Important Secondary Mathematics Enrollment Factors that Influence the Completion of a Bachelor's Degree

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This dissertation titled

Important Secondary Mathematics Enrollment Factors that
Influence the Completion of a Bachelor's Degree

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Abstract

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This dissertation focused on strengthening, clarifying, and extending the importance of secondary mathematics education. Clifford Adelman, in his 1999 and 2006 Toolbox research, demonstrated a strong connection between the secondary mathematics courses completed in high school and the odds of a student completing a bachelor’s degree.

Three additional variables, early entry to algebra (before grade nine), continuous enrollment in secondary mathematics, and secondary mathematics intensity level (MIL) were included in an effort to more carefully study the importance of secondary mathematics for the prototypical college bound student. These three variables, in addition to Adelman’s highest mathematics course completed in high school and his constructed overall academic intensity variable from Carnegie credits earned, were analyzed while controlling for 12th grade
socioeconomic status and 8th grade math proficiency. Logistic regression was used with data from the National Center for Education Statistics’ National Education Longitudinal Study. NELS was conducted from 1988 to 2000. These data provided a rich and large sample size of students with secondary and post-secondary transcripts for this study.

The results of the data analysis confirmed Adelman’s findings. Further, continuous enrollment in secondary mathematics education emerged as important, if not more important, than the completion of a specific secondary mathematics course for students seeking a bachelor’s degree during their post-secondary education. The secondary mathematics intensity level (MIL) significantly increased the odds of bachelor degree completion. The MIL variable was constructed from available NELS variables related to secondary mathematics for each student. The MIL results indicate that secondary mathematics teachers should increase student expectations and classroom intensity in an effort to raise students’ odds of bachelor degree completion.

Finally, the results of this study in conjunction with Adelman’s results solidify the importance of secondary
mathematics as a most important variable to increasing the odds of bachelor degree completion. State departments of education and higher education commissions should consider the results from this study as they move forward regarding secondary mathematics policies. Contains 20 tables and 5 figures.

Approved: _________________________________________________

George A. Johanson

Professor of Educational Studies
This body of research is dedicated to my late grandmother, Amanda Stricklin Guthrie Merkel, who passed away in March of 2007 when this work had just begun. I thank my grandmother whole-heartedly for the educational upbringing and values she instilled upon me. Her value of education and her dedication to educate every one of her 3rd grade students for 30 years, including the poorest students, goes beyond what many educators possess today. Her education values and dedication are things which I wish to pass on to my children, my students, future mathematics teachers, current mathematics teachers, and education professionals in general. Her rural West Virginia upbringing is also something that I have grown to admire and cherish throughout the ACCLAIM doctoral program experience.

Thanks Grandma, I know you watched over me during this process and saw me through the tough times I encountered. I know you are proud of me and I hope I can continue the education legacy you set forth.

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# Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>iv</td>
</tr>
<tr>
<td>Dedication</td>
<td>vii</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>viii</td>
</tr>
<tr>
<td>List of Tables</td>
<td>xv</td>
</tr>
<tr>
<td>List of Figures</td>
<td>xviii</td>
</tr>
<tr>
<td>CHAPTER 1: OVERVIEW OF THE STUDY</td>
<td>1</td>
</tr>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Background of the Study</td>
<td>6</td>
</tr>
<tr>
<td>The History of Increasing Secondary Mathematics</td>
<td>11</td>
</tr>
<tr>
<td>The Policy in Question</td>
<td>13</td>
</tr>
<tr>
<td>How &amp; Why States Justify a Policy Change</td>
<td>15</td>
</tr>
<tr>
<td>Statement of the Problem</td>
<td>18</td>
</tr>
<tr>
<td>Research Questions and Hypotheses</td>
<td>19</td>
</tr>
<tr>
<td>Research Question</td>
<td>19</td>
</tr>
<tr>
<td>Hypothesis 1</td>
<td>19</td>
</tr>
<tr>
<td>Hypothesis 2</td>
<td>19</td>
</tr>
<tr>
<td>Hypothesis 3</td>
<td>19</td>
</tr>
<tr>
<td>Significance of Study</td>
<td>19</td>
</tr>
<tr>
<td>Practical Implications</td>
<td>19</td>
</tr>
<tr>
<td>Theoretical Implications</td>
<td>20</td>
</tr>
<tr>
<td>Limitations and Delimitations of the Study</td>
<td>22</td>
</tr>
</tbody>
</table>
Limitations.......................................... 22
Delimitations........................................ 24
Definitions of Terms................................. 26
Summary................................................ 29
Organization of Study............................... 30
CHAPTER 2: REVIEW OF RELATED LITERATURE................. 32
Introduction......................................... 32
Topical Overview..................................... 33
Theoretical Position................................. 38
Possibilities of Theoretical Divergence.......... 39
Review of Existing Literature....................... 41
Overview of this Segment........................... 41
Middle School Mathematics Achievement......... 41
Early Enrollment in Algebra........................ 44
Secondary Math Achievement & Classroom Standards..... 50
College Mathematics Readiness..................... 54
College Remediation................................ 56
Mathematics Connected to Overall College Success..... 57
Secondary Mathematics Linked to College Graduation... 59
Summary................................................ 65
Conclusion............................................. 68
CHAPTER 3: METHODOLOGY...................................... 69
Selection of Participants............................ 69
Definition of Variables................................. 75
MIL Variable Construction Methodology............ 78
Secondary Analysis (Brief Discussion)............ 87
Methodology for Main Analysis..................... 88
Exploration of Variable Interaction............... 90
Assumptions of Statistical Methodology.......... 95
Assessing the Statistical Results............... 97
Summary............................................... 100

CHAPTER 4: STATISTICAL RESULTS.................. 102
Overview of Chapter 4................................ 102
Part 1: Results of Main Analysis for Universe of Study. 104
Descriptive Statistics................................ 104
MIL Construction..................................... 106
Block 1 Analysis of Covariates..................... 112
Block 2 Analysis of Covariates..................... 114
Block 3 Analysis of Covariates..................... 116
Part 2: Adelman’s Universe of NELS Participants.... 118
Overview of Part 2.................................. 118
Descriptive Statistics................................ 119
MIL Construction..................................... 119
Block Entry of Covariates........................... 122
Part 3: Universe MIL Minus the Standardized Math Score. 124
Overview of Part 3.................................. 124
Logistic Regression Comparison
Path 1 Discussion (Comparing Part 1 and Part 2)
Part 3 and Part 4 Discussions
MIL Comparisons
Part 3 and Part 4 Logistic Regression
Summary
Conclusions
Recommendations
References
Appendix A
Appendix B
Appendix C
Appendix D
Appendix E
Appendix F
Appendix G
Appendix H
Appendix I
Appendix J
List of Tables

Table 1. The Math Ladder for 1982 and 1992 12th-graders: Odds Ratios and Parameter Estimates of Earning a Bachelor’s Degree at Each Rung, Controlling for SES Quintile............................................ 62
Table 2. Initial Discriminant Analysis Pilot Results for MIL Construction.................................... 80
Table 3. Final Discriminant Analysis Pilot Results for MIL Construction........................................ 86
Table 4. Descriptive Statistics for Universe of Participants of Study.............................. 105
Table 5. Initial results for MIL construction for Universe of Participants.................................... 107
Table 6. Overview of Each Step During MIL Construction for Universe of Participants of this Study............ 111
Table 7. Final Results for MIL Variable Construction for the Universe of Participants in this Study........ 112
Table 8. Block 1 Entry of Covariates for the Main Analysis of the Universe of Participants............... 113
Table 9. Block 2 Entry of Covariates for the Main Analysis of the Universe of Participants............. 115
Table 10. Block 3 Entry of Covariates for the Main Analysis of the Universe of Participants .............. 117
Table 11. Descriptive Statistics for Adelman’s Universe of NELS Participants ................................. 120
Table 12. Final Results for MIL Variable Construction for Adelman’s Universe of NELS Participants .............. 121
Table 13. Overview of Each Step During MIL Construction for Adelman’s Universe of NELS Participants .............. 122
Table 14. Block Entry of Covariates for Adelman’s Universe of NELS Participants ................................. 123
Table 15. Overview of Each Step During MIL Variable Construction for Universe of Participants Without Standardized Math Score ................................. 126
Table 16. Overview of Each Step During MIL Variable Construction for Universe of Participants Without Standardized Math Score ................................. 127
Table 17. Entry of Covariates for the Main Analysis of the Universe of Participants Without Standardized Math Score in MIL ................................................. 128
Table 18. Final Results for MIL Variable Construction for Adelman’s Universe of NELS Participants Excluding the Standardized Math Score ................................. 130
Table 19. Overview of Each Step During MIL Construction for Adelman’s Universe of NELS Participants Excluding Standardized Math Score........................... 131
Table 20. Block Entry of Covariates for Adelman’s Universe of NELS Participants Without Standardized Math Score in MIL......................................................... 132
List of Figures

Page

Figure 1. U.S. Long-Term NAEP Trends for Mathematics Achievement......................................... 50

Figure 2. Percent of Grades Received in College Mathematics Courses Related to Time of Degree Completion........ 58

Figure 3. Hypothetical Path 1 Odds Calculation........... 185

Figure 4. Hypothetical Path 2 Odds Calculation........... 186

Figure 5. Hypothetical Path 3 Odds Calculation........... 187
CHAPTER 1: OVERVIEW OF THE STUDY

Introduction

For many decades, researchers have studied and demonstrated the correlations between high school coursework/achievement and college success (Conley, 2003, 2005, 2007; House, 1998; Keller, 2006; R.W.B., 1945; Russell, 2007; Watley & Merwin, 1967; Wesley, 1994). Recently, the general public and the education community have questioned whether high schools are adequately preparing students for college as effectively as in previous decades (ACT, 2007; “ACT report finds high school courses lack rigor”, 2007; Beecher & Fischer, 1999; Kitto, 2007; Olson, 2006; Pro Principal, 2007; Rosen, 2007; Saffold & Thomas, 2005). Today, with increasing college enrollment, the question of secondary education operating as an effective preparatory agent for students has gained significant importance.

In 1983, A Nation at Risk (NAR) made recommendations that every high school student should complete a minimum of four years of English, three years of mathematics, three years of science, three years of social studies, and a half-year of computer science. College bound students
should complete an additional two years of foreign language study. Today, it is rare to find a state where admissions standards to state four-year public institutions are less than the NAR recommendations from 1983. Arguably, these standards seem to be a majority consensus among state four-year public institutions for setting the minimum admissions standards. High school graduation requirement policies can be as individual as the state with recommendations for course requirements as variant as the state itself. Additionally, each state has different minimum scores on standardized tests (ACT & SAT) for admission to states’ public four-year institutions. Exact coursework and standardized test scores remain different state-to-state, but higher education, because of increased remedial course enrollments and flat college graduation rates, agrees that high schools need to improve student’s college readiness.

According to the Southern Regional Education Board (SREB, 2005a, 2005b, 2006a, 2006b, 2006c), high school graduation requirement standards for college bound students have increased in the past quarter of a century in many states. The secondary graduation requirement increases typically come from the state department of education,
although some individual school districts raise the standards above state recommendations. Additionally, many four-year state colleges and universities have raised admission requirements. These policies are typically set by a state’s higher education commission or board of regents with input and recommendations from the institutions themselves. Some institutions themselves may set the standards. Today, even with increased standards for high school graduation and increased college admissions standards, a large percentage of public state four-year schools have not seen significant increases in freshmen college readiness. Furthermore, six-year graduation rates at public four-year institutions have failed to increase significantly, according to the SREB. However, researchers, in an effort to offer students the best opportunity for successful completion in the major of their choice upon entering college, are trying to pinpoint what factors will increase the likelihood of completing a bachelor’s degree. More specifically, researchers seek to answer the question: What can be done better in high schools to help students have increased college readiness and successfully completing a bachelor’s degree? This body of research aimed
to focus on exploring the avenue of secondary mathematics related to the completion of a bachelor’s degree.

In the last ten years, research has found secondary mathematics is the predominant predictor of earning a bachelor’s degree. The most common secondary mathematics variable used to predict college degree completion is the highest mathematics course completed in high school (Adelman, 1999, 2004, 2006; Rose & Betts, 2001). Further, mathematics standardized achievement is a variable that has been used to predict college degree completion (Scott & Ingels, 2007). Adelman (2006) demonstrated that overall academic intensity in secondary schools is also a key predictor for bachelor degree momentum. Adelman’s overall academic intensity variable was constructed from earned Carnegie credits across the Nation at Risk recommended subject areas.

This study examined the additional variables of continuous enrollment in secondary mathematics, the academic intensity of secondary mathematics, and the initial enrollment year of an algebra course related to secondary mathematics as significant predictors of bachelor degree completion. Further, this study aimed to strengthen, clarify, and extend Adelman’s (1999, 2006) research that
secondary mathematics is the crucial subject area during high school preparation for college bound students to maintain bachelor degree momentum. Moreover, this study focused on a specific population of college bound students. More specifically, this population was derived by cutting the tails off Adelman’s universe of study. In other words, students who attended highly selective colleges (as defined in the Postsecondary Education Transcript Study – PETS) or students who sought less than a bachelor’s degree were removed from this study’s universe and analyzed so that high achievers and students not seeking bachelor’s degrees would not dually affect the outcome. Students attending highly selective colleges amounted to just fewer than 3% of the PETS.

In an effort to strengthen the national importance of secondary mathematics, this study examined to what extent continuous enrollment and the intensity of secondary mathematics contributed to the odds of this specific population of students completing a four-year degree. Moreover, this study considered distal variables such as socioeconomic status (SES) and prior mathematics achievement as controlling variables. Socioeconomic status has long been shown to be highly correlated and predictive
of overall academic achievement (Attewell & Domina, 2008; Caldas & Bankston, 1997; Clemons, 2008; Lewis, 2007; Shernoff & Schmidt, 2008; Sirin, 2005; Stanfiel, 1973; White & Reynolds, 1993). This study aimed to add to the collection of research findings so policy makers may have clear scientific findings regarding secondary mathematics graduation requirements and subsequent college admissions standards—knowledge that would hypothetically be useful in facilitating eventual bachelor’s degree completion by a larger percentage of students in America. This study will arguably give more students more opportunities in choosing a career path—the hallmark and motivation of this research is student opportunity.

Background of the Study

Recent research has indicated that secondary mathematics is the strongest predictor of successful completion of a bachelor’s degree (Adelman, 1999, 2006; Rose & Betts, 2001; Scott & Ingels, 2007; Trusty & Niles, 2003). However, recent college enrollment suggests that not only do average or prototypical students avoid challenging mathematics courses in high school, they avoid mathematics their entire senior year of high school before beginning their postsecondary education careers. This avoidance
exists and seems to have increased in the past 10 or 15 years (Ma, 2000a; SREB, 2005a, 2005b). The avoidance of advanced and intense mathematics in high school has debatably led to college service-level and remedial mathematics enrollments growing at many public four-year institutions. A random online search of course enrollments indicated 50-80% of college freshmen at public four-year institutions begin college mathematics in a basic algebra course or a remedial mathematics course. Thirty years ago, very few four-year institutions offered remedial and service-level mathematics courses. If a college or university offered these courses, then the classes had small enrollments. Adelman (2004) indicates that these types of college mathematics courses comprise half of the top ten courses failed or withdrawn in postsecondary education in the past two decades. Debatably, students have to spend greater time in college mathematics because they lack the mathematical knowledge to begin college mathematics beyond an algebra course. Mathematics seems to have emerged as the gatekeeper by which many students either complete or do not successfully complete their higher education goals (Moses & Cobb, 2001; Moses & Cobb, 2002; Rech & Harrington, 2000). Mathematics typically ends
up being a prominent factor by which many students are
forced into a collegiate major with less of a mathematics
requirement to complete a bachelor’s degree, or worse, they
do not finish college because of the rigors of
postsecondary mathematics. Hypothetically and financially
speaking, students may spend additional semesters trying to
complete the mathematics requirements for their major.
Hence, the result ends up costing students, taxpayers, and
higher education thousands of extra dollars; this
expenditure in both human and financial resources may have
been prevented or reduced had students received adequate
mathematics preparation in high school prior to attending
college.

A national debate about increasing high school
mathematics graduation requirements and subsequent college
admissions standards has taken center stage in many states.
Ma and Wilkins (2007) indicate the debate is about whether
the content of secondary mathematics courses or the
quantity of courses is a more important influence in
preparation for college coursework. This study looked to
discover the importance of the quality and quantity of
secondary mathematics on the path to a bachelor’s degree.
In America, some states have already raised high school mathematics credit graduation requirements for college bound students. Other states have begun to reevaluate existing requirements. Through state legislation, a few states such as Georgia and Massachusetts have tried to hold school districts financially responsible for remedial costs in higher education. Additionally, state boards of higher education or regent boards have reexamined college admissions standards (SREB, 2005b). These changes, proposals, and evaluations look to reduce college remediation in mathematics and increase college mathematics readiness.

Nationally, data and research support secondary mathematics as one of the most important factors influencing students to maintain momentum on the path to a bachelor’s degree. However, certain groups of students such as students from inner city and urban schools, rural schools, or poorer school districts may be at a serious mathematics disadvantage upon high school graduation. Theoretically, by examining the link between secondary mathematics and college degree completion nationally, this study looked to produce additional scientific evidence about the true importance of continuous enrollment in and
intensity of secondary mathematics for the advancement of young adults’ human capital in order to provide opportunity for America’s next generations.

