course, but has not mastered the content. If a student receives a final grade of E, the student did not pass the course.

Data Analysis

Montgomery College freshman class student cohort data will be analyzed and compared with high school course enrollment; final grade, demographic data, Free and Reduced-priced Meals System status, English Speakers of Other Languages designation, special education services, and feeder high school articulation information from the 25 high schools with graduates in 2009 to determine the impact that those factors have on the enrollment of students in developmental course work. Only students enrolled in the 25 comprehensive high schools are included in the data set. Students enrolled in alternative programs or in external placements are not captured in the data. As a result, the overall number of students shown to enroll at Montgomery College in the fall of 2009 is lower than the actual enrollment number of Montgomery County Public School graduates who enrolled.

A quantitative analysis of the data set will be completed using a logistic regression for questions one, two, and three, and descriptive analyses employed for question four. Logistic regression is used when the outcome is dichotomous (Wright, 1995, p. 217). In this study, the outcome variable is a dichotomous variable and is based on whether a student is enrolled or not enrolled in developmental mathematics. The use of logistic regression models offers the opportunity to study the relationship between a binary dependent variable “enrolled” in developmental mathematics and “not enrolled” in

developmental mathematics and the combined effects of the independent variables that impact the enrollment of students in developmental mathematics courses (Tabachnick & Fidell, 2001, pp. 546-547). The logistic regression analysis will hold constant a number of controls and predictors, while determining the relationships among different groups of students. A logistic regression model will be run for each independent variable providing a measure of the relationship between and among one or more independent variables with the binary dependent variable of "required developmental mathematics" or "did not require developmental mathematics".

The logistic regression analyses results will be reported by percent change, a conversion from odds ratio (OR) to assist with interpretation (Wright, 1995, p. 223). The magnitude of the relationships is provided by the effect size. The interpretation of effect sizes (ES) are based on the Cohen's d (Cohen, 1988): large (d = 0.8), modest (d = 0.5), and small (d = 0.2). If the odds of an outcome are increased, the predictor has a positive effect. If the odds of an outcome are decreased, the predictor has a negative effect. For example, if a group of students have all completed a specified level of math, and they are not enrolled in developmental mathematics, the specified level of mathematics may be a predictor or a positive outcome. Each independent variable will be measured and will contribute to the model. The importance of the variable as a predictor will be measured by how high or how low the value.

Following the completion of the logistic regression analyses for questions one, two, and three, the study will employ descriptive analyses for research question four. Taking the findings from the first three research questions an additional step, the study will place the conclusions in the context of the 25 Montgomery County high schools to

determine if students who graduated from some high schools are more likely to be required to enroll in a developmental mathematics course than students who graduated from other high schools. The data will be analyzed through the lens of race/ethnicity, Free and Reduced-priced Meals System, English Speakers of Other Languages status, and special education services. These findings will provide a hypothesis and context for whether or not student preparation in mathematics is a countywide issue, or if certain specific schools are struggling to prepare students for the rigor of college-level mathematics course work.

Finally, a survey sent to all high school principals in the district will provide additional information and context for the overall study findings. The principals will be asked to anonymously categorize themselves based on the percentage of Free and Reduced-priced Meal students enrolled in their school. Selecting from among several pre-identified categories, the principals will also be asked to identify their belief regarding the primary factor contributing to individual student enrollment in developmental mathematics courses. The final question asks each respondent to recommend actions schools and/or school districts should take to reduce the number of students required to enroll in developmental mathematics courses at the postsecondary level. Preselected areas of focus are provided as well as an opportunity for respondents to list their own area of recommended focus.

CHAPTER 4

DATA ANALYSIS

This chapter will focus on a secondary analysis of mathematics data of the 2009 Montgomery County Public Schools graduates who attended Montgomery College. The purpose of this study is to examine what factors (level of high school mathematics course attainment, final grades in mathematics courses, and demographic variables) are predictors of placement in developmental mathematics courses at Montgomery College. A survey of high school principals is descriptively analyzed to identify their beliefs regarding the need for student enrollment in developmental mathematics as well as their recommendations for areas of focus in order to strengthen mathematics teaching and learning. SPSS was utilized to employ a logistical regression analysis of the data. The chapter is organized by research question.

Research Question 1

To what extent does the enrollment in high school Geometry, Algebra II, Precalculus, or Calculus predict a student's enrollment in a developmental mathematics course?

In order to earn a Maryland high school diploma, students are required to enroll in and earn credit in algebra and Geometry. Both Algebra I and Geometry are full-year courses that carry 1 high school credit. Montgomery County Public Schools requires students to complete 4 credits of mathematics, which includes the two state-mandated courses. Although there is a generally accepted pathway beyond Geometry of Algebra II and Precalculus, there are students who take other mathematics courses that are

considered less "rigorous" to fulfill their mathematics graduations requirement. This study focuses on the postsecondary pathway of Algebra II, Precalculus, and Calculus.

The logistic regression for the first research question used the variables of enrollment in Geometry, Algebra II, Precalculus, and Calculus or a higher-level course. Each variable was coded "1" if the student was enrolled in the course and "0" if the student was not enrolled in the course. Table 9 displays the results of the statistical analysis.

Table 9. Statistical Analysis of Enrollment in High School Mathematics Courses

Course	B	S.E.	Wald	df	Sig.	Odds Ratio (OR)	% change in Odds[a]	ES[b]
Geometry	.239	.261	.840	1	.360	1.270	26.98	0.13
Algebra II	.249	.099	6.266	1	.012	1.282	28.21	0.14
PreCalculus	-.225	.095	5.540	1	.019	.799	-20.11	-0.12
Calculus +	-1.453	.132	121.363	1	.000	.234	-76.62	-0.80
Constant	.460	.266	2.998	1	.083	1.585		

+This analysis includes students enrolled in Calculus and courses beyond Calculus

[a]OR in Percentage = (OR -1) *100 (Chan, 2004)

[b]The formula below puts effect sizes, Cohen's *d*, and the odds ratio on a common metric (Kline, 2004)

$$\text{logit } d = \frac{\ln\left(Exp(B)\right)}{\pi/\sqrt{3}}$$

The variables that have the most significant relationship to non-enrollment in developmental mathematics are enrollment in Precalculus (b=-.225) and Calculus or higher courses (b=-1.453). The percent Odds ratio indicates students enrolled in a Precalculus course during high school are 20 percent less likely to require enrollment in a developmental mathematics course at Montgomery College. Even though Precalculus is statistically significant, it does not have practical significance because the effect size is small (d=-0.12). The prediction strength for non-enrollment in developmental course

work is significantly stronger for those students who enrolled in calculus courses or courses beyond Calculus. The percent Odds ratio shows that students enrolled in Calculus or courses beyond Calculus are 77 times less likely to require enrollment in developmental mathematics. The effect size (d=-0.80) illustrates that the magnitude of the relationship is large.

The analysis of the high school mathematics course enrollment data for the 2009 graduating cohort shows that course enrollment in high school is a predictor of postsecondary developmental mathematics course enrollment. Those students who enroll in courses beyond Algebra II are less likely to require enrollment in developmental mathematics and significantly less likely to require remediation if they enroll in a Calculus course or courses beyond calculus. When the course variables of Geometry, Algebra II, Precalculus, and Calculus or above are included in the logistical regression model, only enrollment in Precalculus and Calculus or above are significant.

Research Question 2

Is the final course grade in Geometry, Algebra II, Precalculus, or Calculus a factor in determining enrollment in a developmental mathematics course?