The opening chapter lays out the background for this study designed to test three additional secondary mathematics enrollment variables that might strengthen the predictive ability of current regression models for the completion of a bachelor’s degree. Additionally, this study looked to contribute to existing research that already has established the importance of secondary mathematics on bachelor’s degree completion. For example, this study should serve researchers with more insight as to why secondary mathematics is vigorously correlated with bachelor degree completion. Further, this study provides testimony regarding secondary mathematics requiring further rigor and time devoted to mathematics in college preparation curricula. These potential benefits seem practical and theoretically important to America’s youth in order to increase students’ opportunity and human capital. The last 50 years has seen secondary mathematics receive criticism and increased importance.
The History of Increasing Secondary Mathematics

On October 4, 1957, the Soviet Union was the first country in the world to put a satellite into space. When the Soviet Union put the satellite Sputnik into space, the United States along with the rest of the developed world saw the Soviet’s success as a testament to the shortcomings of the United States’ educational system. The Soviet’s success, in effect, had been assured by the comparatively poorer quality of schooling in the US, especially the lack of rigor in the teaching and learning of mathematics and science. As a result, the so-called New Math curriculum was developed (Barlage, 1982).

New Math stressed mathematical structures through abstract concepts like set theory and number systems with bases other than 10. Beginning in the early 1960s, this new educational canon was implemented, not only in the United States but also all over the western world. Western countries were driven to catch up to the Soviet Union’s seeming technological pre-eminence. However, because parents and teachers felt New Math was too advanced for secondary classrooms, this curriculum was short-lived. Additionally, that New Math was outside students’
accumulated experiences (Bacon, 1965; Klein, 2003; Rappaport, 1977).

On July 20, 1969, the United States landed on the Moon, a feat that in effect put the New Math of the 1960s to bed. The historic event led to the western world erroneously believing that free-world technology had caught-up or surpassed Soviet technology. As America entered the 1970s, the United States’ mathematics education curriculum went back to the basics, curricula that focused on basic arithmetic, computation, and algebraic skills. By the end of the 1970s, however, decline seemed once again to overtake U.S. schooling (Barlage, 1982). In April of 1983, A Nation at Risk was published and a storm of worry revisited the American education system.

A Nation at Risk claimed massive problems nationwide with the United States’ education system. More specifically, secondary mathematics was of utmost concern to the nation at risk. Findings indicated that students were taking far less challenging secondary mathematics courses. Mathematics teacher shortages existed in more than 80% of states in America. Hence, over one-half of newly employed mathematics teachers were unqualified; that is to say, secondary mathematics teachers did not possess a
bachelor’s degree in mathematics and/or did not possess a state teaching license in mathematics (National Commission on Excellence in Education, 1983). Throughout the late 1980s and early 1990s, an increasing number of students graduated from high school with more mathematics credits in algebra and geometry than in the 1970s and early 1980s (Adelman, 1999; Rose & Betts, 2001). Arguably, this increase in mathematics course taking resulted from A Nation at Risk’s findings. Also evident during this time period, college bound students entered higher education with more advanced mathematics credits such as trigonometry pre-calculus, and calculus. As a result, most states and colleges mandated three secondary mathematics credits as the stepping-stone for admission to many public colleges.

The Policy in Question

Ten to 15 years ago, very few states, if any, required more than three secondary mathematics credits as a prerequisite for entrance to public four-year institutions because these institutions typically followed the suggestions of the NAR document. The three core courses generally required were the traditional courses of Algebra-1, Geometry, and Algebra-2. Today, students in schools where integrated mathematics curricula are being used must
complete the first three courses, which is equivalent to the traditional sequence.

Recently some states have raised their requirements to four mathematics credits for admission to public four-year institutions. States, however, rarely require the fourth course to be trigonometry or pre-calculus or a course beyond a third integrated curricula course. Electives such as statistics, discrete mathematics, or advanced math typically satisfy the additional credit mandated by boards of higher education and/or state departments of education. Moreover, some states actually allow two credits in algebra-1, typically referred to as algebra-1A and algebra-1B, to count toward the requirements. Policies in North Carolina and Georgia have required four credits (through algebra-2 or beyond) for admission to public four-year schools for years. For the 2008 incoming college freshman, West Virginia will require four mathematics credits. Further, a short list of states has instituted an increase from three to four credits that will take place over the next few years. For example, Colorado’s freshmen entering public four-year institutions in 2010 will be required to complete four mathematics credits. Nonetheless, other states (e.g., Alabama and Kentucky) still require only
three mathematics credits (see appendix A for example policies in selected states) for admission to public four-year schools. There exists a lot of admissions variations within states at public four-year schools regarding SAT-ACT test scores, GPA, and other measures, but the earned credits in specific subjects tends to go across the board within states.

*How & Why States Justify a Policy Change.*

States’ higher education commissions or boards of regents, with input and/or recommendations from higher education institutions, have used data from studies such as Adelman’s *Answers in the Tool Box* (1999) and *Toolbox Revisited* (2006) or the Southern Regional Education Board’s (SREB) reports on higher education to warrant policy change for admission to public four-year institutions. State departments of education have also increased secondary mathematics graduation requirements in an attempt to increase students’ college mathematics readiness. Simultaneously, of course, state departments of education and higher education institutions have an interest in decreasing remedial mathematics coursework in higher education. In theory, the four-credit policy seems to imply students will have mathematics continuously in high school
rather than taking a year off from mathematics just before college. The increase to four credits can thus be understood as a reasonable tactic to short-circuit the need for remedial mathematics among college freshmen.

Furthermore, a large number of collegiate majors outside humanities and literature require the completion of at least one calculus course. Thus, today’s generation of students who enter college have a challenging mathematics path to complete.

At some four-year non-selective institutions, more than two-thirds of incoming freshmen start out in service-level or remedial mathematics courses. This deficiency sometimes results in one, two, or three additional semesters of mathematics coursework in preparation for enrolling in a calculus course required by a student’s major course of study. These extra semesters theoretically may delay students entering their major course of study for a year or two. Additionally, remedial and high service-level mathematics course enrollments fatigue university mathematics departments and drain resources while increasing student costs. As a result, service-level mathematics courses end up being taught in large lecture formats (40 to 300 seats as discovered browsing online
enrollment across the nation). Students who require mathematical assistance are placed in classroom settings least conducive to the sort of learning tasks that confront them; indeed, it seems sadly ironic that educators should imagine that remediation would be possible, let alone effective, in such settings. Colleges, however, reap the benefits of lecture-hall sized classrooms; they are revenue-generating sources of income on campuses nationwide. One may assume some institutions of higher education may arguably be reluctant to give up these revenue-generating classrooms because higher education budgets are stretched thin.

All of these reasons, including fiscal decisions, have led some states to adopt the increase of secondary mathematics credits from three to four in an effort to increase college preparedness of today’s college bound students. Hypothetically, more challenging mathematics coursework in high school may result in greater classroom work ethics and achievement. In time, most states may well follow suit; that is, if additional research conducted in the states already following the four-credit requirement seems to confirm the hoped-for benefits of such a policy.
Statement of the Problem

On its face, it may seem that a policy change from three secondary mathematics credits to four is needed or justified. However, decision makers still lack a breadth of research debatably needed to set the appropriate policy or to fine-tune partially effective policies. In this light, additional research will help to develop knowledge about influences and relationships between secondary mathematics and college success that can improve policy decisions.

Better policy could minimize or even eliminate a large percentage of mathematics remediation at the college level, while at the same time keeping higher education accessible to students from a wide range of backgrounds when higher education costs are reduced. Stronger policy may also shorten the time to degree completion for students in higher education, while simultaneously increasing college graduation rates. Hypothetically, this would reduce education costs for both students and institutions of higher education, thus making college more affordable, accessible, and doable for more students.
Research Questions and Hypotheses

Research Question
Do continuous enrollment in secondary mathematics, mathematics intensity level, and enrollment in algebra prior to high school (grade 9) predict the successful completion of a four-year degree beyond the predictors of highest mathematics course completed and Adelman’s overall academic intensity measure?

Hypothesis 1.
Students who remain continuously enrolled in secondary mathematics are more likely to complete four-year degrees.

Hypothesis 2.
Students with a higher secondary mathematics intensity level are more likely to complete four-year degrees.

Hypothesis 3.
Students who enroll in algebra-1 (or equivalent) prior to high school are more likely to complete four-year degrees.

Significance of Study

Practical Implications

The purpose of this study was to extend and strengthen Adelman’s 1999 and 2006 Toolbox research regarding secondary mathematics preparation for higher education in
order to improve future policy decision-making and inform the public. Practical implications possibly resulting from this study include: (a) Higher secondary mathematics achievement resulting in more students fully prepared for college mathematics; (b) remediation in mathematics may be reduced significantly at higher education institutions; (c) time to degree may be reduced significantly and will not extend well beyond the normal four years; (d) college graduation rates and freshman retention may be increased; (e) lower costs of higher education for students and colleges; (f) smaller class sizes for service-level and remedial mathematics courses; and (g) increased adult population possessing a bachelor’s degree.

Theoretical Implications

Researchers can posit the argument that the upper quartile of intelligent and motivated students will take more mathematics, achieve, and finish college much more frequently than the two middle quartiles of college bound students. This argument may explain why the highest mathematics course taken in high school is a leading predictor of college completion. Researchers can also argue that cultural and economical conditions explain low educational achievement and attainment. Both arguments have
the potential to explain much of the highest and lowest quartiles of high school students completing or not completing a bachelor’s degree.

This research looked to strengthen the argument that the middle two quartiles of high school students seeking four-year degrees can be positively affected by a challenging secondary mathematics curriculum and strong encouragement by educational influences on the path to a bachelor’s degree. Statistically, the argument was that adding the variables of early entry to algebra, secondary mathematics intensity, and continuous enrollment in secondary mathematics would strengthen regression models that predict bachelor degree completion. This research proposed that current models might not be adequately specified. The proposed inadequacy of existing models considering only highest mathematics and overall academic intensity (by Carnegie credits earned) may provide insufficient information for prudent policy making. Further, not all students necessarily need to be driven to pre-calculus or calculus in high school; early, intense, continuous, and challenging mathematics may make the difference for prototypical students who seek to complete a bachelor’s degree.
Limitations and Delimitations of the Study

Limitations

This study presents a number of limitations. For one, it required access to student level transcript data over a long period. The most recent data existing today that allowed for such a longitudinal study are the completed National Center of Educational Statistics (NCES) longitudinal studies NELS:88-2000, HS&B:1982, or NLS:1972. These large national longitudinal studies possessed the data needed for this research. NELS is the most recently completed study and uses data from eighth graders in 1988, high school graduates of the class of 1992. It has follow-up surveys and data collection in 1994 and 2000. The sample size of these data sets is extremely large, thus allowing the study to examine a nationally representative sample of the population. However, NELS used cluster sampling techniques and certain demographics are under or overrepresented. Research using the NELS data set requires the use of a weighted analysis so standard errors are not inflated.Weights must be used to counteract for unequal probabilities of selection and to adjust for the effects of non-responding students in the sample (Thomas & Heck, 2001).
Thus, by using weights appropriately, researchers can generalize to national and/or specific target populations.

Student level data such as mathematics courses completed, grade level taken, grades in the courses, and college transcript data may not be enough to make strong conclusions. The quality, not necessarily quantity, of mathematics courses taken in high school was addressed by constructing the MIL variable using as many applicable variables available as possible. SAT and ACT mathematics scores were used in addition to the NELS administered assessment scores recently converted to NAEP equivalent scores and published by Scott & Ingles in September 2007. However, not all of these variables may be enough to account for the quality of students’ mathematics preparation in high school. This circumstance may pose a minimal threat to conclusions.

The data revealed high correlations and predictive results. Conclusions may not necessarily be caused by the variables tested. On one hand, students who took mathematics continuously through high school may just have been driven to succeed more than students who were not continuously enrolled. On the other hand, one must consider that continuous enrollment in challenging mathematics
courses may have instilled the drive to be successful. Either way, it seems that instilling good study habits and work ethics prior to college might benefit all students pursuing a degree in higher education.

Finally, this research is limited to the variables available within the NELS data set. A comprehensive review of all NELS variables was performed alongside a review of Adelman’s PETS variables. Thus, this study is limited to the analysis of these variables alone. See Appendix J for NELS and PETS variables used in this study.

**Delimitations**

Delimitations of the study will be the clustered sample of the population in the NELS data set. It is entirely possible that Appalachia, the upper mid-west, and/or other clusters are underrepresented in the data. American Indians and Asians were over-sampled in NELS. This study examined only students with complete secondary and postsecondary transcript data. The traditional sequence of mathematics courses such as algebra-1, geometry, algebra-2, trigonometry, pre-calculus, and calculus were virtually ubiquitous in secondary schools in 1988-1992.

Today, however, many new curriculums integrate topics from traditional courses although they are not, in fact,
widely used. The National Council of Teachers of Mathematics (NCTM) encouraged massive mathematics curriculum changes after 1992. Reform mathematics curriculums would be present on some high school transcripts within the current NCES data set, ELS, but not in NELS. More traditional mathematics curricula would be present in the NELS data set. These new modern-day reform math curricula may vastly alter how we view secondary and pre-college preparation in mathematics. This study did not intend to make comparisons between traditional and contemporary curricula. This study aimed to find additional secondary mathematics enrollment variables that significantly influence college success. The results may not necessarily be extendable to current integrated mathematics curricula. However, researchers may be able to generalize results to continuous enrollment in high school mathematics.

A number of factors that may influence or affect college graduation were not reviewed for the literature review in this research. Secondary school subjects other than mathematics connected to college success were not reviewed. This delimits this research to only secondary mathematics and demarcates the line of generalization to
that subject area. Additionally, higher education research was limited to the review of secondary and higher education success connected solely to mathematics. Thus, mathematics jointly researched with other subjects affecting college successes/failures may exist but was not located using descriptors mathematics, education, higher education, graduation, and secondary, in many combinations.

Definitions of Terms

Graduation Rates (Successful completion of a college degree) - When referring to college students’ graduation rates, nearly all four-year colleges define graduation rates as first-time freshman enrolling in a fall semester and completing a four-year degree within (150% of normal time) six calendar years. For example, a freshman enrolling in August of 2000 would need to complete his/her bachelor’s degree by the end of summer in 2006. Some colleges have quarters or trimesters rather than semesters so typically graduation rates use six calendar years.

Human Capital - For the sake of this research, human capital was conceptualized to represent opening up doors of opportunity, an individual’s productive ability, the knowledge an individual possesses, and the ability to learn and adapt in today’s world (Becker, 1993).
Intensity of high school mathematics curriculum (MIL) – Assessments and grading in every classroom in America are not standardized within the educational system; thus, a student with an A on the transcript may have learned less than a student with a B in the same course at a different school. High and low stakes standardized measures were used to classify the mathematics curriculum intensity level (MIL) and achievement rather than high school GPA in mathematics. Additionally, student, teacher, parent, and principal questionnaires were examined in the determination of a student’s MIL (greater detail on the construction of this variable is outlined in chapter 3). Finally, the graduation requirements were considered as a measure for ranking the intensity of a student’s mathematics curriculum and rigors of secondary mathematics.

Middle School – Grades 6 through 8.

Non-Highly Selective Institutions – Public four-year institutions that were not classified as ‘highly selective’ under the NELS-PETS variable REFSELCT (see appendix J). This includes selective, open admissions, non-selective, open-door, and unrated institutions.

Prototypical College Student – The student hypothesized as the universe of study in this research.
This is the prototypical student referred in this research who attended college in the fall after high school graduation, enrolled full-time at non-highly selective institutions, and attended a four-year school at some point in postsecondary education. Delayed entrants to college are not part of this study’s participants analyzed. Two-year original enrolling students must have enrolled in a four-year school at some point in higher education to meet this definition. This universe of students was derived by using specific PETS variables listed in appendix J.

Remedial Mathematics Courses – Developmental (algebra remediation) or non-credit mathematics courses at the college level.

Secondary Mathematics – Mathematics in grades 9 through 12.

Service-Level Mathematics Courses – The family of pre-calculus courses that include college or applied algebra, trigonometry, geometry, finite mathematics, liberal arts mathematics, and pre-calculus. For this study, applied, business, and mainstream calculus were not considered service-level mathematics courses.
Summary

This study attempted to strengthen current and future secondary mathematics curricula and graduation requirements for college-bound students. It examined the previously mentioned secondary mathematics variables that further increase the odds of college success and subsequent bachelor degree completion. A change in current policy will encourage secondary mathematics teachers and students to have success in mathematics. For future students planning to go to college, success in this context means increased secondary mathematics workload and college preparation accountability during high school. For secondary mathematics teachers, it means more accountability in preparing students bound for college. For school administrators, it means expanding secondary mathematics enrollments and course offerings. For policy makers, it means reexamining the language of current policy and debating the language that reflects appropriate practice.

This study raises concerns that may not be accepted first hand by some. However, the concerns should not overshadow the big picture, which is to further the educational attainment and human capital of all citizens of the United States while raising society’s estimated
importance of secondary mathematics education. This study did not intend to imply all students should be forced or tracked into a bachelor degree seeking secondary curriculum, nor did this study imply that all students should pursue a bachelor’s degree to increase America’s standing in a global economy. However, this study did intend to demonstrate which secondary mathematics paths give students the best opportunity to successfully complete a bachelor’s degree if the student so chooses to pursue a bachelor’s degree at an institution of higher education. Additionally, structures need to be in place that will allow students to accomplish their educational goals.

Organization of Study

This study is organized into five chapters. The first chapter introduces a brief overview of the study at hand, the research question, the hypotheses, and brief discussion of the methodology. Chapter 2 is a review of the associated literature documenting secondary mathematics linked to the successful completion of a bachelor’s degree. Chapter 2 is presented chronologically from eighth grade through college graduation. Chapter 3 includes information regarding the process of selecting the participants of study, the variables of analysis, methodology and procedure for
creating the MIL variable, the statistical analyses to be performed, and the statistical assumptions. Chapter 4 presents the results of the statistical analyses of the data and subsequent secondary analyses. Chapter 5 provides a summary of all analyses and the interpretation of the results. Additionally, recommendations are presented in an effort to inform practice and future research.
CHAPTER 2: REVIEW OF RELATED LITERATURE

Introduction

This chapter has three overarching sections. The beginning of the chapter lays the framework for the study’s theoretical position. The opening section briefly examines related literature that explores secondary mathematics variables related to college success. Additionally, the opening section makes the argument for exploring additional secondary mathematics variables untested as possible predictors of bachelor degree completion. The opening section concludes with the study’s theoretical position derived from existing research.

The second section delves more deeply into the related research. It follows the path from middle school mathematics through high school and then college. This section discusses the strengths and weaknesses of the related literature. The final section of the chapter summarizes Adelman’s (1999, 2006) research. The end of the last section summarizes the chapter and addresses some concerns existing research findings invite.
Topical Overview

To fully understand the secondary mathematics enrollment factors related to obtaining a bachelor’s degree, tangibles need to be researched. These tangibles include: (a) The number of mathematics credits a student completes in high school; (b) the highest mathematics course completed in high school; (c) the intensity of a student’s high school mathematics coursework; (d) a student’s secondary mathematics achievement; (e) a student’s secondary mathematics course enrollment patterns (i.e. early entry into algebra, continuous enrollment in secondary mathematics); (f) mathematics remediation in postsecondary education; (g) successes and failures in postsecondary coursework related to mathematics; and (h) the completion of a four-year degree related to mathematics coursework. Each of these variables have correlations to an extent, some more than others (Adelman, 1999; Adelman, 2006; Ma, 2005b; Ma & Wilkins, 2007; Parker, 2005; Rose & Betts, 2001; Scott & Ingels, 2007; Trusty & Niles, 2003). Although secondary mathematics is supported by research as a key academic predictor of completing a bachelor’s degree, a magic bullet variable that directly influences the
successful completion of a bachelor’s degree does not exist.

In the past two decades, tangible factors related to the prediction of college success have received intense research while some have been untested. For example, Adelman (1999, 2003, & 2006), Rose & Betts (2001), and Trusty & Spencer (2003) indicate the highest secondary mathematics course completed in high school is one of the most significant predictors of bachelor degree completion. Specifically, secondary mathematics curricula have a strong effect on college graduation. More advanced [higher] mathematics courses have more of an effect on college graduation than unchallenging courses. Adelman (2006, p.xix) reports that “the highest level of mathematics reached in high school continues to be a key marker in pre-collegiate momentum, with the tipping point of momentum toward a bachelor’s degree now firmly above algebra-2.” Further, the number of secondary mathematics courses completed is important but not as important as the rigor of the mathematics courses (Rose & Betts, 2001). Trusty & Spencer (2003) indicate that intense mathematics courses (algebra-2 and above) provide the stepping-stones to completing a bachelor’s degree.
That said, it becomes important to the researcher to define an intense mathematics curriculum. Adelman (2006) made a strong assertion that a **rigorous curriculum** in high school can be a huge misnomer. Two students who complete a **rigorous curriculum** at school A and school B may have received instruction with very different standards for success. Student A in school A could have a 4.0GPA in mathematics and so could student B in school B. However, student A may be in the top quartile nationally in mathematics achievement while student B may be near the national mean. The interpolation of this observation is supported by the research findings of Hoyt & Sorensen (2001) whose research indicates the number of mathematics courses or highest mathematics course taken must be interpreted with caution. For example, they report that 30% of students in New Jersey who took calculus in high school failed to demonstrated proficiency in elementary algebra. Mathematics achievement at this level debatably equates to earning a C in algebra-1. Student A and student B both completing high school calculus in two different schools may possess vastly different mathematical ability. Hence, the variable of academic intensity ends up being the preferred measure of college preparation rather than solely
the highest mathematics course completed. By examining the extent by which secondary mathematics intensity contributes to the likelihood of completing a four-year degree, it can be postulated that researchers can then demonstrate the need to strengthen both policy and mathematics curricula intensity nationally.

As students prepare mathematically for college, a number of significant variables influence mathematics achievement in secondary schools. For example, Ma (2000a, 2000b, 2003, & Jiangmin 2004, 2005a, 2005b, 2005c) indicates that early entry into algebra in grade eight results in greater mathematics growth in high school for all ability levels. Ma & Wilkins (2007) indicate that if students delay entering algebra until grade nine, statistically speaking, students will regress in mathematical ability during their senior year of high school. Additionally, earning more mathematics credits in high school is another variable resulting in higher mathematics achievement (Ma & Wilkins, 2007; McClure, Boatwright, McClanahan, & McClure, 1998; Ozturk & Singh, 2006; Reynolds & Walberg, 1992). The farther up the mathematics ladder a student climbs, the more a student achieves mathematically.
Higher mathematics achievement in high school will lessen the likelihood that a student needs remedial mathematics coursework upon entering a postsecondary institution. Research has demonstrated that in addition to lowering the likelihood that students will complete a four-year college degree, students who enroll in remedial mathematics courses in college take longer to complete a four-year degree (Attewell, Lavin, Domina, and Levey, 2006). Further, mathematical skill deficiencies not addressed in high school impact college students by placing them in remedial or service-level mathematics courses. These skill deficiencies influence achievement in non-mathematics courses and ultimately program completion (Hagedorn, Siadat, Fogel, Nora, & Pascarella, 1999; Illich, Hagan, & McCallister, 2004; Jacobson, 2006; Johnson & Kuennnen, 2004). As Parker (2004, p.29) aptly phrased it, “a student’s timely progress to a four-year degree is in one way reflected in his or her success in mathematics, particularly when one compares the success rates and failure rates of students in mathematics courses.” The sequential path from algebra in middle school to the completion of a bachelor’s degree is a distinct path worth further investigation.
Theoretical Position

If prototypical college-bound students are given the opportunity to enroll in algebra in middle school and encouraged to do so, then they will achieve and grow mathematically if they remain continuously enrolled in challenging and intense mathematics courses through high school graduation. Subsequently upon entering college, these students will not be placed into remedial mathematics courses and will have the highest probability of succeeding in college mathematics and general courses while completing a bachelor’s degree in a timely fashion (see Appendix B for concept map). Many parts of this theory are well supported by existing literature. This research aimed to clarify, extend, and strengthen existing research findings. More importantly, this research seeks to demonstrate that continuous enrollment in secondary mathematics, early entry to algebra, and secondary mathematics intensity level (MIL) can increase the odds that average mathematics achieving students will complete a bachelor’s degree.

In addition to the mathematics variables previously mentioned, it is important to note there are many other distal and propensity variables that may contribute to the successful completion of a bachelor’s degree. Some distal
variables include parental income (SES), parental expectations, and middle school (prior) mathematics achievement. Propensity variables include student motivation, expectations, ability, and self-efficacy. While it is true that secondary schools rarely can affect distal variables, secondary schools can make valid efforts to increase propensity variables. Secondary school personnel can instill values while motivating and encouraging students to reach goals and, thus, increase student ability at the high school level. Hence, propensity variables that were available in the NELS data were incorporated into the MIL variable. When possible in educational research, distal variables are used as controlling variables. This study looked to use SES and eighth grade mathematics achievement as controlling variables in the analysis. The methodology will be discussed further in chapter 3.

Possibilities of Theoretical Divergence

The proposed theory hinges on two important concepts untested in research. First, controlling for SES and prior achievement, students must remain continuously enrolled in mathematics from middle school through high school graduation. Last and most important, secondary mathematics coursework must remain intense, and standards must not be
compromised for all college bound students throughout high school. If either of these concepts fails, the proposed theory will not yield a significant increase in the odds of completing a bachelor’s degree.

Additionally, high correlations between secondary mathematics variables and bachelor degree completion do exist in current research, and correlations may be increased by incorporating this study’s additional variables of study. However, correlations do not necessarily imply causality though strong correlations in existing research appear to yield partial causality. From a policy perspective, it is important to know more about the links between secondary mathematics and college graduation. Without further research and policy debate, appropriate practice may elude policy makers. Hence, existing policy may affect student educational attainment and the human capital of every student in our society. Students who increase their human capital will have more opportunity to choose a career path of their choice. This study aspired to give more opportunity to students.
Review of Existing Literature

Overview of this Segment

This segment evaluates the strengths and weaknesses of existing research that support the underpinnings of the proposed theory. Sequentially, this segment begins by examining middle school mathematics in an effort to examine mathematics achievement before high school. Next, the section examines the research supporting secondary mathematics achievement factors and then continues through college coursework and evaluates the research theoretically tying secondary mathematics to college graduation. Last, a brief summary of research regarding secondary mathematics and college graduation is discussed.

Middle School Mathematics Achievement

From 1978 to 2004, middle school mathematics achievement has consistently risen (U.S. Department of Education, 2007). Since 1978, eighth grade students in public schools have steadily increased achievement scores by nearly two full years of academic achievement. This means a student in eighth grade in 2004 had the same achievement scores as a tenth grade student (on average) in 1978. Perie et al (2005) indicate that 10 NAEP scale points
equate to one year of academic achievement. In 1978, public school eighth graders’ national mean score was 263. In 2004, the mean score was 280. The 17 points equates to 1.7 years of increased academic achievement in mathematics. For nearly 20 years, America’s middle school students have consistently increased their mathematics achievement. The increase in national means during each testing year for eighth grade students has been reported to be significant (Braswell et al, 2003; Perie et al, 2005). Statistically significant increases each testing year arguably implies mathematical academic progress is being made at the eighth grade level nationally.

Debatably, it seems more students are prepared to begin rigorous and challenging secondary mathematics than students were prepared in prior decades. Additionally, the research hypothetically indicates that a large percentage of middle school students have the ability to enroll in algebra prior to high school. Specifically, over two-thirds of eighth grade students tested at the proficiency level of basic or above in mathematics achievement in 2004 while nearly one-third tested proficient or advanced. However, NAEP reports only about one-quarter of contemporary middle grade students enroll in algebra prior to high school, up
from about one-fifth in 1992. There are a few reasons some students are not afforded the opportunity to take algebra prior to grade nine. For example, in some rural middle schools, algebra is not always offered. In some disadvantaged urban middle schools, parent and student demand for algebra in middle school is low. Hypothetically, this may be due to college enrollment failing to be a long-term goal for students and parents. Additionally, some schools only have a limited number of seats in eighth grade algebra and are typically available to high achievers over average achievers. Schools sometimes do not encourage average achievers to enroll in algebra in grade eight. Whatever the situation, reasons do exist that prevent some students from entering algebra prior to grade nine. These examples may well be reasons some algebra-ready students fail to enroll in algebra-1 in grade eight. Hence, these examples could highlight why NAEP reports only 20% of eighth graders enroll in algebra-1 while one-third of students are proficient or advanced in mathematical ability in grade eight.

Another important issue needs to be considered. NAEP reports on all middle grade students rather than specifically on students with the expectations of attending
college. Student expectations were not an available variable for analysis in many NAEP testing years. Therefore, researchers and policy makers are faced with the question: Should at least one-third or maybe one-half of middle school students be enrolled in algebra before high school? These facts seem to signify that roughly two-thirds of college bound students would enroll in algebra-1 prior to grade nine. The implied benefits of increasing algebra enrollment in grade eight for average achieving college-bound students are discussed next.

*Early Enrollment in Algebra*

Since 2000, Xin Ma, a professor of mathematics education in the College of Education at the University of Kentucky, has established himself as a leading researcher on the effects of students entering algebra-1 prior to grade nine. Having published numerous peer-reviewed publications regarding long-term secondary mathematics achievement related to early entry into algebra in middle school for students of all levels of ability and prior achievement, Ma (2005a, 2005b) reports strong evidence that accelerating average students into algebra in middle school outweighs the doubts of such a policy. Ma (2005b) claims:
The Longitudinal Study of American Youth (LSAY), a six-year (Grades 7–12) panel study of middle and high school students, is particularly well suited to the current analysis because the LSAY focuses on mathematics (and science) education and includes measures of student and school characteristics across junior and senior high school years. (p.107)

In both published articles, Ma claims that accelerating low-achieving students into algebra in middle school is more beneficial than the acceleration of high-achieving students. To be precise, the rate of growth in mathematics achievement for accelerated low-achieving students is far greater than the growth rate of accelerated and non-accelerated honors and gifted students. The idea of holding back average students from algebra in grade eight debatably may drastically lower a students’ future human capital.

Ma examined specific content strands of mathematics to pinpoint more accurately the mathematical growth for students of different ability levels. These strands were basic skills, quantitative literary, algebra, and geometry. Although growth rates varied, accelerated low-achieving students grew at greater rates than all other classified students did. Ma contends that preventing low-achieving
students from accessing algebra in middle school may set them up for failure in high school. Moreover, denied access to algebra in middle school for average-achievers may result in boredom and the loss of motivation in secondary mathematics classrooms. Hypothetically, lower mathematics achievement may be the result when average students are held back from growing mathematically and placed in non-intensive classrooms with non-college bound students.

The LSAY used a nationally representative sample of students while tracking them from grade seven to grade twelve. Additionally, Ma used hierarchical linear modeling (HLM) techniques, which allows for student, parent, and school level variables to be factored into student achievement. Growth rates were highly correlated across all mathematics strands. However, Ma contends the LSAY population is too small for more advanced statistical analyses because of the number of participants and fewer variables needed to perform advanced research. Additionally, data was not available for LSAY participants prior to seventh grade nor was teacher and curricula information available. This introduces the possibility of skewed results because classroom variables and prior achievement are very important variables to consider.
Ma & Wilkins (2007) further advanced the analysis of the LSAY by examining the when aspect of enrolling in mathematics courses, namely, when specific mathematics courses were taken and how mathematics achievement is connected to when students enrolled in specific mathematics courses. Ma & Wilkins’s (2007) indicate students who wait to enroll in algebra until the ninth or tenth grade have two significant disadvantages compared to their counterparts who enroll in algebra prior to grade nine. Students who took algebra-1 in seventh or eighth grade saw steady growth in mathematics achievement all throughout high school, regardless of ability while students who delayed algebra-1 until ninth or even tenth grade saw a regression in mathematics achievement during the later year(s) of high school. The drop in achievement could signify the reasons why these students may avoid mathematics their senior year and supports the contention that continuous enrollment is important to mathematics achievement prior to college. Second, there is a large achievement gap between these two groups. Students who do not enroll in algebra prior to high school lag behind dramatically in mathematics achievement. This result signifies a higher probability of mathematics remediation
at the college level for these students. Arguably, the most important conclusion drawn by Ma & Wilkins (2007) is:

Overall, given the mathematics courses that we investigated, our findings highlight the importance of pre-algebra, algebra-1, and trigonometry that can make important contributions to a healthy growth of all students in mathematics achievement. Our findings suggest that the mathematics content of these courses is useful for advancement in mathematics achievement independent of their preparatory values for more advanced coursework and may provide those students who do not intend to take more advanced coursework with valuable alternative courses for continued growth in mathematics achievement. (p.254-255)

These findings support part of this study’s theoretical position. College bound students should hypothetically have access to algebra in middle school but must remain continuously enrolled through high school graduation. Otherwise, the tipping point of pre-collegiate momentum beyond algebra-2 (Adelman, 2006) would not be reached by many students. Students may well choose to stop climbing the mathematics ladder before high school graduation after reaching the minimum number of credits needed for high
school graduation and college admission. Thus, continuous enrollment, from a policy perspective, warrants scientific study as one reasonable approach to increase college mathematics readiness.

The strengths of the Ma & Wilkins (2007) study are demonstrated by multiple analysis methods. The use of graphical analysis and a two-level HLM model yield strong results with sound methodologies. The weakness of the study for policy debate is the LSAY is a relatively small national database tracking mostly science and mathematics related variables. The Ma & Wilkins study can be improved with analyses performed on a greater sized database. Additionally, the collection of data was primarily before NCTM implemented the curriculum and evaluation standards in place today. The modern courses of probability and statistics or discrete mathematics were not incorporated into the study. The largest weakness is Ma & Wilkins could not control for students’ self-selection, that is to say, whether or not students are placed or personally elected to enroll in algebra initially. However, the minor weaknesses of their research does not diminish the call for further research that may well provide additional findings supporting early algebra entry opportunities and the
proposed continuous mathematics requirement in secondary schools for college bound students.

*Secondary Math Achievement & Classroom Standards*

While eighth graders have shown considerable gains in mathematics achievement since 1978, the story is not the same for twelfth graders. Since 1978, NAEP long-term trend analysis indicates that only slight increases in ability and achievement (see figure 1) have occurred.