The logistic regression for the second research question used the variables of successful completion of Geometry, Algebra II, Precalculus, and Calculus or a higher-level course. For the purposes of this research, successful completion is defined as a course grade of C or higher. Each variable was coded “1” if the student was enrolled in and completed the course with a grade of C or higher and “0” if the student was enrolled

and completed the course with a grade of D or lower. Table 10 displays the results of the statistical analysis.

Table 10. Statistical Analysis of Final Grade of C or Higher in High School Mathematics Courses

Course	B	S.E.	Wald	df	Sig.	Odds Ratio (OR)	% change in Odds	ES
Geometry	-.147	.089	2.704	1	.100	.864	-13.65	-0.08
Algebra II	-.093	.094	.986	1	.320	.911	-8.90	-0.05
PreCalculus	-.262	.101	6.775	1	.009	.769	-23.07	-0.14
Calculus +	-1.373	.154	79.749	1	.000	.253	-74.66	-0.76
Constant	.904	.066	188.503	1	.000	2.471		

+This analysis includes students enrolled in Calculus and courses beyond Calculus

The variables that have the most significant relationship to a final course grade of C or higher in developmental mathematics are Precalculus (b=-.262) and Calculus or higher courses (b=-1.373). For students who earn a grade of C or higher in Precalculus, the percent Odds ratio of -23.07 indicates those students are 23 percent less likely to require enrollment in a developmental mathematics course. The effect size (d=-0.14) for Precalculus is small and does not have practical significance. The prediction strength of non-enrollment in developmental course work by earning a final course grade of C or higher is statistically significant for those students who enroll in Calculus courses or courses beyond Calculus. The percent Odds ratio shows that students who earn a final grade of a C or higher in Calculus or courses beyond Calculus are 75 times less likely to require enrollment in developmental mathematics. The effect size (d=-0.76) is large and exemplifies the relationship of course grades and the lack of need for postsecondary mathematics remediation.

The secondary analysis of course enrollment and successful completion defined as a grade of C or higher shows that successful completion of Precalculus or Calculus with a final grade of C or higher is a predictor of postsecondary developmental mathematics course enrollment. Those students who successfully completed courses beyond Algebra II are less likely to require enrollment in developmental mathematics.

Research Question 3

Do demographic factors such as student race/ethnicity, Free and Reduced-priced Meals System identification, English Speakers of Other Languages status, and special education services predict student enrollment in developmental mathematics courses.

In the research reviewed for this project, some of the studies included demographic information for students enrolled in developmental course work. In general, these studies do not analyze or provide predictive information on which students might be required to enroll in developmental courses based on their race/ethnicity or by the student services they receive. The logistic regression for the third research question used the variables of race/ethnicity, Free and Reduced-priced Meals System identification, English Speakers of Other Languages status, and special education services. White students are the reference group and are coded "0". For the race/ethnicity variables, the code was "1" if the student was of the specified race/ethnicity. The reference group for each special service area is the non-special services students and they are coded as "0". For example, the reference group for English Speakers of Other Languages is all non-English Speakers of Other Languages students. The code was "1"

for each student in the specified special service group. Table 11 displays the results of the statistical analysis.

Table 11. Statistical Analysis of Demographic Factors and Student Services

Course	B	S.E.	Wald	df	Sig.	Odds Ratio (OR)	% change in Odds	ES
Asian American	-.172	.124	1.923	1	.166	.842	-15.83	-0.10
African American	.366	.113	10.437	1	.001	1.442	44.24	0.20
Hispanic	.487	.111	19.318	1	.000	1.627	62.75	0.27
FARMS	-202	.101	3.994	1	.046	.817	-18.30	-0.11
ESOL	-1.707	.192	78.675	1	.000	.181	-81.86	-0.94
Special Education	-.238	.130	3.331	1	.068	.789	-21.15	-0.13
Constant	.562	.070	64.244	1	.000	1.754		

In the area of race/ethnicity, two variables offer notable results as an outcome of the logistical regression analysis. The most significant relationship of race/ethnicity and enrollment in developmental courses are African American (b=.366) and Hispanic (b=.487). Although the effect size is small (d=0.20), the percent Odds ratio indicates that African American graduates are 44 percent more likely than White students to enroll in a developmental mathematics course. Also with a small effect size (d=0.27), the percent Odds ratio shows that Hispanic students are 63 percent more likely than White students to be required to enroll in a developmental mathematics course.

The special services variables include students who were receiving the service only during their senior year (Grade 12). Students who received a designated service prior to their senior year in high school are not identified as receiving services in this study. The relationship of the English Speakers of Other Languages variable to non-enrollment in developmental courses is statistically significant (b=-1.707) and the

relationship of the Free and Reduced-priced Meals System variable is marginally significant (b=-.202). The percent Odds ratio shows that English Speakers of Other Languages students are 82 percent less likely than their non-English Speakers of Other Languages peers to require enrollment in a developmental mathematics course. The effect size (d=-0.94) is large. For the Free and Reduced-priced Meals service group, the percent Odds ratio reveals that Free and Reduced-priced Meals System students are 18 percent less likely than their non-Free and Reduced-price Meals System peers to be required to enroll in a developmental mathematics course. The effect size for Free and Reduced-price Meals System students (d=-0.11) is small.

The analysis of the special services data includes an unexpected finding. English Speakers of Other Languages students are significantly less likely to require enrollment in developmental mathematics. In this graduating cohort, English Speakers of Other Languages students beat the odds in terms of non-enrollment in mathematics developmental course work. In addition, Free and Reduced-priced Meals System students are less likely to require enrollment in developmental mathematics; however, the effect size is minute and does not have practical significance. The analysis of the race/ethnicity data shows an outcome that is consistent with findings in previous research—African American and Hispanic students are significantly more likely to require enrollment in developmental course work.

Research Question 4

Are students' who graduated from some high schools more likely than students' who graduated from other high schools to be required to enroll in a developmental

mathematics course? What are the patterns when data are disaggregated by race/ethnicity, Free and Reduced-priced Meals System, English Speakers of Other Languages status, and special education services?

Montgomery County Public Schools has 25 comprehensive high schools. For this analysis, each of the 25 high schools has been numbered 1 through 25 in order to retain the anonymity of the school. The school numbers were assigned based on the percentage of students enrolled in developmental courses at Montgomery College. For example, the school with the lowest percentage of developmental course enrollees from among the 25 high schools is assigned the number 1. The school with the largest percent of total developmental course enrollees from among the high schools is assigned the number 25. This system of school numbering is consistent throughout the study.

The number of students who matriculated from Montgomery County Public Schools' 25 comprehensive high schools to Montgomery College in the fall of 2009 was 2,821. Developmental course enrollment was required for 1,807 students representing 64.1 percent of the total cohort. The number of students who matriculated from individual high schools ranged from 33 to 178. When disaggregated by high school, there is a significant range in the postsecondary mathematics enrollment patterns. The student enrollment numbers for developmental mathematics range from 16 to 120. The student enrollment in developmental courses as a percentage of total Montgomery College enrollees in each high school ranges from 48.5 to 74.8 percent. Table 12 displays the total number of students enrolled from each high school at Montgomery College, the number of students who enrolled in developmental mathematics, as well as

the number and percentage of student enrollment by school sorted by percentage enrolled for the 2009 graduate cohort.