![Figure 1. U.S. Long-Term NAEP Trends for Mathematics Achievement](source)

*Figure 1. U.S. Long-Term NAEP Trends for Mathematics Achievement*

Specifically, twelfth graders have shown only a six-point increase during the same period that eighth graders showed a 17-point increase. High school seniors have actually had points in time where national achievement has regressed (U.S. Department of Education, 2007). This data strongly implies that secondary mathematics should be of serious concern nationally. Further, the data invites the following question: Are high school mathematics classrooms losing focus and failing to prepare college bound students for the rigors of earning a four-years degree at the college of their choice?

Using the ACT-math score as a dependent variable, McClure et al (1998) indicate that taking more mathematics courses in high school results in higher secondary mathematics achievement. This finding is consistent with other researchers’ findings (Ma & Wilkins, 2007; Ozturk & Singh, 2006; Reynolds & Walberg, 1992). The results indicate moving students continuously up the mathematics ladder should perhaps have students better prepared for the rigors of college coursework. However, there are mixed thoughts about whether increasing mathematics requirements will result in students being better prepared for the rigors of college coursework.
Because of variables that include grade inflation and/or variant classroom standards, students enrolling in additional and higher mathematics courses may not necessarily achieve and learn on higher levels. For example, in the New Jersey Higher Education study, Hoyt & Sorenson (2001) reported how students can complete high levels of mathematics courses in high school and yet have very low achievement and proficiency. Moreover, current research has shown that grade inflation and lower curriculum standards in secondary mathematics courses may wash out the mathematics achievement sought by increasing secondary mathematics credit requirements (Conley, 2000; Glenn, 2004; Schmidt, 2007; Sraiheen & Lesisko, 2006; Woodruff & Ziomek, 2004). In other words, students enroll in more mathematics courses, receive passing grades, but fail to grow mathematically because classroom standards have been lowered. Schmidt (2007) contends two recent publications by the U.S. Department of Education support his claim of grade inflation and lower classroom standards. ACT, inc. (2007) supports Schmidt’s claims of grade inflation and lower standards in high school mathematic classrooms. However, while grade inflation and variable class standards are provocative in of themselves, this
study aimed to demonstrate classroom intensity is an important factor for bachelor degree momentum.

The preceding discussions regarding classroom standards and grade inflation raise interesting concerns regarding increasing high school mathematics graduation requirements for college bound students. Students may hypothetically take more mathematics but fail to increase achievement and knowledge prior to college if standards are compromised. Further, research possibly supports the notion that classroom standards are significant. Additionally, the highest mathematics course taken and high school math GPA may not necessarily be the strongest variables in predicting high school mathematics achievement and college readiness. Findings in current research support this study’s theoretical perspective that mathematics intensity level is an important variable to consider while analyzing policy regarding the increase of secondary mathematics credits required for college bound students.

Mixed results, which constitute a significant weakness, exist in the previously discussed research. Some research shows slight indications of grade inflation and lower classroom standards, while other research demonstrates that grade inflation exists to a higher
degree. To further complicate the conversation, other literature asserts that grade inflation is over-embellished (Viadero, 2001). Regardless, classroom standards are more important to secondary mathematics achievement than the title of a course in which students enroll (Klopfenstein & Thomas, 2006). Research supports the need for a secondary mathematics intensity level (MIL) variable in analyzing secondary mathematics and college readiness.

**College Mathematics Readiness**

Attewell et al (2006) report approximately 31% of students entering non-selective four-year institutions took some form of remediation and that remedial mathematics is the most common remedial course in which undergraduates enroll. At one large non-selective state-supported four-year university, nearly three-quarters of incoming freshmen (74%) placed into remedial mathematics courses (Jacobson, 2006). These numbers suggest the possibility that secondary mathematics is not preparing students for college mathematics as well as it should. Additionally, college remedial and service-level mathematics courses comprise over one-half of the top-20 courses failed or dropped in higher education (Adelman, 2004). Adelman’s (2004) research indicates college mathematics readiness is a problem that
arguably stems from unchallenging secondary mathematics curricula.

Hagedorn et al (1999) and Letterell & Frauenholtz (2007) suggest solutions to the college-mathematics readiness problem. Some suggestions indicate that students who are challenged more in high school develop better out-of-school study habits. Challenged high school students are more likely to form cooperative and advanced study methods upon entering college. Additional suggestions indicate the senior year of high school should perhaps have students exercising more responsibility in their studies. Research suggests the senior year of high school should begin to resemble college classrooms in that they should begin to prepare students to exert self-discipline and responsibility for their studies. Growing remedial and service-level mathematics enrollments may well signify many students are not being challenged in their secondary mathematics college preparation courses. Policy may be an avenue to warrant further research in an effort to potentially increase mathematics achievement for a larger percentage of students for the demands of college coursework. Although some students will still require
remediation upon entering college, research does not always conclude that college remediation is untoward in of itself.

_College Remediation_

Attewell et al (2006) are strong proponents that college remediation can be beneficial and increase college success. Their research used NCES data from the NELS longitudinal study. Their findings indicate that remediation in mathematics reduces (only slightly) the likelihood of college completion. Specifically, Attewell at al summarize their findings to say, “...most of the gap in [college] graduation rates has little to do with taking remedial classes in college. Instead, the gap reflects preexisting skill differences carried over from high school” (2006, p.915). However, when only four-year degree seeking students are the subject of study, remedial mathematics students are marked for unsuccessful completion of a bachelor’s degree (Hagedorn et al, 1999). From all perspectives, students who are better prepared in secondary mathematics succeed in college mathematics more often than students unchallenged in high school, whether they enroll in remedial mathematics in college or not. The answers sought from the research noted here is whether remediation
in mathematics is a success or not for students. Success in college mathematics debatably appears to be correlated to overall college success.

**Mathematics Connected to Overall College Success**

Parker (2004, p.29) indicates that a student’s timely progress to a four-year degree is in one way reflected in his or her success in mathematics, particularly when the success rates and failure rates of students in college mathematics courses is compared. Parker’s study indicates that students who graduated from college in four years earned A’s in mathematics courses over three times more frequently than students who are still working on the successful completion of their bachelor’s degree after four years (see figure 2). Students not in college after four years earned A’s in mathematics six times less frequently than students completing a bachelor’s degree in four years did. Figure 2 shows the letter grade distribution for these three groups of students studied by Parker.

Parker (2004) indicates mathematical success decreases time to degree while keeping students on track to completing their degree. Students finishing bachelor’s degrees more quickly had higher grades while students who dropped out had more F’s and W’s. However, because this
study focused specifically on mathematics course grades, it puts forward mathematical successes and failures as a strong indicator of timely degree completion and overall college success. Further, Parker’s study points to mathematics as an indicator of non-mathematics coursework success at the collegiate level. That is to say, success in college mathematics extends into non-mathematics coursework.

In another small study, Johnson & Kuennen (2004) found that college students requiring mathematics remediation succeeded in non-mathematics courses less often than their
counterparts did. Their findings suggest that remedial students do better if they immediately enroll in remedial mathematics upon entering college. This study, along with Parker (2004), supports the contention that timely degree completion and overall college success is linked to college mathematics success.

Parker (2004) and Johnson & Kuennen (2004) share similar weaknesses. Both studies are restricted to a specific university. Each study incorporates sound methodology that uses transcript analysis, longitudinal data, course assessments, and grades. Their research tells a story that perhaps appears on campuses nationwide more than expected. Although, these studies cannot be generalized to extend to all four-year non- or semi-selective institutions, they do present insight on how researchers might conduct similar studies on a larger national scale and warrant further research. Examining transcripts on a large national scale can extend these findings to a national level while raising the national importance of secondary mathematics and college success.

Secondary Mathematics Linked to College Graduation

There are a number of secondary mathematics variables absent from research. For example, the mathematics
curriculum students experience in high school tied to their success or failure in college mathematics has yet to receive extensive research. Teacher efficacy variables are lacking quality research connected to college success. Additionally, there potentially exist a number of variables outside of secondary mathematics that may well affect college graduation. For example, the writing skills and reading ability of students impact the successful completion of a bachelor’s degree (Attewell, Lavin, Domina, and Levey, 2006). However, this study aimed to focus specifically on secondary mathematics variables available in NELS.

Clifford Adelman is often recognized as the leading researcher who has linked secondary mathematics to college graduation. The past 10 years of Dr. Adelman’s research has been influential and laid the foundation for setting up this study. In 1999, Adelman published Answers in the Tool Box: Academic Intensity, Attendance Patterns, and Bachelor’s Degree Attainment. His research used the NCES longitudinal study HS&B comprised of 1980 and 1982 high school graduates. Adelman (1999) states:

Of all pre-college curricula, the highest level of mathematics one studies in secondary school has the
strongest continuing influence on bachelor's degree completion. Finishing a course beyond the level of Algebra-2 (e.g. trigonometry or pre-calculus) more than doubles the odds that a student who enters postsecondary education will complete a bachelor's degree. (p.vii)

Further, Adelman urged college leadership to ensure admissions standards emphasize the rigor and intensity of secondary curricula over GPA, class rank, and test scores. His research indicated that overall secondary intensity (based on Carnegie credits earned) predicted the completion of a bachelor’s degree with the highest secondary mathematics course completed as the more predictive variable than overall Carnegie credit accumulation.

In 2006, Adelman strengthened his 1999 research findings by publishing *The Toolbox Revisited: Paths to Degree Completion from High School through College*. This research used the most recently completed NCES longitudinal study NELS comprised of 1992 high school graduates. Again, Adelman demonstrated on a national level that secondary mathematics is the strongest indicator of bachelor’s degree completion. However, the highest mathematics course completed in high school that predicted bachelor degree
completion changed. In 1999, the results indicated that algebra-2 completion was the tipping point; that is, where the parameter estimate changes from negative to positive, thus raising the odds of bachelor degree completion from less than one to greater than one. In 2006, the tipping point was firmly above algebra-2, i.e. the successful completion of trigonometry or pre-calculus (see table 1).

Table 1
The Math Ladder for 1982 and 1992 12th-graders: Odds Ratios and Parameter Estimates of Earning a Bachelor’s Degree at Each Rung, Controlling for SES Quintile

<table>
<thead>
<tr>
<th>Highest math in HS</th>
<th>HS&amp;B 1982 12th grade cohort</th>
<th>NELS 1992 12th grade cohort</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Odds ratio</td>
<td>Parameter estimate</td>
</tr>
<tr>
<td>Calculus</td>
<td>8.18</td>
<td>2.102</td>
</tr>
<tr>
<td>Pre-calculus</td>
<td>6.34</td>
<td>1.846</td>
</tr>
<tr>
<td>Trigonometry</td>
<td>3.76</td>
<td>1.352</td>
</tr>
<tr>
<td>Algebra-2</td>
<td>1.82</td>
<td>0.599</td>
</tr>
<tr>
<td>Geometry</td>
<td>0.63</td>
<td>-0.468</td>
</tr>
<tr>
<td>Algebra-1</td>
<td>0.19</td>
<td>-1.666</td>
</tr>
<tr>
<td>Pre-algebra</td>
<td>0.06</td>
<td>-2.778</td>
</tr>
</tbody>
</table>

† Variable did not reach minimum level of significance (p<0.10) in a two-tailed test. SOURCE: Adelman (2006).
One way to interpret the higher tipping point moving up the secondary mathematics ladder is to ascertain that secondary mathematics has become less intense or has failed to be rigorous. That is to say, high school graduates had to take more secondary mathematics to achieve the same results in higher education as the prior decade’s high school graduates. Alternatively, the change in the tipping-point could be an indication that college coursework difficulty increased. Either way, it signifies more intense secondary mathematics is needed for college bound students to achieve and succeed at the college level.

Adelman’s Toolbox transcript studies, utilizing nationally representative samples of students, are strengthened, and the results are confirmed by two additional studies. Rose & Betts (2001) solidified Adelman’s 1999 findings. Adelman’s 2006 study correlated nearly perfectly with Trusty & Nile’s 2003 findings. Additionally, this study looked to strengthen, clarify, and extend Adelman’s Toolbox results even further. Including variables for early entry to algebra, secondary mathematics intensity (MIL), and continuous enrollment in secondary mathematics enhanced Adelman’s longitudinal transcript
studies and the predictability of bachelor degree completion.

The three variables of this study are missing from analysis in these bodies of research. Trusty & Nile (2003) mention intense secondary mathematics. However, their definition is not the same as this research. Trusty & Nile’s intense secondary mathematics definition is taking advanced secondary mathematics courses rather than based on students’ achievement or the rigorous demands of their secondary mathematics courses. Finally, this study aimed to discover a definition of intense secondary mathematics that best defines bachelor degree preparation in secondary schools. A definition that potentially may reshape the secondary mathematics classroom for college bound students. That is, reshaping the secondary mathematics classroom more so than merely recommending that students need to reach trigonometry or pre-calculus in high school to increase their odds of completing a bachelor’s degree.

Because of the semi-evident lowering of secondary mathematics rigor and grade inflation, this study has postulated its theoretical perspective that secondary mathematics intensity is a variable needed to strengthen Adelman’s research (Conley, 2000; Glenn, 2004; Schmidt,
Thus, it was imperative to assign an intensity level to the secondary mathematics curricula. The notion of academic intensity is supported by the overall academic intensity variable Adelman constructed in his 2006 study. Adelman’s overall academic intensity used just Carnegie credits over the broad spectrum of secondary coursework (see appendix C). Earning credits does not necessarily imply increased achievement or college mathematics readiness (Hoyt & Sorenson, 2001).

This study intended to discover the available NELS components that define secondary mathematics intensity that predict bachelor degree completion by examining student achievement, mathematical growth, course and classroom demands, and secondary mathematics credits available for analysis. There exist a number of variables in the NELS longitudinal data available for analysis in shaping a secondary mathematics intensity level. These variables are discussed in greater detail in chapter 3.

Summary

Research indicates a well-documented link between algebra in middle school and secondary mathematics achievement (Ma, 2005a, 2005b; Ma & Wilkins, 2007).
Research also links mathematics success (Parker, 2005) to the completion of a bachelor’s degree (Adelman 1999, 2006; Rose & Betts, 2001; Trusty & Niles, 2003). These results should not come as a surprise to the research community. Students taking challenging secondary courses will succeed academically more often in college if driven to do so in a supportive environment. However, students of average ability heading to college can easily avoid mathematics their senior year of high school or complete the minimum amount of secondary mathematics coursework in preparation for college without encouragement and support to move up the mathematics ladder. Many students do avoid advanced or challenging mathematics late in high school (SREB, 2005b). Further, students of average ability completing only the minimum number of mathematics credits in high school may inadvertently sabotage their collegiate career because the results of doing the minimum sets students up for low achievement and possibly failure at the collegiate level.

This research intended to examine the theoretical position that the prototypical college-bound students should remain continuously enrolled in intense mathematics courses throughout high school. This population of students should have the opportunity to take algebra in middle
school and be encouraged to do so when college is eminent. The prototypical average student referred to signifies students who will not attend highly-selective (see definitions) four-year institutions, as well as, the students who only seek two-year degrees or certificates less than a bachelor’s degree.

The unit of analysis in this study is different from Adelman’s unit of analysis. Adelman used all students in the NELS study with high school and college transcripts. This study will utilize students who attended only non-highly selective four-year institutions specifically. A much larger percentage of students attend schools with other classifications than highly selective higher education institutions. A simple rationale explains this decision. The best and brightest who attend highly selective institutions are going to have a stronger secondary mathematics background or they would fail to be admitted to highly selective schools. Additionally, students who attended only two-year colleges could skew results because calculus is rarely required for two-year degree courses of study and bachelor’s degree attainment is the outcome sought in this study.
Conclusion

Existing research strongly indicates that mathematics achievement and mathematics preparation in high school are resilient predictors of successful coursework in higher education. It is also evident that success in college mathematics courses will ultimately decrease time to degree and increase overall college coursework success. The critical thinking skills and problem solving abilities learned within the realm of mathematics appears to proliferate into other non-mathematics courses (Johnson & Kuennen, 2004; Parker, 2005, Williams & Worth, 2001). These findings are a debatable signal that an easy or cruising mathematics curriculum in high school may be very detrimental to college success and bachelor degree momentum. This research strived to aid the parties who set policies regarding college preparation requirements in secondary school mathematics and public four-year college admissions standards.
CHAPTER 3: METHODOLOGY

This research anticipated strengthening Adelman’s 1999 and 2006 research by focusing on key additional secondary mathematics variables and a more specific target population. These key variables may strengthen the predictability of bachelor degree completion for the prototypical college bound student who may not necessarily reach the mathematics ladder rung Adelman points to as the tipping point of bachelor degree momentum. More importantly, this research may reveal that reaching a specific rung on the mathematics ladder should not necessarily be the ultimate goal of college bound students. To be precise, continuous intense mathematics enrollment (even if a course is failed) may be just as important as moving beyond algebra-2 alone. Further, the MIL may compensate for not reaching beyond algebra-2 when considering the odds of bachelor degree completion. This chapter presents the statistical methodology and rationale for this study’s analysis.