Table 12. 2009 Graduate Cohort Data by Graduating High School

School Number	Developmental Course Enrolled Number	Developmental Course Enrolled Percent	Montgomery College Total Enrolled Number
1	16	48.5	33
2	51	55.4	92
3	55	56.7	97
4	48	57.8	83
5	35	58.3	60
6	78	60.5	129
7	71	60.7	117
8	91	61.1	149
9	85	61.2	139
10	32	61.5	52
11	63	61.8	102
12	92	62.2	148
13	63	63.0	100
14	42	63.6	66
15	68	63.6	107
16	105	64.4	163
17	100	65.8	152
18	84	66.1	127
19	88	66.2	133
20	76	66.7	114
21	120	67.4	178
22	113	68.1	166
23	71	72.4	98
24	62	72.9	85
25	98	74.8	131
	1807	64.1	2821

In order to answer the second part of question four, school-level data disaggregated based on race/ethnicity and special services were reviewed. In many cases, the number of students for certain variables was small. With small student numbers and without the benefit of multiple years of data, confidence in any significant findings would be questionable. Therefore, to ascertain if race/ethnicity and/or student services impact

student enrollment patterns in developmental courses, a composite percentage was formulated for each high school.

The composite percentage includes the following five variables, which comprise the total enrollment at each high school: percentage of African American enrollment, percentage Hispanic enrollment, percentage of students identified as receiving Free and Reduced-priced Meals, percentage of students identified for English Speakers of Other Languages services, and percentage of students identified for special education services. African American and Hispanic enrollment were selected as variables based on the question three findings that African American and Hispanic students are 44 and 63 percent more likely to enroll in developmental courses than their White peers that served as the reference group. The analysis showed that white and Asian American students have significantly lower enrollment rates in developmental courses at Montgomery College. The composite percentage for each school is the mean percentage of the five variables. Schools were then grouped into three categories—low, medium, and high. For example, the high composite-level schools include a combination of a higher percentage of African American students, Hispanic students, the percentage of students receiving Free and Reduced-priced Meals, the percentage of students identified for English Speakers of Other Languages services, and the percentage of students identified to receive special education services.

Three schools were in the high composite-level group and had a lower rate of students enrolled in developmental mathematics compared with other schools within the high composite-level group. Similarly, three schools in the low composite-level group had a higher rate of students enrolled in developmental mathematics. However, there is

minimal variation in the rate of enrollment in developmental mathematics for schools in the medium composite-level group. Table 13 displays a comparison of the percentage of students enrolled in developmental courses with the five-variable composite and the composite levels.

Table 13. Composite-level Chart for Students Enrolled in Developmental Courses

School Number	Developmental Course Enrolled Percent	Five Variable Composite Percent	Composite Level
10	61.5	3.8	Low
3	56.7	5.1	
5	58.3	5.3	
1	48.5	5.9	
14	63.6	8.6	
2	55.4	9.8	
15	63.6	10.1	
8	61.1	11.5	
7	60.7	12.7	Medium
18	66.1	14.6	
21	67.4	15.4	
12	62.2	16.5	
11	61.8	17.0	
20	66.7	17.5	
24	72.9	18.0	
19	66.2	18.6	
9	61.2	20.3	High
23	72.4	20.5	
16	64.4	23.7	
4	57.8	24.5	
22	68.1	24.5	
6	60.5	25.7	
17	65.8	25.9	
13	63.0	28.4	
25	74.8	31.6	

In order to provide qualitative context to research question four, an online survey was sent to all 25 comprehensive high school principals. Twenty-two principals responded to the three-question survey. The response rate was 88 percent. The data and findings for each survey question will be discussed separately. The complete survey is

found in the appendix. The first question asked the principals' to self-identify based on the percentage of Free and Reduced-priced Meals students enrolled in their school. Figure 2 displays the results of question one.

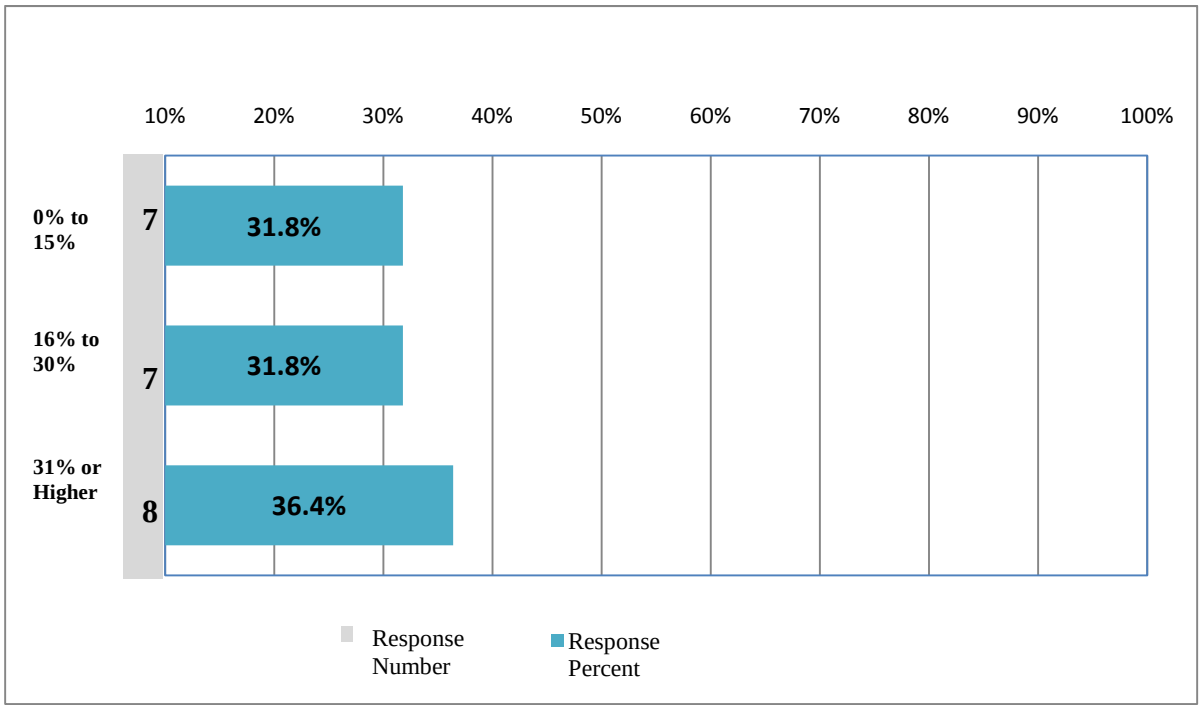

Figure 2. School Enrollment Based on Free and Reduced-priced Meals

The responses to question one were almost evenly divided. Seven respondents (31.8%) reported that their school fell into the 0 to 15 percent range in the overall enrollment of students receiving Free and Reduced-priced Meals. Seven respondents (31.8%) indicated that their school enrolled between 16 and 30 percent of students receiving Free and Reduced-priced Meals, and eight respondents (36.4%) reported an enrollment rate of 31 percent or higher.

The second survey question asked the principals to select the primary factor they believe caused a student to be required to enroll in a developmental mathematics course. Figure 3 displays the results of question two.

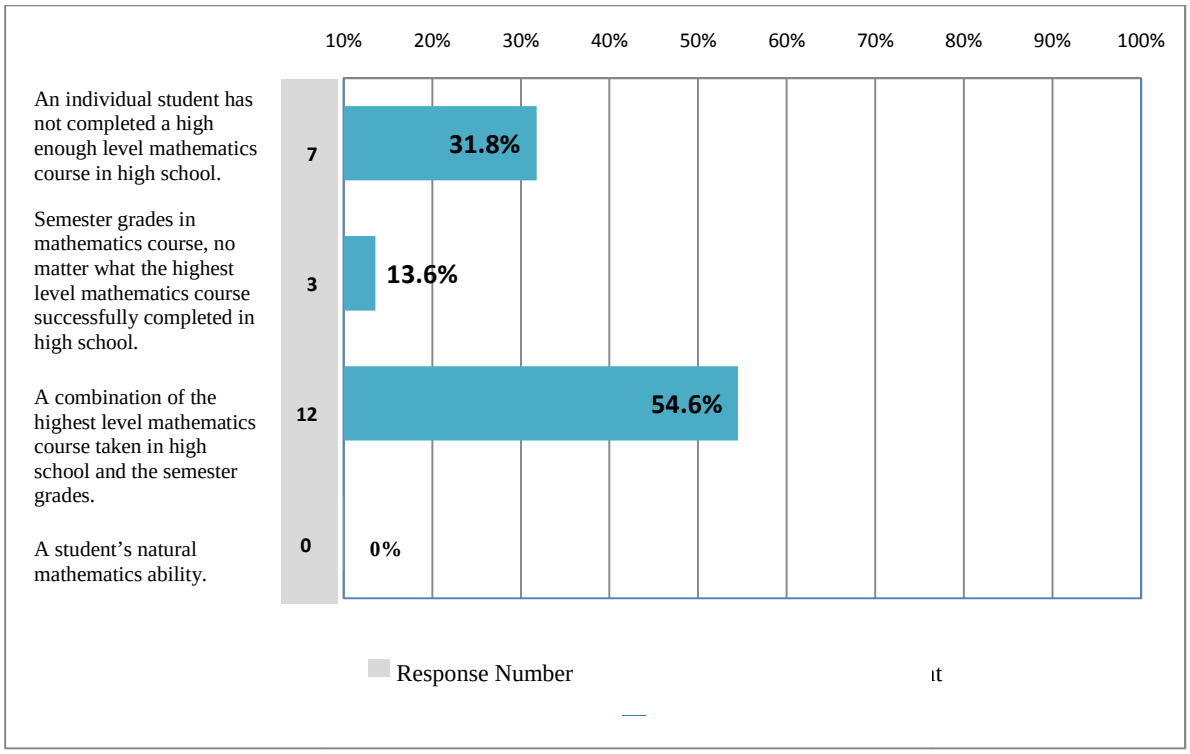

Figure 3. Primary Factor for Enrollment in Developmental Mathematics Courses

Fifty-five percent of the principals indicated that a combination of the highest level mathematics course taken in high school and the semester grades is the primary factor for enrollment in developmental mathematics courses. Thirty-two percent of principals believe that enrollment in developmental mathematics is a result of not completing a high enough level of mathematics course in high school. Only 14 percent of the principals indicated semester grades in mathematics courses in high school were the most important factor in enrollment in developmental mathematics courses.

The final question in the survey asked principals to recommend steps school districts could take to reduce the number of students enrolled in developmental mathematics at the postsecondary level. This question asked principals to comment in all the areas they believed would have the most impact in reducing the number of students

required to enroll in developmental mathematics course work. To focus the responses, six areas were pre-selected and listed in the survey. Principals were given the option to comment in multiple areas. Respondents also had the opportunity to offer other areas of focus not listed by commenting in an "other" section. Table 14 displays the results of question three.

Table 14. Recommendations to Reduce Enrollment in Developmental Mathematics

Area of Focus	Frequency Selected Percent
School resources	40.9
Principal leadership	36.4
Course alignment to postsecondary education	36.4
Teacher experience, attitude, expectations, etc.	50.0
Student/teacher relationship	54.5
Extra time to teach math to struggling students (long periods)	54.5
Out-of-school-hour tutoring	27.3
Other, specify	59.1

Among the pre-selected recommendation focus areas, teacher experience, attitude, and expectations, student/teacher relationship, and extra time to teach mathematics to struggling students were the most selected. When reviewing the 12 narrative comments provided by principals for the recommendation of extra time for struggling students, 50 percent of the respondents specified that more time would be "counter-productive" and 50 percent indicated that additional time is "crucial" for struggling students to master the content. The following statement characterizes all the statements against providing more time for mathematics instruction: "I see it less as an issue of quantity of time and more an issue of quality of time." Since one of the highest rated responses included two contradictory perspectives, the remaining two most selected recommendations are teacher experience, attitude, and expectations, and student teacher relationship.

There were 13 comments in the "other" section of survey question three. This section received more responses than any of the preselected recommendations. However, there was no particular overarching theme or themes that could be gleaned from the collective responses. Respondents offered comments in numerous areas including professional development for teachers, additional staffing, curricula content and pacing, students' overreliance on calculators, addition of summer school programs, incentive programs, over-acceleration in elementary and middle school, and the use of the Accuplacer in high school to identify students who need interventions prior to graduation. The randomness of the responses in the "other" section of question three, as well as the lack of any pervasive themes, indicates that there is no additional information to mitigate the extent to which the two preselected themes of teacher experience, attitude, and expectations, as well as student teacher relationship were most selected by the responding principals.

In summary, this research includes both quantitative and qualitative analysis. The SPSS logistical regression quantitative analysis found that enrollment in Precalculus or Calculus or higher with a grade of C or higher are predictors of enrollment in developmental mathematics. In addition, students who are African American or Hispanic are more likely to enroll in developmental mathematics than their White or Asian American peers, and among the student services groups, English Speakers of Other Languages students are significantly less likely to enroll in developmental mathematics. A review of a composite of demographic data found some outlier schools that are high impact in terms of their likelihood to have students who will enroll in developmental mathematics courses; however, the data show that they have a lower percentage of

students enrolled than similarly impacted schools. Finally, in a survey of the high school principals in Montgomery County, a majority of the respondents listed a combination of the highest-level mathematics course and semester grades as the most important factor related to required enrollment in developmental mathematics. The survey also showed that teacher experience, attitude, expectations, as well as student teacher relationship were the most selected recommendations among the respondents for reducing the number of students who require postsecondary remediation in mathematics. In the next chapter, the study findings will be discussed in the context of conclusions, implications, and areas for further inquiry.

CHAPTER 5

DISCUSSION

Introduction and Context

The need for developmental course work at the postsecondary level has been of concern to business leaders, government officials, and educators for decades. These concerns have been heightened in the 21st century with the increased apprehension related to the global economy, national security, and long-term anxiety regarding the ability of the United States to compete with countries such as China in the corporate and education arenas. It is believed that, without a strong education system, the United States will lose its competitive edge and ultimately its premier status as a world leader. A change in stature could result in a lower standard of living and significant national security issues.

In recent years, the educational community has taken unprecedented steps to strengthen the framework of the educational system. The National Governors' Association and business leaders formed Achieve, Inc. in 1996 with the goal of improving educational outcomes throughout the United States (Achieve, 2012). Achieve, in partnership with the National Governors' Association and the Council of Chief State School Officers, has led an effort to develop the Common Core State Standards, which have been adopted by 45 states and the District of Columbia. In addition, the Partnership for Assessment of Readiness for College and Careers and Smarter Balance Consortium are collaborative state-led efforts that create standardized assessments to measure the implementation of the Common Core State Standards. This work is underway to bolster K–12 education across the United States, with the intended result of increasing student preparation for postsecondary study and the workforce. One of the implied goals of this

national effort is to reduce the number of students' requiring developmental mathematics upon entry into postsecondary education.

During the past decade, Montgomery County Public Schools has been on the forefront of educational reform. Significant work has been implemented to revise curriculum and locally developed assessments, and to provide professional development for instructional staff. The first group of Montgomery County students to fully participate in the initial reforms instituted in 2001 will graduate in 2013. A second wave of reform is now underway as the State of Maryland and the Montgomery County Public Schools begin implementation of the Common Core State Standards. As with the first reform initiative, it will take several years before the Common Core State Standards are fully implemented and any improvement in academic achievement results are systemically measured.