Selection of Participants

For nearly 40 years, the United States Department of Education (USDOE) and the National Center for Education
Statistics (NCES) has collected longitudinal data on students in the United States. The data is overseen by NCES, a subdivision of the Institute for Education Sciences (IES). The most recently completed national longitudinal database with both high school and college transcript data is NELS. This longitudinal study consisted of a nationally representative sample of eighth graders in 1988 in which students, parents, and school personnel were interviewed. Additionally, student achievement and transcript data were collected and chronicled. These students were then followed through high school. The students were surveyed in 1990 as sophomores and again late in their senior year in 1992. The sample was refreshed in 1990 and 1992 with a nationally representative high school class to account for the loss of participants from 1988 to 1990 and from 1990 to 1992. In 1990, this amounted to roughly 4% of the final longitudinal group and in 1992, was less than 1%. The participants were surveyed two years after high school graduation in 1994 and again in 2000, 8.5 years after high school graduation.

After the final follow-up in 2000, complete postsecondary transcript data was released for roughly 45% of the original nationally representative sample of 1988 eighth graders and 1992 twelfth graders. The base-year (1988)
sample consisted of approximately 25,000 students. Thus, roughly 12,000 students in NELS participated in the full study (1988-2000) of data collection. NELS presented an extremely large data set to proceed exploring this study’s research question and hypotheses. Such a large and methodically collected data set can allow for generalizations to the entire population, which is a strength for using such data sets.

Participants in the NELS study have been assigned weights so as to not bias against participants in which full transcript data were not collected (see appendix D for the full weight description used in this study) and to account for the complex sampling designed discussed in the limitations and delimitations section of chapter 1. Weights must be used to allow for generalization to the national population. For example, assume a population size of 200 is being studied. If two participants have vastly large outlying data from the norm and a low chance of random selection, then these two participants can greatly affect an outcome variable if weighted the same as the norm. However, by assigning a small weight to these two participants and higher weights to the group of participants more highly representative of the population
with a higher random selection probability, the outcome can be more precisely predicted, analyzed, and interpreted. Although there is merit in examining these two outlying participants for probable noteworthy findings, this study set sights on examining a nationally representative sample of students.

NELS is the most comprehensive completed longitudinal data set available for this study, and no state department of education currently has longitudinal student level data covering twelve and one-half years, though some states began the collection of student longitudinal data in recent years. Using the NELS longitudinal data for this study offers a feasible method to answer the research question posed.

Participants within NELS were selected based on the following criteria and are referred to as the universe of participants within this body of research: (a) Participants must have transcript data from secondary and postsecondary education; (b) Participants must have entered some type of postsecondary institution full-time before January-1993 after high school graduation (direct entry); (c) Participants must have attended a four-year degree granting institution at some point in time (allows for deletion of
associate-only degree seekers); and (d) Participants did not attend a highly selective four-year institution initially after high school graduation. This population is the universe Adelman studied minus high achievers and many non-bachelor degree-seeking students as discussed previously. Thus, the target population is more representative of the prototypical college student seen on non-elite four-year campuses nationwide. This population was selected and coded from within NELS by using Adelman’s PETS variables (see appendix J for actual variables). The PETS variable REFSELCT offers the classification of the first true institution attended by the NELS participant. Categories (percent of subjects attending classification) available were highly selective (3%), selective (9%), non-selective (29%), open-door (28%), and unrated (2%).

Roughly, 28% of participants had missing data or no claim to postsecondary education and were not part of the analysis.

The rationale behind these criteria was centered on the notion that this study looked to analyze whether or not the prototypical college-bound bachelor degree-seeking students should take intense mathematics continuously throughout all four years of high school after entering
algebra prior to grade nine. This research aimed to examine if such a policy significantly increases the likelihood of graduating with a four-year degree at non-highly selective four-year institutions. Even more so, this study expected to find results that would be able to establish the bridge from high school to college so to set up a bridge for a successful transition and that students pursuing a four-year degree will be adequately prepared to cross that bridge.

Part-time, late-entry, and transient students may have an infinite number of reasons why they do not attend college full-time immediately after high school or transfer from school to school. Two-year degree seeking students comprise a large percentage of the NELS population. However, the mathematical demands of two-year degrees are well below the demands for many four-year degrees. The aim of this research was to encourage discourse as to what may be the best path to successful completion of a bachelor’s degree for the more typical group of college bound students who attend non-highly selective four-year institutions. Although participants who fail to meet this criteria were not the focus of this research study, they too, could benefit from similar research that would seek to determine
if part-time or two-year college students succeed at greater rates with a more intense and continuous high school mathematics curriculum. That said, this study focused on the group of prototypical students who seek a four-year degree with the intent to do it full-time without a considerable delay after high school graduation.

These criteria generate a large percentage of the college-bound population who enter postsecondary education after high school graduation seeking a bachelor’s degree. Roughly, 55% of the NELS weighted sample of 1992 high school graduates said they anticipate their highest level of education to be more than two years of college. Additionally, roughly 53% of 1990 high school sophomores reported the same aspirations (NCES, 2007). The weighted number of participants in this study’s selected universe was roughly half a million 1992 high school graduates.

Definition of Variables

The dependent variable of analysis in this study was the dichotomous categorical variable—bachelor degree recipient. The independent variables untested in existing research analyzed in this study include: (a) The dichotomous categorical variable continuous enrollment in secondary mathematics; (b) The dichotomous categorical
variable entry to algebra prior to grade nine; and (c) Secondary mathematics intensity level (MIL).

Continuous enrollment in secondary mathematics was coded ‘1’ if students’ transcripts indicated whether the student was enrolled in a mathematics course (not necessarily passed the course for credit) during all four years of high school coursework; otherwise, a code of ‘0’ was used. If a student’s continuous enrollment was unable to be determined, then ‘9’ was used to indicate missing data.

The same zero-one coding scheme was used for the dichotomous variable for early entry into algebra. Students’ transcripts were examined to determine if students were enrolled in an algebra course prior to grade nine (not including pre-algebra). Finally, the same coding was used for the dependent variable. Students were coded ‘1’ if they were bachelor degree earners and ‘0’ if they did not possess a bachelor’s degree at the time of the last follow-up of data collection in NELS (end of the year 2000, 8.5 years after high school graduation).

The MIL variable was a continuous variable constructed from analyzing a number of available variables in the NELS longitudinal data to classify or rank the classroom and
curriculum intensity of students’ secondary mathematics most likely to predict bachelor degree completion. The entire NELS variable codebook was scanned entirely twice over a two-week period selecting all variables that may be associated in some fashion with secondary mathematics classroom and school characteristics. Variables considered for MIL inclusion were: (a) high and low stakes mathematics achievement measures; (b) student questionnaire responses regarding their mathematics classrooms in 10th and 12th grades; (c) school personnel questionnaire responses; and (d) the number of mathematics credits required for high school graduation. The MIL variable included a student level achievement measure to balance survey responses that may indicate an intense classroom but fails to increase students’ mathematical knowledge and/or lacks demanding coursework. Additionally, the standardized mathematics measure of achievement will be used in lieu of mathematics grade point average because no mathematics classroom in America assigns grades identically or bases such grades on a standardized grading scale. To determine which variables will construct the MIL variable, discriminant analysis will be used. Discriminant analysis is the statistical procedure used to determine the variables that contribute to group
separation. The groups are bachelor degree earners and non-bachelor degree earners.

To recapitulate the argument thus far, the fundamental idea motivating the use of discriminant analysis was to determine whether these two groups differ significantly with regard to the mean of any of the variables being considered. A pilot study on a random sample (≈15%) of all NELS participants (not the target population) with complete high school and college transcripts was performed to determine the construction methodology for the MIL variable that would be used during the main analyses of this study. The purpose of the pilot study was to determine a set of rules for MIL inclusion during the main analysis of this study. The results of the pilot study are presented and discussed in the next section.

*MIL Variable Construction Methodology*

The secondary mathematics intensity variable for this study was constructed using available NELS variables determined to be predictors of group separation between bachelor degree earners and non-bachelor degree earners. This variable was significant in predicting bachelor degree completion based on the method of construction. However, the degree to which the MIL contributes beyond known
predictors of bachelor degree completion remained to be determined. Hence, it was feasible that the MIL variable in this study may not significantly predict above and beyond Adelman’s (2006) significant predictor variables.

All students in NELS with complete transcript data and were participants in all waves of the NELS study were retrieved. NELS variables considered for analysis were selected by reviewing all NELS variables in an exhausting review of classroom and achievement related variables. Two weeks were spent sorting through the NELS restricted data set and tagged as possible candidates. Around 15 variables were tagged for consideration. Using SPSS 15.0 as the statistical analysis package, a random sample of 15% of the participants were obtained. Next, using the NELS weight F4PHP3WT (see appendix D), discriminant analysis was performed utilizing many independent variables for MIL consideration (see appendix G, H, and I for complete NELS coding of the variables used for the MIL variable in the main analysis, also see appendix J for the actual NELS variable label). The weighted population sample size without any missing data for all variables was approximately 166,000 students. The analysis resulted in correctly classifying 73.5% of the cases as bachelor degree
earners or not. The Wilks’ Lambda was 0.711 for the discriminant analysis. These results indicate a strong classification model. However, some of the variables contributed very little to group separation (see table 2 below). Additional analysis was performed to determine a simpler model with fewer variables without sacrificing a large drop in the percentage of correctly classified cases or a major increase in the Wilkes Lambda.

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Structure Matrix</th>
<th>Standardized Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACTm(true) or SATm–PSATm (converted to ACT)</td>
<td>0.867</td>
<td>0.586</td>
</tr>
<tr>
<td>12th grade NELS administered mathematics assessment</td>
<td>0.813</td>
<td>0.287</td>
</tr>
<tr>
<td>Time spent on Math HW outside of school - 12th grade</td>
<td>0.441</td>
<td>0.391</td>
</tr>
<tr>
<td>Time spent on Math HW outside of school - 10th grade</td>
<td>0.312</td>
<td>0.182</td>
</tr>
<tr>
<td>All students expected to do HW 12th grade (school personnel response)</td>
<td>0.198</td>
<td>0.185</td>
</tr>
<tr>
<td>Students place high priority on learning (school response)</td>
<td>0.192</td>
<td>0.103</td>
</tr>
<tr>
<td>Time spent on Math HW inside school - 12th grade</td>
<td>0.171</td>
<td>-0.196</td>
</tr>
</tbody>
</table>
Table 2 (Continued).

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Structure Matrix</th>
<th>Standardized Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers press students to achieve 10&lt;sup&gt;th&lt;/sup&gt; grade (principal response)</td>
<td>0.161</td>
<td>0.114</td>
</tr>
<tr>
<td>Teachers encourage academic achievement 12&lt;sup&gt;th&lt;/sup&gt; grade (principal response)</td>
<td>0.093</td>
<td>-0.036</td>
</tr>
<tr>
<td>Classroom activities are highly structured (school response)</td>
<td>0.063</td>
<td>-0.021</td>
</tr>
<tr>
<td>Students expected to do HW 10&lt;sup&gt;th&lt;/sup&gt; grade (school response)</td>
<td>0.055</td>
<td>0.101</td>
</tr>
<tr>
<td>Math growth 8&lt;sup&gt;th&lt;/sup&gt; grade to 12&lt;sup&gt;th&lt;/sup&gt; grade (NELS administered assessments)</td>
<td>-0.042</td>
<td>-0.092</td>
</tr>
<tr>
<td>Discipline emphasized at this school</td>
<td>-0.035</td>
<td>-0.067</td>
</tr>
<tr>
<td>Graduation requirements for mathematics</td>
<td>-0.025</td>
<td>0.024</td>
</tr>
<tr>
<td>Time spent on Math HW inside school – 10&lt;sup&gt;th&lt;/sup&gt; grade</td>
<td>0.022</td>
<td>-0.014</td>
</tr>
</tbody>
</table>

Notes: All variables determined to be significant at p<0.05. In addition, where student-teacher responses and/or transcript data indicated no math was being taken in 10<sup>th</sup> or 12<sup>th</sup> grades, zero was coded as amount of time in and out of school doing mathematics homework.

The structure matrix values presented in table 2 are similar to factor loadings and indicate the substantive nature of the independent variables in relationship to each other’s contribution to the MIL. Bargman (1970) and Bray & Maxwell (1985) argue that high structure matrix values contribute most to group separation, while lower values contribute least to group separation. The standardized coefficients range from ±1 and speak of the relative
contribution of each variable in the model. In table 2, some variables have positive and negative structure matrix values. The absolute value of the structure matrix values is the important factor to consider. Additionally, some values in table two appear positive in one column and negative in the other column. This can be explained based on the coding of the variable. Some variables are mean-centered while others are not.

In table 2, it was discovered that the NELS low stakes administered test and ACT high stakes mathematics scores were both predominant predictors for group separation. At this point, a correlation between each variable was performed. The Pearson correlation coefficient for the random sample was 0.845 and was significant at the p<0.001 level deeming a very high correlation between the NELS senior mathematics test score and standardized ACT-math score. In an effort to allow for other variables to account for group separation, the ACT high stakes score was removed and the discriminant analysis was performed again. The choice to remove the high stakes assessment score was made because ACT is known to predict college success (Bassiri & Schulz, 2003). Further, the ACT math score may not have occurred at the end of high school. The NELS math test
score was given to NELS participants at or near the end of high school. Moreover, because the NELS math test score is highly correlated to the ACT math score, the NELS math test was used.

After removal of the ACT math score, no change to the order of variables in the structure matrix occurred. Changes to the structure matrix values and standardized coefficients did occur but were minimal. Further, to strengthen the results of this study, two separate analyses will be performed. One analysis will be performed with the NELS senior math test score included in the MIL and an analysis without the standardized math score included in the MIL. This will be done to verify or confirm the notion that the standardized mathematics variable may highly bias the results or soak up too much of the variance for group separation.

In an effort to pinpoint the most significant variables and to simplify the MIL variable, the lowest contributors to group separation were removed, and the analysis was repeated and compared. The variable contributing the least to group separation was removed, and the analysis was repeated. Next, the same methodology was instituted for the variable contributing least to group
separation until a MIL variable could be constructed where the Wilkes Lambda and the percentage of cases correctly classified remained consistent. The rationale is to simplify the MIL variable to a point where fewer participants have missing data and to allow for the analysis of a larger number of participants. Discriminant analysis deletes any cases with a variable that has missing data. As a variable was removed to simplify the MIL variable, it was anticipated the weighted sample size would actually increase. The analysis also anticipated the possibility of a stronger MIL variable as variables contributing little or nothing to group separation were removed from the MIL construction.

Table 3 presents the final results for the determination of the MIL variable in the pilot study. For the main analysis in this study, variables used to determine the MIL variable would be constructed using the same methodology as the pilot study. Each repeated discriminant analysis resulted in little change to the Wilks' Lambda value, and the cases correctly classified showed minimal change. In fact, at times, when an independent variable was removed, fewer cases had missing data and allowed for a greater number of cases to be
analyzed. This actually raised the percentage of correctly classified cases at times. Table 3 resulted in a Wilks’ Lambda of 0.705 and correctly classified 73.8% as bachelor degree recipients or not. The weighted sample size for the final pilot analysis was approximately 238,500 students. The increase in cases correctly classified was a result of fewer participants with missing data initially excluded for analysis when more than 10 independent variables were considered for the MIL construction. During the main analysis for this study, a threshold for the structure matrix value of approximately 0.150 (or about a five to one ratio of highest to lowest of structure matrix values) was the threshold for inclusion or removal of a variable constructing the MIL variable. Particular attention was paid to the Wilks’ Lambda and cases correctly classified by the model. Table 3 shows unstandardized coefficients while table 2 did not. The reason for this was the unstandardized coefficient is not needed until after all variables were determined for MIL inclusion. The structure matrix and standardized coefficients determined the relative contribution to group separation and determination of included variables in the MIL variable.
Table 3

Final Discriminant Analysis Pilot Results for MIL Construction

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>12&lt;sup&gt;th&lt;/sup&gt; grade NELS administered mathematics assessment</td>
<td>0.906</td>
<td>0.826</td>
<td>0.108</td>
</tr>
<tr>
<td>Time spent on Math HW outside of school – 12&lt;sup&gt;th&lt;/sup&gt; grade</td>
<td>0.502</td>
<td>0.444</td>
<td>0.346</td>
</tr>
<tr>
<td>Time spent on Math HW inside school – 12&lt;sup&gt;th&lt;/sup&gt; grade</td>
<td>0.263</td>
<td>-0.015</td>
<td>0.346</td>
</tr>
<tr>
<td>Students place high priority on learning (school response)</td>
<td>0.254</td>
<td>0.127</td>
<td>0.245</td>
</tr>
<tr>
<td>Time spent on Math HW outside school – 10&lt;sup&gt;th&lt;/sup&gt; grade</td>
<td>0.237</td>
<td>0.087</td>
<td>0.078</td>
</tr>
<tr>
<td>Teachers press students to achieve 10&lt;sup&gt;th&lt;/sup&gt; grade (principal response)</td>
<td>0.186</td>
<td>0.085</td>
<td>0.124</td>
</tr>
</tbody>
</table>

Notes: Wilkes’ Lambda=0.705, cases correctly classified=73.8%, and weighted sample size N=238,500.

Using the final unstandardized coefficients, the MIL variable will be constructed in the main analysis of the study so that each variable contributes based on the coding of the variable. For example, if both a continuous variable with a maximum score of 30 and a categorical variable with only three categories contribute the same to group separation, then the continuous variable must have a much
smaller coefficient than the categorical variable so the continuous variable does not over contribute to the model.