Currently, Montgomery County Public Schools, like other school districts, has a significant number of students who require remedial course work in mathematics at the postsecondary level. This is clearly demonstrated through the 2009 graduate cohort of which approximately 33 percent of the students attended Montgomery College. The cohort data ascertained for this research study shows that 64.1 percent of the students were required to enroll in a developmental mathematic course as first-semester students at Montgomery College. Montgomery County, and the rest of the nation, must identify strategies, remedies, and solutions to reduce and eliminate the epidemic enrollment in remedial mathematics courses.

Conclusions for Research Questions 1 and 2

When the course variables of Geometry, Algebra II, Precalculus, and Calculus or above are compared through the logistical regression model, only enrollment in Precalculus and Calculus or above are significant. Students enrolled in a Precalculus course during high school are 20 percent less likely to require enrollment in a developmental mathematics course in college. Those students who enroll in Calculus or a higher-level course are 77 times less likely to require enrollment in a developmental mathematics course at Montgomery College. In the 2009 Montgomery County Public Schools graduating cohort, those students who enrolled in either of these two college-preparatory mathematics courses beyond Algebra II were significantly less likely to require developmental mathematics course work at Montgomery College.

SOAR 2011 found that the remedial course enrollment rate for students who completed a "core" curriculum in high school entered postsecondary institutions with a lower rate of required enrollment in developmental mathematics than those students who completed a non-core curriculum. One of the components of the defined core curriculum in Maryland is the completion of three or more years of mathematics. The Ohio Board of Regents (2005) defined a component of the "complete" core curriculum as four years of mathematics. Roth, Crans, et al. (1997), Adelman (1999 and 2006), Duranczyk and Higbee (2006), and Hoyt (1999) directly address the completion of Algebra II as a variable impacting individual student enrollment in postsecondary developmental courses. Spade, Columba, and Vanfossen (1997) asserts that the most significant student achievement variable controlled by a school is course enrollment (p. 125). The findings of this study suggest that completion of courses beyond Algebra II is required to significantly reduce enrollment in developmental mathematics courses.

For administrators, school counselors, and parents, this is an important finding. Montgomery County Public Schools, like other school districts across the United States, require students to take and earn credit in four mathematics courses. In Maryland, Algebra I and Geometry are required for graduation. Algebra II is the course many students enroll in following Geometry; however, it is not required. There are mathematics course options available to students that allow them to complete their mathematics credit graduation requirements without taking Algebra II, Precalculus, or Calculus. The analysis in this study shows that by enrolling in either Precalculus or Calculus, a student reduces his or her chance of required enrollment in developmental mathematics. School district staff should strongly encourage students to enroll in college-preparatory mathematics courses beyond Algebra II in order to gain exposure to more rigorous curriculum content, with the goal of reducing the probability of required enrollment in postsecondary developmental mathematics courses.

The logistic regression for the second research question used the variables of successful completion of Geometry, Algebra II, Precalculus, and Calculus or a higher-level course, with a C or higher defined as successful completion of the course. The statistical analysis found that, from among the four courses, students who completed Precalculus were 23 percent less likely to be required to enroll in developmental mathematics. Those students who successfully completed Calculus or a higher course with a grade of C or higher were 75 times less likely to require enrollment in developmental mathematics courses at Montgomery College. The analysis for this study shows that course enrollment beyond Algebra II and final course grades in Precalculus and Calculus are a predictor of college readiness in mathematics.

The Maryland Higher Education Commission (2009), Fong, Huang, and Goel (2008), Adelman (1999 and 2006), Hoyt (1999), Hoyt and Sorensen (2001), and Roth, Crans, et al. (1997) all discuss GPAs and/or grades in relationship to the need for remedial mathematics course work at the postsecondary level. These researchers, in one form or another, point to higher GPAs and/or grades as having a strong influence in reducing postsecondary mathematics remediation. Sawyer (2008) and Boylan and Saxon (2001) maintain that there are differences in grading practices among teachers as well as schools and subjectivity along with grade inflation are factors that impact remedial enrollment rates. Although these factors should be considered in any study of the impact of grades on postsecondary developmental course enrollment, the logistical regression used in this study includes the consideration of both grades and course enrollment. By considering multiple variables, and focusing comprehensively on the question of the outcome of a student earning a grade of C or higher in several high school mathematics courses, the threat of grade subjectivity and inflation are reduced.

Enrolling in and successfully completing courses beyond Algebra II is important if a student is to significantly reduce his or her chances of being required to enroll in a developmental mathematics course. From a public policy perspective, school districts should consider increasing the number and types of required mathematics courses. Currently in Maryland, only 3 credits of mathematics are required to earn a Maryland graduation diploma. As previously stated, Montgomery County Public Schools requires 4 credits of mathematics for graduation. Both the state of Maryland and Montgomery County require completion of Algebra I and Geometry courses to earn the Maryland diploma. To improve achievement outcomes, Maryland and districts outside of Maryland

should require a fourth credit of mathematics and consider naming the content of the courses required for graduation as has been done for algebra and Geometry. For example, Maryland could add Algebra II as a required course. This would align the K–12 expectations with the University of Maryland System, which requires applying students to have completed Algebra II in order to apply to campuses in the system. Another option is to define each of the 4 credits for graduation to include Algebra I, Geometry, Algebra II, and Precalculus.

When considering this type of policy change, states and districts must study the short- and long-term implications. If a change in course requirements were to be instituted, school systems would likely see an initial decrease in graduation rates. States and districts would need to contemplate a phase-in approach to any augmentation in mathematics graduation requirements. This approach might require a delay in implementation until the full implementation of the Common Core State Standards, or waivers of specified requirements for some students as states and districts work to update curriculum and instruction to align with the new requirements. The implementation of the Common Core State Standards, development of new curriculum, augmentation of teacher training, and a corollary expansion of educational funding provide states and districts with an opportune time to consider intensifying high school course requirements in mathematics.

Conclusions for Research Question 3

Previous research studies in the area of developmental course enrollment at the postsecondary level has included data that showed higher developmental course enrollment rates for African American and Hispanic students than their Asian American

and White peers (Snyder and Dillow, 2011; SOAR, 2011). The use of a logistic regression model offered the opportunity to predict the enrollment rates based on race/ethnicity and student services. The logistic regression for the third research question used the variables of race/ethnicity, Free and Reduced-priced Meals System identification, English Speakers of Other Languages status, and special education services.

The analysis found that African American students were 44 percent more likely than White students to require remedial mathematics and Hispanic students were 63 percent more likely than their White peers to require enrollment in developmental mathematics at Montgomery College. In most areas of educational attainment, African American and Hispanic students do not achieve at the same level as Asian American or White students. The results of this study show the continued and persistent racial/ethnic achievement gap among African American and Hispanic students and their Asian American and White peers as revealed through enrollment in college-level remedial mathematics courses.

Research question three also analyzed students receiving special services during their senior year in high school. Of the three areas of student services reviewed in this research, Free and Reduced-priced Meals, English Speakers of Other Languages, and special education, the logistical regression analysis found that English Speakers of Other Languages students are 82 percent less likely than their non-English Speakers of Other Languages peers to require enrollment in a developmental mathematics course and Free and Reduced-priced Meals students are 18 percent less likely than their non-Free and Reduced-priced Meals peers to be required to enroll in a developmental mathematics

course. Although the small effect size for the Free and Reduced-priced Meals students made the findings marginally significant, the overall findings were not anticipated.

In the case of both Free and Reduced-priced Meals and English Speakers of Other Languages students, one might expect these students to be "high-risk" populations. Free and Reduced-priced Meals students are discussed in research literature as students who have less educational opportunity due to poverty. In the analysis of the 2009 cohort data for Montgomery College, they are enrolled in developmental mathematics courses at a lower rate that their non-Free and Reduced-priced Meals peers. Because the effect size was small for Free and Reduced-priced Meals students, it is difficult to speculate the reason for the results. More study is needed to determine if this is a one-time anomaly or if there is a consistent pattern in the Free and Reduced-priced Meals results over time.

English Speakers of Other Languages students are enrolled at a significantly lower rate than their non-English Speakers of Other Languages peers. The students identified in this study are students receiving English Speakers of Other Languages services during their senior year in high school. This means that they are likely to have enrolled in Montgomery County Public Schools while in high school and may indicate that the students had strong mathematics instruction in their country of origin, and language is not a barrier to reading and understanding mathematics problems.

There is little research in the areas of socioeconomic status and English Speakers of other languages and enrollment in postsecondary developmental mathematics course work. The Ohio Board of Regents (2005) study did classify districts in Ohio by socioeconomic status and found that school districts with larger numbers of students impacted by poverty had higher postsecondary remedial course enrollment. Adelman

(1999) studies socioeconomic status in the context of high school mathematics course enrollment and attainment of bachelor's degrees. Adelman found that the level of mathematics course completed was significant, while the correlation of socioeconomic and the level of mathematics attained had minimal significance (p. 16). The data analysis for this study found that the Free and Reduced-priced Meals System status of a student was marginally significant in relation to postsecondary mathematics developmental course enrollment; however, it must be considered that the effect size was small.

The results of this study show that policy makers and educational leaders need to continue their focus on the African American and Hispanic achievement gap. Although significant focus and resources have been devoted to improving the achievement of minority students through national efforts such as *No Child Left Behind* as well as initiatives at the state and local levels, a persistent achievement gap continues. As with the conclusions for questions one and two, the Common Core State Standards hold some level of promise if there is fidelity of implementation of the new curriculum with thorough and significant professional development for principals and teachers. School districts also need to review and address the belief systems of their leaders and teachers. If there is a belief that all students can learn at high levels, and the resources are in place to support the schools, the United States will have an educational system that truly serves all students.

In terms of short-terms goals, principals, teachers, and counselors must establish procedures and processes to systematically review the course schedules of their African American and Hispanic students to ensure enrollment in the most challenging mathematics courses prior to high school graduation. Students and parents must be aware

that the choice to complete Precalculus and/or Calculus may make the difference in required enrollment in postsecondary developmental mathematics courses and ultimately resulting in the attainment of a college degree.

Conclusions for Research Question 4

The final research question descriptively analyzed demographic enrollment patterns in developmental mathematics at Montgomery College and studied enrollment patterns by high school. In addition to the descriptive review of data, a survey of the Montgomery County high school principals was administered to gather additional information that might contribute to the overall findings in this study. As discussed above, schools were categorized into three composite-levels: low, medium, and high. This structure provides the opportunity to discuss findings relative to student enrollment based on race/ethnicity and student services. Three schools have a lower percentage of students enrolled in developmental mathematics courses even though they fall within the high composite-level range. It appears that the three schools have created conditions that provide more of their students with the knowledge and skills needed to enroll directly in postsecondary credit-bearing mathematics courses in the fall of their freshman year than other similarly situated schools.

This finding leads to an additional question. What is happening at these three schools related to mathematics teaching and learning that reduces the percentage of students required to enroll in developmental mathematics at Montgomery College? Certainly, more research is needed to answer this question. However, using the results of the principals survey, one can hypothesize potential reasons. In the high school principal survey, the respondents most frequently selected teacher experience, attitude, and

expectations, and student-teacher relationship as the recommended areas on which they suggest school districts should focus to reduce enrollment in postsecondary developmental mathematics courses. Rigor, relevance, and relationships are components often cited as key to educational reform. Teacher experience and student expectations are other crucial areas designated as important to student achievement. While this study does not delve into the details of the specific conditions that may be responsible for lower rates of enrollment in postsecondary developmental mathematics courses, the findings do show that it is possible for schools to improve the college readiness of their students.

Summary Conclusions and Implications

School districts should increase the levels of mathematics required for all students to graduate from high school. At a minimum, students should be required to complete Algebra II and strongly encouraged to enroll in college-preparatory courses beyond Algebra II such as Precalculus and Calculus. According to the National Center for Educational Statistics, 67 percent of high school graduates completed one or more semesters of Algebra II, and only 28 percent of high school graduates completed one or more semesters of Precalculus in 2004 (U.S. Department of Education NCES, 2007, pp. 7-9).

A change in "policy" regarding curriculum standards and assessments has already been undertaken by most states, with the adoption of the Common Core State Standards, and the move toward standardized state-level assessments through the Partnership for Assessment of Readiness for College and Careers and the Smarter Balance Consortium. These standards and assessments are not curriculum, per se, and they do not provide requirements for the highest-level math courses students must take to graduate in a given

state or district. In addition, these newly adopted standards do not include written curriculum, formative assessments, instructional materials, or specific guidance for professional development. State and local Boards of Education and their superintendents will ultimately make decisions in the areas of policies and funding related to graduation requirements and instructional supports.

The implementation of the Common Core State Standards provides an unprecedented opportunity for policy makers and school leaders to implement cutting-edge reform in mathematics education. One of the major issues for educational leaders is how to institute this level of change in a schooling model that has been in place for the last century. School districts cannot expect to create significant changes in student outcomes in mathematics devoid of modifications to curriculum, instructional materials, and assessments. Change of this magnitude will also require a sizable investment in systematic and an ongoing professional development program for central office and school-based staff. These transformational components, combined with increased expectations for the level of mathematics students must complete in order to graduate from high school, could reduce the number of students stuck in the purgatory of postsecondary developmental mathematics courses.

Based on the five-variable composite percentage, students from three high schools had noticeably lower developmental course enrollment rates in mathematics at Montgomery College than similarly situated high schools. Although the remediation rates for students in these schools are still unacceptably high, the findings of this study suggest that schools can create an environment in which the number of students required to enroll in postsecondary developmental mathematics courses is reduced, moderately or

significantly. This encouraging finding suggests that school leadership and policies can reduce the number of students "at-risk" of needing to enroll in developmental mathematics courses. However, in the three schools with lower percentages of students enrolled in developmental courses, it was not possible to identify which variables have led to the positive result.

High school principals who responded to the survey selected teacher experience, attitude, and expectations, and student-teacher relationship as primary factors contributing to a reduction in the number of students who had to enroll in postsecondary developmental mathematics courses. However, the survey results did not show consensus about which factor was determinative. Without consensus about a "decisive" approach, the researcher concludes that each school's approach represents a convergence of approaches, rather than a formula-driven strategy. This is consistent with the school management approach of decentralization. It is not always possible, nor is it always recommended, to lift an initiative or an instructional approach from one school and place it in another. In this study, the principals may be on the right track to attempt different approaches to achieve sustainable results. Albeit there is not currently a systematic professional learning discussion among Montgomery County Public Schools principals regarding this problem of practice, there is rich potential for principals within Montgomery County and within other districts to work together to review their data, identify lessons learned, and use successful practices in ways that provide the best results for their schools.