Secondary Analysis (Brief Discussion)

This research anticipates readers to question the inclusion of a standardized mathematics score in the MIL variable due to the predictive nature of such a variable. This research will address this concern by conducting a separate analysis as noted in the next section of this chapter. The standardized mathematics score was not included in the MIL variable during the secondary analysis, and results will be compared to the initial analysis and MIL determination. Further, to compare the analysis for this study’s universe of participants to Adelman’s unit of analysis, the methodology of this study was performed identically on Adelman’s unit of study. Thus, chapter 4 consists of four parts where the results of the statistical analysis are presented. Part 1 will be this study’s universe of prototypical students with the standardized mathematics score included in the MIL. Part 3 will not include the mathematics score for this universe of students. Parts 2 and 4 analyzes Adelman’s universe of study with part 2 including the standardized mathematics score in the MIL and part 4 without.
Methodology for Main Analysis

The main analysis in this study used logistic regression with a strategic and sequential block entry of independent variables (covariates). Additionally, the appropriate weights were used to adjust for the complex sampling design of NELS. The dependent variable is bachelor degree recipient or not by the time of the final NELS follow-up (roughly December 2000). Covariates were entered in different blocks. The first block entry consisted of students’ SES at the time of high school graduation and students’ eighth-grade mathematics achievement score administered to participants by the NELS data collectors. The second block of covariates entered in the model was the highest mathematics course completed in high school and Adelman’s overall academic intensity variable constructed from earned Carnegie credits (see appendix C). The third and final block of covariates was the variables of study in this research. The block 3 covariates were: (a) Continuous enrollment in secondary mathematics; (b) initial enrollment in algebra prior to grade nine; and (c) the constructed MIL variable discussed previously in this chapter.

To answer the research question and to control for known predictors of bachelor degree completion, each block
of covariates were entered strategically. The first block of covariates was to level the playing field; that is to say, to determine how much of bachelor degree completion is predicted alone by distal variables SES and eighth grade mathematics achievement. Effectively, this will produce the contribution of SES and prior mathematics achievement before high school towards predicting bachelor degree completion. It is well documented that SES, prior achievement, and bachelor degree attainment are correlated to varying degrees (Adelman, 1999; Adelman, 2006; ASHE, 2007; Caldus & Bankston, 1997; Ma, 2005c; Ozturk & Singh, 2006; Sirin, 2005; White & Reynolds, 1993). The methodology used here was to control for prior achievement and SES. These two variables essentially cannot be affected directly by secondary schools.

Block 2 consisted of Adelman’s two predictive independent variables of highest mathematics course completed in high school and overall academic intensity constructed from Carnegie credit totals. Adelman (1999, 2006) reported that the highest mathematics course taken in high school was the predominant predictor of bachelor degree completion. Additionally, Adelman (2006) added the overall academic intensity variable as an additional key
predictor of bachelor degree completion. The research question in this study aimed to determine if this study’s three additional variables add predictability above-and-beyond block 1 and block 2 covariates.

*Exploration of Variable Interaction*

In each block entry of covariates, the interaction terms between covariates were explored. In the first block, the interaction term was SES*8thMathAchievement. The second block term, HighMath*OverallAcademicIntensity was the interaction term explored. In the final block, the variables of study in this research had three two-way interactions and a three-way interaction to be explored. The interaction terms were ContinMath*Algebra8th, ContinMath*MIL, MIL*Algebra8th, and MIL*ContinMath*Algebra8th.

The interaction terms were being considered because the study anticipated the effect of predictor variables on the outcome variable would differ depending on the value of another predictor variable (referred to as moderator variable in some literature). More precisely, the effect of early entry into algebra on whether or not a student completes a bachelor degree may well differ for higher MIL classrooms than lower MIL classrooms. In this case,
bachelor degree completion is the outcome variable; early entry to algebra is the predictor variable, and MIL is the other predictor variable (moderator variable), which is to say that early entry to algebra might predict bachelor degree completion better depending on the MIL. Including this interaction term permitted the analysis to conclude if the odds increase for a student who entered algebra in grade eight but had a below average MIL. The student might have greater odds at completing a bachelor’s degree than if the student waited until ninth grade to take algebra with a below average MIL. Further, the interaction between MIL and continuous enrollment in secondary mathematics was worth exploring. Specifically, a student continuously enrolled in higher MIL classrooms may well predict bachelor degree completion better than a student continuously enrolled in a lower MIL classroom may. This interaction term allowed the analysis to conclude if continuous enrollment can make up for a low MIL. Alternatively, this interaction term allowed the analysis to conclude if a high MIL can make up for students who fail to remain continuously enrolled in secondary mathematics.

The interaction between early algebra entry and continuous enrollment may be significant. However, it is
anticipated that this interaction term would not be needed. If a student had both categorical variables coded as a ‘1’, then the student would reach at least pre-calculus and perhaps even more likely calculus. Enrolling in algebra in grade eight and remaining continuously enrolled in secondary mathematics would mean completing five courses (five years) of secondary mathematics. Ultimately, this effectively means a student would complete calculus while climbing up the mathematics ladder of courses. If a failure occurred along the way, then it would still mean completion beyond algebra-2 (Adelman’s tipping point). Hence, this interaction term may theoretically be equivalent to the variable highest mathematics course completed, which will be entered in block 2.

The final interaction in block 3 is the three-way interaction term MIL*ContinMath*Algebra8th. Hypothetically, this variable should be significant beyond any other variable being analyzed in this study. It can be reasonably argued, based on the literature in chapter 2, that a student who enters algebra in grade eight and remains continuously enrolled in a high MIL classroom will complete a bachelor’s degree much more often than students who fail to be continuously enrolled and/or who do not
enter algebra in grade eight and/or are in lower MIL classrooms. The three-way interaction term should significantly predict bachelor degree completion. However, what may turn out to be more interesting is the predictability of this three-way interaction for low MIL students continuously enrolled in mathematics since grade-eight algebra. Hence, the odds may increase significantly for low achieving students who remain continuously enrolled in mathematics after enrolling in algebra in grade eight. However, if the two-way interaction between early algebra entry and continuous enrollment is not significant, then the three-way interaction term may not be significant.

The first block interaction term and the second block interaction term were not anticipated to contribute to the model in a significant way. The first block interaction term tends to be correlated in research. It was anticipated that the block 1 interaction will not improve the model but may well be significant. In block 2, the interaction was not anticipated to end up in the final model. The two covariates in block 2 were anticipated to be highly correlated. However, these two interaction terms were examined before making a final decision on inclusion.
At each block entry of covariates, a procedure was performed to determine if the interaction term(s) was to be included in the model. The method was fairly simple. Initially, the analysis was performed without the interaction in block 1. Next, the analysis was performed with the interaction SES*8thMathAchievement term included in the model. The two models were compared to determine if the interaction term is found to be significant. If the two models were trivial (odds ratio approximately one) or the covariates are highly correlated (>0.7), then the interaction term was not included as the analysis moved forward. The same method was performed at each block entry level of the model. Last, some independent variables were highly correlated and may introduce an interaction term that biases the model. According to Jaccard (2001), high correlations between predictor variables can lead to serious problems with interaction terms. A simple correlation matrix was generated to inspect the correlation between independent variables in each block of covariates. This summarizes the methods used to determine the final model.
Assumptions of Statistical Methodology

Each student (case) was independent of each other. During the analysis, each particular block of covariates was checked for multicollinearity. Variables were centered at the mean to avoid or reduce the possibility of multicollinearity prior to the logistic regression and to aid in the interpretation of interaction effects. Each independent variable was checked for linearity with all predictor variables. This was accomplished by running a linear regression model using the same dependent and independent variables as the logistic regression model. This produced collinearity statistics and diagnostics. Each variable was then explored for collinearity by examining the variance inflation factor (VIF). Extraneous variables were not used, and all significant variables were used in the model; however, the exception was the construction of the MIL variable. It is possible, for example, that a teacher survey question is significant for group separation during the MIL construction alone. Moreover, should the variable contribute very little to the MIL, it may be removed if it fails to meet the structure matrix coefficient of 0.150 or contributes 1/5 or less than the highest structure matrix value (threshold established
in pilot study). For example, the pilot study indicated a very high contribution level for the standardized mathematics score while smaller contributing variables were weak. In table 3, the ratio of the top and bottom structure matrix values is just over 5 to 1. Hence, the pilot study led to setting the structure matrix threshold of approximately 0.150 (or a 5 to 1 ratio for highest to lowest structure matrix values) for inclusion in the MIL variable.

The ratio of participants to independent variables was extreme. The actual un-weighted ratio of participants to variables used in the analysis is well over 100 to one. This was important because if the ratio is, say 20 to one, then at the p<0.05 level, one could expect one independent variable to be significant by chance alone. Based on the random sample pilot study for the MIL construction, it was anticipated that there would be approximately eight (+/-) variables constructing the MIL variable. Adding the SES, eighth grade mathematics achievement, highest mathematics, Adelman’s overall academic intensity variable, early entry to eighth grade algebra, and continuous enrollment variable, results in the total number of independent variables end up around 15. Thus, following the logistic
regression rule of thumb of 10:1 (Field, 2005), the sample size needed to be a minimum of 150. The un-weighted sample size for the main analysis exceeds 150 by more than 10-fold so it is not expected that any statistical assumptions were not met in this study.

Assessing the Statistical Results

In logistic regression, the log-likelihood (LL) is based on summing the probabilities associated with the predicted and actual outcomes (Tabachnick & Fidell, 2001). In this analysis, it was anticipated that the $-2\cdot\text{LL}$ will be very large ($-2\cdot\text{LL} > 1000$). Typically, large values of the log-likelihood indicate a poorly fitting model when sample sizes are relatively small. As the log-likelihood increases, the more unexplained observations there will be in this type of statistical procedure. However, this does not indicate that the model cannot assess the degree of predictability for each of the independent variables. The NELS longitudinal data has a weighted sample size over 2.0 million students. If multiple regression was the statistical test being used, then the sum of the squared errors (residuals) would also be extremely high due to a very large sample size. The log-likelihood in logistic regression is analogous to the sum of squared errors in
multiple regression. It was expected this study would
have a large log-likelihood value but that the model would
still be very predictive in nature.

To assess the predictability and goodness-of-fit for
the model, the Cox & Snell R-square and Nagelkerke R-square
were monitored in each block entry step during the
analysis. These two statistical measures provided a measure
of the significance of the model. These two statistics are
not the same as the $R^2$ statistic in multiple regression.
However, they are similar in their interpretation and are
sometimes used incorrectly as to say the percentage of the
variance explained as with multiple regression. Thus,
caution must be taken when interpreting these statistics.
The Cox & Snell value does not max out at a value of one.
The Nagelkerke value does max out at value of one and is
the more highly reported or referred to statistic regarding
the associative power of a logistic regression model
reported in literature. Both values are reported in chapter
4 and discussed in chapter 5.

In addition to the Cox & Snell R-square and Nagelkerke
R-square statistics, the classification table generated
during the analysis was examined during each block-entry of
predictor variables. For example, if the percentages of
cases correctly classified were 50% after block 1, 70% after block 2, and 80% after block 3, then the model would indicate that each set of predictor variables contributes to a large number of cases being correctly classified in each block.

Another measure of analysis to check for participants that may bias the model was the examination of the standardized residuals for cases above the absolute value of three. Additionally, cases with standardized residuals outside of ±2.58 (two standard deviations) were examined further and considered as possible outliers influencing the model. To determine the influence of these cases, Cook’s distance was examined. This is the same method used for linear regression. If Cook’s distance is greater than one, then further examination will occur by examining the leverage value. It was not anticipated that such a large sample size would yield any outliers that would need to be eliminated. NCES data cleaning (imputation) typically takes care of outliers. However, the statistics were checked to confirm this notion and reported if such outliers required removal from the analysis.

The final measure was to examine the contribution (effect size) of each variable to the model. The Exp(B)
values will be explored (B is the Beta value or coefficient in the logistic regression model). The Exp(B) values indicated the change in odds resulting from a unit change in the predictor. For example, if the continuous secondary mathematics enrollment variable has an Exp(B)=2, then it means that a student who remains continuously enrolled in secondary mathematics has twice the odds of completing a bachelor’s degree than a student who does not remain continuously enrolled while holding all other variables constant.

Summary

It should be clear from the pilot study that the MIL variable will significantly predict bachelor degree completion based on the methodology of construction. However, the degree to which the MIL predicts bachelor degree completion above and beyond known predictors was yet to be determined. Additionally, the MIL allowed this study to present a scientifically based outcome that may well begin to define an intense secondary mathematics classroom. However, the focus was to remain on the continuous enrollment in secondary mathematics and early entry to algebra variables. The focus was aimed to spur discussion on secondary mathematics academic policy that may
potentially raise the likelihood of earning a bachelor’s degree for the prototypical college bound high school student, which is to say that beyond classroom characteristics and achievement (the MIL variable construction) continuous enrollment in secondary mathematics and/or early entry into algebra are important and significant towards maintaining bachelor degree momentum. Moreover, that many variables exist in the MIL that teachers and school personnel can change that will positively increase students’ likelihood of bachelor degree completion.

Chapter 4 presents the results in the four parts previously mentioned in chapter 3. Interpretations of the results follow in chapter 5.
CHAPTER 4: STATISTICAL RESULTS

Overview of Chapter 4

This chapter presents the results of the statistical analysis of the NELS data collected by NCES. The study used quantitative statistical methodologies to answer the following research question and to test the following hypotheses:

Do continuous enrollment in secondary mathematics, mathematics intensity level, and enrollment in algebra prior to high school (grade 9) predict the successful completion of a four-year degree beyond the predictors of highest mathematics course completed and Adelman’s overall academic intensity measure?

H₁: Students who remain continuously enrolled in secondary mathematics are more likely to complete four-year degrees.

H₂: Students with a higher secondary mathematics intensity level are more likely to complete four-year degrees.

H₃: Students who enroll in algebra-1 (or equivalent) prior to high school are more likely to complete four-year degrees.
Discriminant analysis was used to construct the mathematics intensity level (MIL) variable and logistic regression was used for the main analysis. The analyses were performed using SPSS 15.0 graduate pack, which is equivalent to the standard SPSS 15.0 statistical software package with the exception of a limited four-year license.

This chapter is divided into four parts. Part 1 presents the results for the analysis of the universe of participants in this study. Part 2 presents the results for all participants in NELS with secondary and postsecondary transcripts without using the filtering criteria for the universe of this study noted in chapter 3. Part 2 used the universe of NELS participants that Adelman used for his 2006 Toolbox Revisited research. The purpose of part 2 was to present the findings for comparison to the universe of participants for which this study focused. Part 3 and part 4 present the results of the analyses using the same methodology and participant universes as parts 1 and 2 respectively, but these two parts do not include the NELS standardized mathematics achievement score in the constructed MIL variable. These results are presented in anticipation of readers of this research questioning-if the standardized math score greatly influences the MIL in a way
that may overly bias the results and predictability of the MIL variable.

In all four parts of chapter 4, multicollinearity was addressed by examining the variance inflation factor statistics as suggested by Field (2005) when using logistic regression. No causes for concern arose in any analysis reported in chapter 4.

Part 1: Results of Main Analysis for Universe of Study

Descriptive Statistics

Table 4 gives the descriptive data for the universe of participants in this study. A correlation matrix for part 1 is presented in appendix E. These data are presented so the reader can picture the makeup of the participants for the universe of this study.

In table 4, as well as all of the results presented in chapter 4, the highest mathematics course completed in high school was recoded differently than NCES’ coding. NCES used a ‘1’ to code calculus and numbering increased for courses down the mathematics ladder. The coding was reversed for this study so the beta-value for this variable would be positive. ‘0’ was coded for the highest mathematics course completed in high school as algebra-2 based on Adelman’s
### Table 4

#### Descriptive Statistics for Universe of Participants of Study

<table>
<thead>
<tr>
<th>Statistic</th>
<th>SES 12th grade</th>
<th>8th grade math score</th>
<th>High math course</th>
<th>Overall academic intensity</th>
<th>Continuous enrollment</th>
<th>Early entry to algebra</th>
<th>Math intensity level MIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>N Valid</td>
<td>391,267</td>
<td>418,522</td>
<td>437,719</td>
<td>434,930</td>
<td>426,876</td>
<td>437,305</td>
<td>272,686</td>
</tr>
<tr>
<td>Missing</td>
<td>46,841</td>
<td>19,586</td>
<td>389</td>
<td>3,178</td>
<td>11,232</td>
<td>802</td>
<td>165,422</td>
</tr>
<tr>
<td>Mean</td>
<td>0.000</td>
<td>0.000</td>
<td>0.68</td>
<td>17.66</td>
<td>0.55</td>
<td>0.01</td>
<td>0.000</td>
</tr>
<tr>
<td>Range</td>
<td>4.070</td>
<td>41.660</td>
<td>6</td>
<td>30</td>
<td>1</td>
<td>1</td>
<td>7.526</td>
</tr>
<tr>
<td>Minimum</td>
<td>-2.207</td>
<td>-18.670</td>
<td>-3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-3.827</td>
</tr>
<tr>
<td>Maximum</td>
<td>1.863</td>
<td>22.990</td>
<td>3</td>
<td>30</td>
<td>1</td>
<td>1</td>
<td>3.699</td>
</tr>
<tr>
<td>Percentile 25</td>
<td>-0.464</td>
<td>-6.800</td>
<td>0</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>-0.676</td>
</tr>
<tr>
<td>Percentile 50</td>
<td>-0.076</td>
<td>-0.190</td>
<td>0</td>
<td>17</td>
<td>1</td>
<td>0</td>
<td>-0.025</td>
</tr>
<tr>
<td>Percentile 75</td>
<td>0.494</td>
<td>7.270</td>
<td>2</td>
<td>24</td>
<td>1</td>
<td>0</td>
<td>0.687</td>
</tr>
</tbody>
</table>

Notes: All N weighted using NELS weight F4PHP3WT. ^Only 1.1% of participants entered algebra prior to grade nine. This is worth noting. *54% continuously enrolled, 2.6% missing data/could not determine.
research to be the reference level since most four-year schools require algebra-2 credit. Algebra-1 was coded ‘-2’. Geometry was coded ‘-1’. Trigonometry was coded ‘1’. Pre-calculus was coded ‘2’. Calculus and courses above were coded ‘3’. Courses below algebra-1 were coded as ‘-3’.