There are significant overall implications for states as well as local districts when identifying strategies to significantly reduce the number of students who require

enrollment in postsecondary developmental mathematics courses. If mathematics course requirements are increased by local school systems and states to include Algebra II or PreCalculus, then enhanced student preparation in mathematics at the elementary and middle school levels is necessary. To improve student readiness for advanced high school mathematics courses, school districts must work to increase the mathematics content knowledge and pedagogical skills of elementary and middle school teachers who may have trained as "generalists" in their college teacher education programs, but must have deep mathematical content knowledge to implement the new Common Core State Standards.

These professional development opportunities not only necessitate a focus on content and pedagogy to enhance the knowledge and experience of teachers, moreover, the training also must focus on supporting teachers in their understanding of a high-expectations learning environment as well as coaching on how to build and maintain strong relationships with all students. These areas of focus align with the priorities identified by respondents to the survey of principals included in this study. In addition to professional development employed by local school districts, it is essential that school districts and states work with postsecondary institutions to modify teacher preparation programs to place a stronger focus on mathematics education for Prekindergarten through Grade 8 teacher certification and to consider the shift in focus to the deeper mathematical understanding required by the new Common Core State Standards.

In closing, there are issues related to limitations and generalizability that must be addressed. First, the small cohort of students attending Montgomery College and the one-district data source are limitations of this research. Although Montgomery County

Public Schools is the 16th largest school district in the United States, and is comprised of a demographically diverse student body that is similar in diversity and size of other large suburban school districts, the size of the student cohort attending Montgomery College is relatively small. Second, mathematics curriculum, instructional supports, and teacher professional development opportunities can differ from district to district and state to state. Differences in these instructional areas may impact the readiness of students to pass college entrance exams or placement tests potentially influencing the number of students enrolled in developmental coursework among colleges or universities. Finally, even though community colleges in Maryland utilize the Accuplacer to standardize entrance placement in mathematics, there is not a national standard for two- and four-year college placement exams. As a result, there are different standards for decisions regarding which students are required to take developmental mathematics coursework. Considering these limitations, a state or national data sample would strengthen the generalizablity of the findings and implications to other school districts.

Areas for Further Inquiry

This study provides an examination of specific connections among variables related to the relationship of high school preparation in mathematics to the required enrollment of high school graduates in postsecondary developmental mathematics courses. The conclusions and implications of the study are clearly delineated; however, there is need for additional study not only to corroborate the findings in this research, but to also expand upon certain aspects of the study that raise new questions. There are three areas recommended for further inquiry.

First, given that this is a one-cohort study using data from the Montgomery County Public Schools graduating class of 2009, it would be beneficial to replicate the logistical regression analysis with a recent cohort (e.g. Class of 2011) to determine if the overall findings are consistent. As previously discussed in the summary conclusions and implications section of this chapter, the findings in this study go beyond previous research studies that recommend the completion of Algebra II as a means of reducing enrollment in college-level remedial mathematics courses. The analysis in this study reveals that enrollment and/or completion of Precalculus and Calculus courses are stronger predictors of non-enrollment in postsecondary developmental mathematics courses than is Algebra II. In addition, if the findings of this study are duplicated in a replicated analysis, the recommendations to promote the completion of higher-level mathematics courses, and that Free and Reduced-priced Meal and English Speaker of Other Languages services students are less impacted than "stereotypically" considered, will be strengthened.

A second related area of study might focus on the enrollment rate of English Speakers of Other Languages students in developmental mathematics as compared to the enrollment rates of English Speakers of Other Languages students in developmental reading and writing. How do the developmental course enrollment rates compare? If there are differences in enrollment rates, what are the causes of the differences? Often there are assumptions made among educators that English Speakers of Other Language students struggle with all aspects of academic language. Assessments in mathematics require reading skills, particularly for word problems. The results of this study show that English Speakers of Other Languages students were 82 percent less likely than their non-

English Speakers of Other Language peers to require enrollment in a developmental mathematics course. It would be important to study how the enrollment patterns of English Speakers of Other Languages students in college-level developmental mathematics compares with postsecondary enrollment in developmental reading and writing courses to learn more about what has prepared the English language learner students for their success in high school mathematics and to understand what the data show related to preparation for college-level reading and writing.

Finally, another research project might focus on the three high schools that were found to be high in impact, but enrolled students in developmental mathematics courses at lower rates than similarly situated schools. The principal survey revealed that respondents most often selected teacher experience, attitude, and expectations, and student-teacher relationship as crucial components of student success in high school mathematics. This researcher concurs that these two variables are vital to student success, so it would be beneficial to know if they have played a role in the lower student enrollment in postsecondary mathematics courses at the three identified schools. To specifically identify the variables that contribute to the positive results identified at the three high schools, staff and student interviews, classroom observations, and further data analysis are required. Additional information regarding the environmental variables that lead to more positive outcomes might be helpful as other high schools search for successful strategies that reduce the need for postsecondary developmental mathematics course work.

APPENDIX

Principals' Survey
High School Mathematics and Enrollment in Developmental Mathematics Courses at the Postsecondary Level

1. My school falls into the following range in the percent of Free and Reduced Meals (FARMS) students enrolled (check one):

   _____0 to 15 percent

   _____16 to 30 percent

   _____31 percent or higher

2. What do you believe is the primary factor that requires an individual student to enroll in developmental mathematics courses at the postsecondary level (check one)?

   _____ An individual student has not completed a high enough level mathematics course in high school

   _____ Semester grades in mathematics courses, no matter what the highest level mathematics course successfully completed in high school

   _____ A combination of the highest level mathematics course taken in high school and the semester grades

   _____ A student's natural mathematics ability

   _____ Other Explain:_____

3. What steps do you recommend schools and school districts take to reduce the number of students required to enroll in developmental courses at the postsecondary level? Please comment in the areas that you believe would have the most impact.

School resources:

Principal leadership:

Course alignment to postsecondary education:

Teacher experience, attitude, expectation, etc.:

Student teacher relationship:

Extra time to teach math to struggling students (long periods):

Out-of-school-hour tutoring:

Other, specify:

REFERENCES

Achieve, Inc. (2010). *ADP Assessment Consortium*. Retrieved from http://www.achieve.org/ADPAssessmentConsortium

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. (2006). *The toolbox revisited: Paths to degree completion from high school through college.* Washington DC: U.S. Department of Education.

Attewell, P., Lavin, D., Domina, T., and Levey, T. New evidence on college remediation. *The Journal of Higher Education 77(5),* September/October 2006, 886-924.

Aud, S., Hussar, W., Planty, M., Snyder, T., Bianco, K., Fox, M., Frohlich, L., Kemp, J., Drake, L. (2010). *The Condition of Education 2010* (NCES 2010-028). National Center for Education Statistics, Institute of Education Sciences, Washington, DC: U.S. Department of Education.

Boylan, H., Saxon, D. P. (2001, September). *An evalution of developmental education in Texas public colleges and universities* (technical Report). Austin: Texas Higher Eduation Board. Retrieved from http://www.thecb.state.tx.us/reports

Breneman, D., and Haarlow, W. (1998). *Remediation in higher education: a symposium featuring "Remedial education: costs and consequences."* Washington, DC: Thomas B. Fordham Foundation.

Business Innovation Network. (2011). *Montgomery County Department of Economic Development.* Retrieved from http://www.mcinnovationnetwork.com/why-montgomery-county/

Chan, Y. H. (2004). Biostatistics 202: Logistic regression analysis. *Singapore Medical Journal, 45*(4), 149-153.

Code of Maryland (COMAR). 13A.03.02.04. Retrieved from http://www.dsd.state.md.us/comar/

Cogan, L.S., Schmidt, W. H., & Wiley, D. E. (2001). Who takes what mathematics and in which track? Using TIMMS to characterize U.S. students' eighth-grade mathematics learning opportunities. *Educational Evaluation and Policy Analysis, 23,* 323-341.