**MIL Construction**

The universe of this study was NELS participants who directly entered (within seven months of high school graduation) higher education institutions that were not highly selective (as defined in PETS) institutions and participants who enrolled full-time. Additionally, participants must have attended a four-year institution at some point in their postsecondary education. Table 5 gives the initial discriminant analysis results before finalizing the MIL variable. The structure matrix values are given because Bargman (1970) and Bray & Maxwell (1985) argue that high structure matrix values contribute much more to group separation than lower structure matrix values. Readers are directed to recall that during the pilot study a structure matrix threshold of 0.150 or about a 5 to 1 ratio (highest to lowest contributor) was established for the MIL variable construction. The threshold was established so the MIL is comprised of the variables that greatly influence the MIL.
of a student over variables that only contribute a very small amount. The threshold looks to simply the MIL but create a variable that was well defined based on available variables in the NELS data.

Table 5
Initial results for MIL construction for Universe of Participants

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Structure Matrix</th>
<th>Standardized Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACTm(true) or SATm-PSATm (converted to ACT)</td>
<td>0.612</td>
<td>0.457</td>
</tr>
<tr>
<td>12th grade NELS administered mathematics assessment</td>
<td>0.552</td>
<td>0.245</td>
</tr>
<tr>
<td>Time spent on Math HW outside of school – 12th grade</td>
<td>0.381</td>
<td>0.394</td>
</tr>
<tr>
<td>All students expected to do HW 12th grade (school personnel response)</td>
<td>0.346</td>
<td>0.515</td>
</tr>
<tr>
<td>Teachers encourage academic achievement 12th grade (principal response)</td>
<td>-0.026</td>
<td>-0.406</td>
</tr>
<tr>
<td>Graduation requirements for mathematics</td>
<td>0.171</td>
<td>0.219</td>
</tr>
<tr>
<td>Time spent on Math HW inside school – 10th grade</td>
<td>-0.161</td>
<td>-0.181</td>
</tr>
<tr>
<td>Classroom activities are highly structured (school response)</td>
<td>-0.139</td>
<td>-0.233</td>
</tr>
<tr>
<td>Students place high priority on learning (school response)</td>
<td>0.138</td>
<td>0.235</td>
</tr>
<tr>
<td>Discipline emphasized at this school (principal response)</td>
<td>-0.129</td>
<td>-0.225</td>
</tr>
<tr>
<td>Time spent on Math HW inside school – 12th grade</td>
<td>0.123</td>
<td>-0.185</td>
</tr>
<tr>
<td>Independent Variable</td>
<td>Structure Matrix</td>
<td>Standardized Coefficient</td>
</tr>
<tr>
<td>----------------------------------------------------------</td>
<td>------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>Time spent on Math HW outside of school - 10th grade</td>
<td>0.062</td>
<td>0.039</td>
</tr>
<tr>
<td>Teachers press students to achieve 10th grade (principal response)</td>
<td>-0.053</td>
<td>-0.188</td>
</tr>
<tr>
<td>Students are expected to do homework 10th grade (school personnel response)</td>
<td>0.014</td>
<td>0.025</td>
</tr>
<tr>
<td>Math growth 8th grade to 12th grade (NELS administered assessments)</td>
<td>0.004</td>
<td>-0.062</td>
</tr>
</tbody>
</table>

Notes: All variables significant at 0.05 level. Wilks' Lambda=0.925 with the function significant at p<0.001. N=224,300 and correctly classifying 61.9% of the cases.

After examining the initial results, it became clear the NELS administered senior year mathematics assessment and ACT math scores were contributing to group separation much more than all other variables of consideration. A correlation was performed for these two variables. It was determined both variables were significantly (p<0.001) correlated (0.800). A Pearson correlation coefficient of 0.800 is a very high correlation in social science research (Cohen, 1988) and poses threats of multicollinearity and biased results. The ACT score was removed. The decision to remove the ACT math score was predicated on two facts. First, the NELS senior year mathematics test was a low stakes test given to NELS participants at or near the end
of the senior year of high school. Second, the ACT math score may have been established by students prior to their senior year high school since many students take the ACT prior to their senior year of high school. Theoretically, many of the ACT or SAT-converted math scores in NELS may have been established during students’ junior year of high school. Consequently, the NELS math test score may better reflect the overall secondary mathematics achievement than the ACT math score. Since they were highly correlated, either suffices as a standardized mathematics achievement score for the MIL. Moreover, the low stakes measure better suits the intent of the MIL variable measuring the mathematics achievement over the entire span of students’ secondary schooling since it was given at or near the end of NELS participants’ senior year of high school.

The analysis was performed again without the ACT math score resulting in very little change to the order of variables in the structure matrix. The Wilks’ Lambda was 0.945, and the model correctly classified 61.0% of the cases for a weighted N=257,400. Additionally, a small change occurred to the Wilks’ Lambda and the percentage of cases correctly classified, but the changes were minimal. The math growth variable was at the bottom of the structure
matrix with a value of -0.001 indicating very little contribution to the MIL. This variable was removed, and the analysis performed again. The analysis resulted in no change to the Wilkes Lambda and a small decrease in the percentage of cases correctly classified (59.6%) for a larger N=267,800. The variable contributing least to group separation at this point was the classroom activities highly structured variable. The structure matrix value was -0.069 and did not meet the structure matrix threshold established during the pilot study. This variable was removed, and the analysis was performed again. Table 6 (on next page) gives an overview of each step (variable removal) of the analysis performed in determining the final MIL variable for the universe of participants in this study.
Table 6
Overview of Each Step During MIL Construction for Universe of Participants of this Study

<table>
<thead>
<tr>
<th>Step</th>
<th>Variable removed</th>
<th>Structure Matrix</th>
<th>New Wilks’ Lambda</th>
<th>Cases correctly classified</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-</td>
<td>0.925</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1</td>
<td>ACT Math score</td>
<td>0.945</td>
<td>0.945</td>
<td>61.0%</td>
</tr>
<tr>
<td>2</td>
<td>Math growth 8th to 12th grade</td>
<td>-0.001</td>
<td>0.945</td>
<td>59.6%</td>
</tr>
<tr>
<td>3</td>
<td>Classroom activities highly structured</td>
<td>-0.069</td>
<td>0.946</td>
<td>59.8%</td>
</tr>
<tr>
<td>4</td>
<td>Teachers press students to achieve 10th</td>
<td>0.103</td>
<td>0.946</td>
<td>60.1%</td>
</tr>
<tr>
<td>5</td>
<td>Teachers encourage academic achievement 12th</td>
<td>-0.121</td>
<td>0.948</td>
<td>60.9%</td>
</tr>
<tr>
<td>6</td>
<td>Time spent of math HW outside school 10th</td>
<td>0.147</td>
<td>0.951</td>
<td>61.0%</td>
</tr>
</tbody>
</table>

After the removal of the variable in step 6 above, the MIL variable construction was complete. The final MIL model ended with seven variables and a significant (p<0.001) Wilks’ Lambda. Table 7 below shows the final constructed MIL variable consisting of a standardized measure of mathematics achievement, student responses indicating time devoted to mathematics homework, high school mathematics graduation requirements, and classroom atmosphere variables as reported by school personnel.
Table 7  
Final Results for MIL Variable Construction for the Universe of Participants in this Study

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>12th grade NELS administered mathematics assessment</td>
<td>0.732</td>
<td>0.757</td>
<td>0.101</td>
</tr>
<tr>
<td>Time spent on Math HW outside of school – 12th grade</td>
<td>0.443</td>
<td>0.409</td>
<td>0.296</td>
</tr>
<tr>
<td>Discipline emphasized at this school</td>
<td>-0.274</td>
<td>-0.393</td>
<td>-0.989</td>
</tr>
<tr>
<td>All students expected to do HW 12th grade</td>
<td>0.251</td>
<td>0.273</td>
<td>0.488</td>
</tr>
<tr>
<td>Students expected to do HW 10th grade</td>
<td>0.206</td>
<td>0.094</td>
<td>0.119</td>
</tr>
<tr>
<td>Time spent on Math HW inside school – 12th grade</td>
<td>-0.204</td>
<td>-0.126</td>
<td>-0.096</td>
</tr>
<tr>
<td>Time spent on Math HW inside school – 10th grade</td>
<td>-0.176</td>
<td>-0.237</td>
<td>-0.238</td>
</tr>
<tr>
<td>Graduation requirements for mathematics</td>
<td>0.164</td>
<td>0.222</td>
<td>0.361</td>
</tr>
<tr>
<td>Students place high priority on learning</td>
<td>0.156</td>
<td>0.109</td>
<td>0.206</td>
</tr>
</tbody>
</table>

Notes: Wilks’ Lambda=0.951 with the cases correctly classified at 61.0% and N=271,100

Block 1 Analysis of Covariates

For block 1 of the analysis, two main points were sought. The first point sought was to determine how much SES at the 12th grade level and eighth grade math
achievement (prior achievement) predicted bachelor degree completion. The second point sought was to determine if the interaction between these two variables was significant. In other words, block 1 was comprised of the controlling covariates. The results are presented in table 8.

Table 8

<table>
<thead>
<tr>
<th>Variables Included</th>
<th>B (SE)</th>
<th>Lower Exp(B)</th>
<th>Upper Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.201*** (0.003)</td>
<td>1.222</td>
<td></td>
</tr>
<tr>
<td>SES in 12th grade</td>
<td>0.508*** (0.005)</td>
<td>1.645</td>
<td>1.662</td>
</tr>
<tr>
<td>8th grade NELS math score</td>
<td>0.027*** (0.000)</td>
<td>1.027</td>
<td>1.028</td>
</tr>
</tbody>
</table>

Notes: R²=.047 (Cox & Snell), .063 (Nagelkerke), χ²(2)=18063.6, ***p<0.001, cases correctly classified=60.9%, and N=373,5000

The results indicate that both independent variables are significant in predicting bachelor degree completion. The interaction term was not significant (p-value=0.163), and the correlation between these two variables was 0.194 (low, but significant p<0.001). The results indicate that SES and
prior mathematics achievement have a significant contribution towards bachelor degree momentum.

**Block 2 Analysis of Covariates**

During block 2 of the analysis, four main points were sought. The first point sought was to determine the relative contribution of the highest mathematics course completed in high school towards bachelor degree completion. This is the variable Adelman (1999, 2006) indicates is most predictive towards determining a student’s odds of bachelor degree completion. The second point sought was to determine the contribution of Adelman’s (2006) overall academic intensity variable constructed from Carnegie credits (see appendix C) towards bachelor degree completion. The third point sought was to determine if the interaction between these two variables was a significant contributor to the model. The last point was to determine the relative contribution of these known variables above and beyond (or controlling for) SES and prior mathematics achievement. The results are presented in table 9 below.

The third point was moot for the second block entry of covariates. The correlation between highest math completed in high school and overall academic intensity was very high at 0.716 (p<0.001). According to Jaccard (2001), this may
potentially raise a serious problem by including the interaction term in block 2. However, an analysis was performed including the interaction term to verify the possible contribution of the interaction term. The beta value was 0.002 and the exp(B) was 1.002, which indicated very little contribution to the model and virtually no change in the odds ratio. The decision made was not to include the interaction term in block 2 in light of this data.

Table 9
Block 2 Entry of Covariates for the Main Analysis of the Universe of Participants

<table>
<thead>
<tr>
<th>Variables Included</th>
<th>B (SE)</th>
<th>Lower</th>
<th>Exp(B)</th>
<th>Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-0.032**</td>
<td>0.969</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SES in 12th grade</td>
<td>0.513***</td>
<td>1.654</td>
<td>1.671</td>
<td>1.689</td>
</tr>
<tr>
<td>8th grade NELS math score</td>
<td>0.013***</td>
<td>1.013</td>
<td>1.014</td>
<td>1.014</td>
</tr>
<tr>
<td>Highest math course completed in HS</td>
<td>0.161***</td>
<td>1.166</td>
<td>1.174</td>
<td>1.183</td>
</tr>
<tr>
<td>Overall Academic Intensity</td>
<td>0.007***</td>
<td>1.006</td>
<td>1.007</td>
<td>1.008</td>
</tr>
</tbody>
</table>

Notes: R²=.058 (Cox & Snell), .078 (Nagelkerke), χ²(4)=22269.6, ***p<0.001, **p<0.01, cases correctly classified=61.0%, and N=369,900
Comparing table 8 and table 9 indicate very small changes to the SES and eighth grade math score betas. A large change occurred for the constant in the model. Additionally, the block 2 variable overall academic intensity contributed very little to the model but was significant.

**Block 3 Analysis of Covariates**

The main analysis and focus of this study, a number of important points were sought in this part of the study. The points will be discussed in greater detail in chapter 5. The initial analysis with all three blocks of covariates included in the model indicated that Adelman’s overall academic achievement variable became insignificant (p-value=0.499). It was removed, and the analysis was performed again. The three-way interaction term in block 3 (mentioned in chapter 3) had a p-value=1.0, so this interaction was removed, and the analysis was performed again. The two-way interaction term between early entry to algebra and continuous enrollment was not significant (p-value=0.987). This interaction term was removed, and the analysis was performed again. The final results are presented in table 10 below. Table 10 concludes the results of part 1.
Table 10

Block 3 Entry of Covariates for the Main Analysis of the Universe of Participants

<table>
<thead>
<tr>
<th>Variables Included</th>
<th>B (SE)</th>
<th>Lower</th>
<th>Exp(B)</th>
<th>Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.657* (0.133)</td>
<td></td>
<td>1.929</td>
<td></td>
</tr>
<tr>
<td>SES in 12th grade</td>
<td>0.433*** (0.007)</td>
<td>1.521</td>
<td>1.542</td>
<td>1.563</td>
</tr>
<tr>
<td>8th grade NELS math score</td>
<td>-0.011*** (0.001)</td>
<td>0.988</td>
<td>0.989</td>
<td>0.991</td>
</tr>
<tr>
<td>Highest math course completed in HS</td>
<td>0.303*** (0.004)</td>
<td>1.343</td>
<td>1.354</td>
<td>1.366</td>
</tr>
<tr>
<td>Continuous enrollment in secondary math</td>
<td>0.268*** (0.010)</td>
<td>1.282</td>
<td>1.307</td>
<td>1.333</td>
</tr>
<tr>
<td>Early entry to algebra</td>
<td>-0.758*** (0.133)</td>
<td>0.361</td>
<td>0.469</td>
<td>0.608</td>
</tr>
<tr>
<td>Mathematics intensity level (MIL)</td>
<td>0.992*** (0.153)</td>
<td>1.998</td>
<td>2.696</td>
<td>3.637</td>
</tr>
<tr>
<td>Early entry to algebra * MIL</td>
<td>-0.656*** (0.153)</td>
<td>0.385</td>
<td>0.519</td>
<td>0.701</td>
</tr>
<tr>
<td>Continuous enrollment in secondary math * MIL</td>
<td>-0.155*** (0.009)</td>
<td>0.841</td>
<td>0.856</td>
<td>0.872</td>
</tr>
</tbody>
</table>

Notes: R²=.084 (Cox & Snell), .113 (Nagelkerke), χ²(8)=20887.9, ***p<0.001, *p<0.05, cases correctly classified=62.2%, and N=236,700

As seen in the notes section of table 10, the R-square terms were fairly high for social science research. These two statistics are the most commonly reported R-square values in logistic regression. They do not “give the
variance explained by” but rather are attempts to measure the strength of association. The Nagelkerke R-square term is the most commonly cited statistic as it ranges from 0 to 1 as with linear (multiple) regression. The value in part 1 of 0.113 indicates a reasonable regression model.

Part 2: Adelman’s Universe of NELS Participants

Overview of Part 2

Part 2 of chapter 4 presents the same analysis and methodology used in part 1. The difference between part 1 and part 2 is the selection of participants. Part 1 focused on the typical full-time direct-entry bachelor degree-seeking student. Part 2 removes the restrictions that set the universe of participants for this study and reflects the unit of analysis used in Adelman’s research. Students who sought two-year degrees or students who began college part-time or students who attended highly selective postsecondary institutions are now included in the analysis. Part 2 had a much greater weighted sample size than part 1 with the removal of the filtering criteria for the universe of participants in this study.
Descriptive Statistics

The descriptive statistics for part 2 are presented in table 11. The data is presented so that readers of this research may make comparisons to part 1 participants. Additionally, a correlation matrix is presented in appendix F for part 2.