Cohen, J. (1988). Statistical Power Analysis for the Behavioral Sciences (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates.

Deil-Amen, R. & Rosenbaum, J. (2002). The unintended consequences of stigma-free remediation. *Sociology of Education, 75*, 249-268.

Duranczyk, I.M., & Higbee, J.L. (2006). Developmental mathematics in 4-year institutions: Denying Access. *Journal of Developmental Education, 30*(1), 22-31.

Fong, A.B., Huang, M., and Goel, A.M. (2008). Examining the links between grade 12 mathematics coursework and mathematics remediation in Nevada public colleges and universities (Issues & Answers Report, REL 2008-No. 058). Washington, DC: U.S. Department of Education, Institute of Education Sciences, National Center for Educational Evaluation and Regional Assistance, Regional Educational Laboratory West. Retrieved from http://ies.ed.gov/ncee/edlabs

Gonzales, P., Juan Carlos Guzmán, Lisette Partelow, Erin Pahlke, Leslie Jocelyn, David Kastberg, and Trevor Williams. (2004). *Highlights From the Trends in International Mathematics and Science Study* (TIMSS) 2003 (NCES 2005–005). U.S. Department of Education, National Center for Education Statistics. Washington, DC: U.S. Government Printing Office.

Gonzales, P., Williams, T., Jocelyn, L., Roey, S., Kastberg, D., and Brenwald, S. (2008). *Highlights From TIMSS 2007: Mathematics and Science Achievement of U.S. Fourth- and Eighth-Grade Students in an International Context* (NCES 2009–001 Revised). National Center for Education Statistics, Institute of Education Sciences, Washington, DC: U.S. Department of Education.

Hoyt, J. E. and Sorensen, C. T. (2001). High school preparation, placement testing, and college remediation. *Journal of Developmental Education, 25*(2), 26-33.

Hoyt, J. E. (1999). Level of math preparation in high school and its impact on remedial placement at an urban state college. *College & University, 74*, 37-43.

Hoyt, J. E. (1999). Remedial education and student attrition. *Community College Review, 27*, 51-72.

Ignash, J. M. (1997). Who should provide post secondary remedial/developmental education? In J. M. Ignash (Ed.), *New directions for community colleges (No. 100). Implementing effective policies for remedial and developmental education*. San Francisco: Jossey-Bass.

Kline, R. B. (2004). *Beyond significance testing: Reforming data analysis methods in behavioral research.* Washington D. C.: American Psychological Association.

Kozeracki, C. (2002). ERIC review: Issues in developmental education. *Community College Review*, 29, 83-100.

Maryland Higher Education Commission (2006). *Student Outcome and Achievement Report (SOAR): College Performance of New Maryland High School Graduates.* Annapolis, MD: Maryland Higher Education Commission.

Maryland Higher Education Commission (2009). *Student Outcome and Achievement Report (SOAR): College Performance of New Maryland High School Graduates.* Annapolis, MD: Maryland Higher Education Commission.

Maryland Higher Education Commission (2011). *Student Outcome and Achievement Report (SOAR): College Performance of New Maryland High School Graduates.* Annapolis, MD: Maryland Higher Education Commission.

Maryland State Department of Education. The Fact Book 2009-2010: A Statistical Handbook. Retrieved from http://www.marylandpublicschools.org/NR/rdonlyres/0C24833A-9CBE-4C09-9010-B7BD88F4B1E0/27259/Fact_Book_2009_2011.pdf.

Maryland State Department of Education. (2010). Graduation Requirements. Retrieved from http://hsexam.org/img/MD_HS_Grad_rev%204-2010.pdf

Montgomery County Public Schools. (2009). *Capital Improvements Budget.* Montgomery County, MD: MCPS.

Montgomery County Public Schools. (2009). *Schools at a glance 2008–2009.* Montgomery County, MD: MCPS Office of Shared Accountability.

National Center for Education Statistics (NCES). (2003). *Remedial education at degree-granting postsecondary institutions in Fall 2000: Statistical analysis report* (Technical Report, NCES 2004-0101). Washington, DC: U.S. Department of Education Institute of Education Science.

National Center for Education Statistics (2009). *The nation's report card: Mathematics 2009* (NCES 2010–451). Institute of Education Sciences, Washington, DC: U.S. Department of Education.

National Defense Education Act (NDEA) (P.L. 85-864). *United States Statues at Large, Vol. 72*, pp. 1580-1605.

National Mathematics Advisory Panel. (2008). *Foundations for Success: The Final Report of the National Mathematics Advisory Panel*, Washington, DC: U.S. Department of Education.

Ohio Board of Regents (2005). *Making the transition from high school to college in Ohio 2005: A statewide perspective.* Retrieved from http://www.regents.ohio.gov/perfrpt/hs_2005/

Provasnik, S., and Planty, M. (2008). *Community Colleges: Special Supplement to The Condition of Education 2008* (NCES 2008-033). National Center for Education Statistics, Institute of Education Sciences, Washington, DC: U.S. Department of Education.

Rosenbaum, J. (2001). *Beyond college for all.* New York: Russel Sage.

Roth, J., Crans, G., Carter, R., Ariet, M. and Resnick, M. (1997). Effect of High School Course-Taking and Grades on Passing a College Placement Test. *The High School Journal; Dec 2000/Jan 2001; 84*(2), 72-87.

Roth, J., Crans, G., Carter, R., Ariet, M., Resnick, M. (2001). Effect of high school course-taking and grades on passing a college placement test. *The High School Journal 82*(2), 72-87.

Roueche, J., and Roueche, S. (1999). *High stakes, high performance: Making remedial education work.* Washington, DC: Community College Press.

Sawyer, R. (2008). *Benefits of additional high school course work and improved course performance in preparing students for college.* Iowa City, IA: ACT.

Snyder, T.D., Dillow, S.A., and Hoffman, C.M. (2008). *Digest of Education Statistics 2007* (NCES 2008-022). National Center for Education Statistics, Institute of Education Sciences, Washington, DC: U.S. Department of Education.

Snyder, T.D., and Dillow, S.A. (2011). *Digest of Education Statistics 2010* (NCES 2011-015). National Center for Education Statistics, Institute of Education Sciences, Washington, DC: U.S. Department of Education.

Spade, J.Z., Columba, L., and Vanfossen, B. E. (1997). Tracking in mathematics and science: Courses and course selection procedures. *Sociology of Education, 70*, 108-127.

Tabachnick, B. G., & Fidell, L. S. (2001). Using Multivariate Statistics (4^{th} ed.). Needham Heights, MA: Allyn & Bacon.

University of Maryland Board of Regents. (2009). Policy on Undergraduate Admissions III-4.00. Retrieved from www.president.umd.edu/policies/docs/III-400.doc

U.S. Census Bureau, American Fact Finder. (2009), Data Profiles, Education Attainment. Retrieved from http://factfinder.census.gov/servlet/DatasetMainPageServlet ?_lang=en&_ts=316357232486&_ds_name=ACS_2009_5YR_G00_&_program=

U.S. Department of Education, National Center for Education Statistics. (2004). *The Condition of Education 2004* (NCES 2004–077). Washington, DC: U.S. Government Printing Office.

U.S. Department of Education, National Center for Education Statistics. (2007). *The Condition of Education 2007* (NCES 2007-064). Washington, DC: U.S. Government Printing Office.

Wright, R. E. (2006). Logistic Regression. In L. G. Grimm & P. R. Yarnold (Eds.), *Reading and Understanding multivariate Statistics* (217-244). Washington, D.C.: American Psychological Association.