MIL Construction

The same methodology was used in determining the MIL variable in part 2 as was used in part 1 of this chapter. A structure matrix threshold was again the key marker for inclusion or not. If the Wilks’ Lambda and cases correctly classified did not change dramatically by removing a variable, then the process was repeated. The final results are presented in table 12 followed by a step-wise removal table as was presented in table 6 of part 1. The step-wise removal table is table 13.
<table>
<thead>
<tr>
<th>Statistic</th>
<th>SES 12th grade</th>
<th>8th grade math score</th>
<th>High math course</th>
<th>Overall academic intensity</th>
<th>Contin. enrolled in math</th>
<th>Early entry to algebra</th>
<th>Math intensity level MIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>N, Valid Missing</td>
<td>1,798,079</td>
<td>1,937,141</td>
<td>1,986,529</td>
<td>1,929,563</td>
<td>1,932,654</td>
<td>1,997,096</td>
<td>1,198,597</td>
</tr>
<tr>
<td></td>
<td>206,653</td>
<td>67,591</td>
<td>18,203</td>
<td>75,169</td>
<td>72,078</td>
<td>7,636</td>
<td>806,135</td>
</tr>
<tr>
<td>Mean</td>
<td>0.000</td>
<td>0.000</td>
<td>3.30</td>
<td>17.12</td>
<td>0.45</td>
<td>0.01</td>
<td>0.000</td>
</tr>
<tr>
<td>Range</td>
<td>4.473</td>
<td>42.720</td>
<td>6</td>
<td>31</td>
<td>1</td>
<td>1</td>
<td>6.757</td>
</tr>
<tr>
<td>Minimum</td>
<td>-2.453</td>
<td>-19.160</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-3.527</td>
</tr>
<tr>
<td>Maximum</td>
<td>2.020</td>
<td>23.560</td>
<td>6</td>
<td>31</td>
<td>1</td>
<td>1</td>
<td>3.230</td>
</tr>
<tr>
<td>Percentile 25</td>
<td>-0.503</td>
<td>-7.980</td>
<td>2</td>
<td>11</td>
<td>0</td>
<td>0</td>
<td>-0.799</td>
</tr>
<tr>
<td>Percentile 50</td>
<td>-0.035</td>
<td>-0.690</td>
<td>3</td>
<td>17</td>
<td>0</td>
<td>0</td>
<td>0.069</td>
</tr>
<tr>
<td>Percentile 75</td>
<td>0.513</td>
<td>7.680</td>
<td>5</td>
<td>24</td>
<td>1</td>
<td>0</td>
<td>0.825</td>
</tr>
</tbody>
</table>

Notes: All N weighted using NELS weight F4PHP3WT. ^Only 1.2% of participants entered algebra prior to grade nine. #43.4% continuously enrolled and 3.7% missing data/could not determine.
Table 12

Final Results for MIL Variable Construction for Adelman’s Universe of NELS Participants

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>12th grade NELS administered mathematics assessment</td>
<td>0.898</td>
<td>0.804</td>
<td>0.104</td>
</tr>
<tr>
<td>Time spent on Math HW outside of school - 12th grade</td>
<td>0.527</td>
<td>0.372</td>
<td>0.288</td>
</tr>
<tr>
<td>Time spent on Math HW inside school - 12th grade</td>
<td>0.328</td>
<td>0.046</td>
<td>-0.036</td>
</tr>
<tr>
<td>Students place high priority on learning</td>
<td>0.281</td>
<td>0.131</td>
<td>0.249</td>
</tr>
<tr>
<td>Teachers press students to achieve</td>
<td>0.226</td>
<td>0.053</td>
<td>0.077</td>
</tr>
<tr>
<td>Time spent on Math HW outside school - 10th grade</td>
<td>0.205</td>
<td>0.058</td>
<td>0.053</td>
</tr>
<tr>
<td>Students expected to do HW 10th grade</td>
<td>0.203</td>
<td>0.082</td>
<td>0.107</td>
</tr>
<tr>
<td>All students expected to do HW 12th grade</td>
<td>0.175</td>
<td>0.111</td>
<td>0.200</td>
</tr>
</tbody>
</table>

Notes: All variables significant at 0.05 level. Wilks’ Lambda=0.779 with the function significant at p<0.001 with a weighted N=1,198,600 and classifying 69.7% of the cases correctly.

The ACT math score was removed in the same fashion for the same reasons as in part 1 of this chapter. The correlation between the NELS administered mathematics assessment and the ACT math score was correlated very high (0.836) and significant (p<0.001).
Table 13

Overview of Each Step During MIL Construction for Adelman’s Universe of NELS Participants

<table>
<thead>
<tr>
<th>Step</th>
<th>Variable removed</th>
<th>Structure Matrix</th>
<th>New Wilks’ Lambda</th>
<th>Cases correctly classified</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
<td>0.816</td>
<td>69.7%</td>
</tr>
<tr>
<td>1</td>
<td>ACT Math score</td>
<td></td>
<td>0.773</td>
<td>70.2%</td>
</tr>
<tr>
<td>2</td>
<td>Time spent of math HW outside school 10th</td>
<td>-0.090</td>
<td>0.778</td>
<td>70.3%</td>
</tr>
<tr>
<td>3</td>
<td>Classroom activities highly structured</td>
<td></td>
<td>0.092</td>
<td>70.2%</td>
</tr>
<tr>
<td>4</td>
<td>Graduation requirements for mathematics</td>
<td></td>
<td>0.094</td>
<td>69.2%</td>
</tr>
<tr>
<td>5</td>
<td>Teachers encourage academic achievement 12th</td>
<td></td>
<td>0.099</td>
<td>69.2%</td>
</tr>
<tr>
<td>6</td>
<td>Math growth 8\textsuperscript{th} to 12\textsuperscript{th} grade</td>
<td></td>
<td>0.099</td>
<td>69.7%</td>
</tr>
<tr>
<td>7</td>
<td>Discipline emphasized at the school</td>
<td>-0.110</td>
<td>0.779</td>
<td>69.7%</td>
</tr>
</tbody>
</table>

After computing the MIL variable for Adelman’s universe of NELS participants using the unstandardized coefficients seen in table 12, the mean was calculated. Then, the MIL variable was mean-centered (this can be seen in table 11).

*Block Entry of Covariates*

The analysis methodology in this section of part 2 was performed identically as with part 1. Interaction terms were explored in the same manner to conclude whether they
were significant contributors in the final model. The results of the analysis are presented in table 14 below.

Table 14

<table>
<thead>
<tr>
<th>Variables Included</th>
<th>B (SE)</th>
<th>Lower</th>
<th>Exp(B)</th>
<th>Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-1.419*** (0.084)</td>
<td>0.242</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SES in 12th grade</td>
<td>0.804*** (0.004)</td>
<td>2.218 2.234</td>
<td>2.250</td>
<td></td>
</tr>
<tr>
<td>8th grade NELS math score</td>
<td>-0.009*** (0.000)</td>
<td>0.990 0.991</td>
<td>0.992</td>
<td></td>
</tr>
<tr>
<td>Highest math course completed in HS</td>
<td>0.279*** (0.003)</td>
<td>1.314 1.322</td>
<td>1.329</td>
<td></td>
</tr>
<tr>
<td>Overall academic intensity</td>
<td>0.057*** (0.001)</td>
<td>1.057 1.058</td>
<td>1.059</td>
<td></td>
</tr>
<tr>
<td>Continuous enrollment in secondary math</td>
<td>1.084*** (0.092)</td>
<td>2.469 2.956</td>
<td>3.539</td>
<td></td>
</tr>
<tr>
<td>Early entry to algebra</td>
<td>0.351*** (0.083)</td>
<td>1.207 1.421</td>
<td>1.673</td>
<td></td>
</tr>
<tr>
<td>Mathematics intensity level (MIL)</td>
<td>1.350*** (0.082)</td>
<td>3.283 3.856</td>
<td>4.529</td>
<td></td>
</tr>
<tr>
<td>Early entry to algebra * MIL</td>
<td>-0.927*** (0.082)</td>
<td>0.337 0.396</td>
<td>0.465</td>
<td></td>
</tr>
<tr>
<td>Continuous enrollment in secondary math * MIL</td>
<td>-0.492*** (0.107)</td>
<td>0.496 0.612</td>
<td>0.755</td>
<td></td>
</tr>
<tr>
<td>Early entry to algebra * Continuous enrollment in math</td>
<td>-1.128*** (0.092)</td>
<td>0.270 0.324</td>
<td>0.388</td>
<td></td>
</tr>
</tbody>
</table>
Three additional variables were significant during this phase of analysis than was the result in part 1 of the analysis. Adelman’s overall academic intensity variable was significant along with two additional block 3 interaction terms that were not significant in part 1. The comparison between part 1 and part 2 will be discussed and compared in greater detail in chapter 5. Finally, the Nagelkerke R-square value of 0.397 indicates a relatively strong model for social science research.

Part 3: Universe MIL Minus the Standardized Math Score

Overview of Part 3

Part 3 includes an identical analysis as with part 1 in this chapter. However, the one difference in part 3 was the standardized NELS mathematics score was not used in the construction of the MIL. Part 3 reports the MIL variable

Table 14 (continued).

<table>
<thead>
<tr>
<th>Variables Included</th>
<th>B (SE)</th>
<th>Lower</th>
<th>Exp(B)</th>
<th>Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIL * Early entry to algebra * Continuous enrollment in math</td>
<td>0.636***</td>
<td>1.530</td>
<td>1.888</td>
<td>2.331</td>
</tr>
</tbody>
</table>

Notes: R² = .298 (Cox & Snell), .397 (Nagelkerke), χ²(11) = 364237, ***p < 0.001, cases correctly classified = 74.5%, and N = 1,030,400.
construction and the logistic regression analysis. Descriptive statistics are not presented because the variables for part 3 are identical to part 1 except for the MIL variable. The MIL variable descriptive statistics are presented in the notes section of the MIL table (table 15) because the MIL variable in part 3 is not equivalent to the MIL variable in part 1.

**MIL Construction**

Table 15 presents the results of the construction of the MIL variable for this study’s universe of participants without the inclusion of the standardized NELS mathematics score. Table 15 is followed by table 16 that gives the systematic removal of MIL variables as presented similarly in previous MIL construction results in part 1 and part 2 of this chapter.
Table 15

Final Results for MIL Variable Construction for Universe of Participants Without Standardized Math Score

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Time spent on Math HW outside of school - 12th grade</td>
<td>0.607</td>
<td>0.545</td>
<td>0.395</td>
</tr>
<tr>
<td>All students expected to do HW 12th grade</td>
<td>0.383</td>
<td>0.474</td>
<td>0.852</td>
</tr>
<tr>
<td>Discipline emphasized at this school</td>
<td>-0.286</td>
<td>-0.381</td>
<td>-0.942</td>
</tr>
<tr>
<td>Time spent on Math HW outside school - 10th grade</td>
<td>0.283</td>
<td>0.271</td>
<td>0.268</td>
</tr>
<tr>
<td>Teachers encourage academic achievement</td>
<td>-0.263</td>
<td>-0.498</td>
<td>-0.878</td>
</tr>
<tr>
<td>Students expected to do HW 10th grade</td>
<td>0.261</td>
<td>0.311</td>
<td>0.396</td>
</tr>
<tr>
<td>Graduation requirements for mathematics</td>
<td>0.190</td>
<td>0.166</td>
<td>0.269</td>
</tr>
<tr>
<td>Students place high priority on learning</td>
<td>0.166</td>
<td>0.200</td>
<td>-0.238</td>
</tr>
<tr>
<td>Time spent on Math HW inside school - 10th grade</td>
<td>-0.161</td>
<td>-0.204</td>
<td>-0.203</td>
</tr>
<tr>
<td>Teachers press students to achieve</td>
<td>0.152</td>
<td>-0.050</td>
<td>-0.072</td>
</tr>
</tbody>
</table>

Notes: MIL mean=0.000 with range 7.266 [-3.356,3.910] and weighted N=295,882. Wilks’ Lambda=0.971 and cases correctly classified=59.8%
Table 16

Overview of Each Step During MIL Variable Construction for Universe of Participants Without Standardized Math Score

<table>
<thead>
<tr>
<th>Step</th>
<th>Variable removed</th>
<th>Structure Matrix</th>
<th>New Wilks' Lambda</th>
<th>Cases correctly classified</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>0.975</td>
<td></td>
<td>60.9%</td>
</tr>
<tr>
<td>1</td>
<td>Classroom activities highly structured</td>
<td>-0.018</td>
<td>0.968</td>
<td>58.5%</td>
</tr>
<tr>
<td>2</td>
<td>Time spent of math HW inside school 12th</td>
<td>0.133</td>
<td>0.971</td>
<td>59.8%</td>
</tr>
</tbody>
</table>

Block Entry of Covariates

Table 17 reports the logistic regression results of part 3 following the identical methodology as was presented in part 1. Again, this section is being presented so that readers may distinguish between the inclusion and exclusion of a standardized mathematics achievement score in the MIL variable. Results were similar to part 1 results. The third two-way interaction term was significant and is different from part 1 results. This result will be discussed further in chapter 5. Table 17 concludes the presentation of the results for part 3. The Nagelkerke R-square term of 0.120 indicates a decent model for social science research.
Table 17

Entry of Covariates for the Main Analysis of the Universe of Participants Without Standardized Math Score in MIL

<table>
<thead>
<tr>
<th>Variables Included</th>
<th>B (SE)</th>
<th>Lower</th>
<th>Exp(B)</th>
<th>Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.357*** (0.054)</td>
<td>1.428</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SES in 12th grade</td>
<td>0.441*** (0.007)</td>
<td>1.534-1.555</td>
<td>1.575</td>
<td></td>
</tr>
<tr>
<td>8th grade NELS math score</td>
<td>0.007*** (0.001)</td>
<td>1.006-1.007</td>
<td>1.008</td>
<td></td>
</tr>
<tr>
<td>Highest math course completed in HS</td>
<td>0.330*** (0.004)</td>
<td>1.380-1.391</td>
<td>1.402</td>
<td></td>
</tr>
<tr>
<td>Continuous enrollment in secondary math</td>
<td>0.813*** (0.112)</td>
<td>1.810-2.254</td>
<td>2.807</td>
<td></td>
</tr>
<tr>
<td>Early entry to algebra</td>
<td>-0.534*** (0.069)</td>
<td>0.512-0.586</td>
<td>0.672</td>
<td></td>
</tr>
<tr>
<td>Mathematics intensity level (MIL)</td>
<td>0.994*** (0.079)</td>
<td>2.316-2.703</td>
<td>3.155</td>
<td></td>
</tr>
<tr>
<td>Early entry to algebra * MIL</td>
<td>-0.721*** (0.079)</td>
<td>0.416-0.486</td>
<td>0.568</td>
<td></td>
</tr>
<tr>
<td>Continuous enrollment in secondary math * MIL</td>
<td>-0.022* (0.009)</td>
<td>0.961-0.978</td>
<td>0.995</td>
<td></td>
</tr>
<tr>
<td>Early entry to algebra * Continuous enrollment in math</td>
<td>-0.453*** (0.112)</td>
<td>0.510-0.636</td>
<td>0.792</td>
<td></td>
</tr>
</tbody>
</table>

Notes: R²=.089 (Cox & Snell), .120 (Nagelkerke), χ²(9)=23803.4, *p<0.05, ***p<0.001, cases correctly classified=60.8%, and N=254,100
Part 4: Adelman MIL Minus the Standardized Math Score

Overview of Part 4

Part 4 is presented using the same methodology as in part 2. The MIL variable in part 4 was constructed for all NELS participants with secondary and postsecondary transcripts except the standardized NELS mathematics score was not included in the construction of the MIL variable.

MIL Construction

The results of the MIL variable construction for part 4 are presented in table 18 (on subsequent page) followed by table 19 presenting the step-wise removal of variables during MIL construction.
Table 18

Final Results for MIL Variable Construction for Adelman’s Universe of NELS Participants Excluding the Standardized Math Score

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Time spent on Math HW outside of school – 12th grade</td>
<td>0.813</td>
<td>0.743</td>
<td>0.572</td>
</tr>
<tr>
<td>Time spent on Math HW inside school – 12th grade</td>
<td>0.493</td>
<td>0.014</td>
<td>0.011</td>
</tr>
<tr>
<td>Students place high priority on learning</td>
<td>0.426</td>
<td>0.286</td>
<td>0.538</td>
</tr>
<tr>
<td>Teachers press students to achieve</td>
<td>0.348</td>
<td>0.147</td>
<td>0.209</td>
</tr>
<tr>
<td>Time spent on Math HW outside school – 10th grade</td>
<td>0.348</td>
<td>0.214</td>
<td>0.198</td>
</tr>
<tr>
<td>Students expected to do HW 10th grade</td>
<td>0.327</td>
<td>0.133</td>
<td>0.173</td>
</tr>
<tr>
<td>All students expected to do HW 12th grade</td>
<td>0.266</td>
<td>0.140</td>
<td>0.251</td>
</tr>
<tr>
<td>Classroom activities highly structured</td>
<td>0.171</td>
<td>0.060</td>
<td>0.115</td>
</tr>
<tr>
<td>Graduation requirements for mathematics</td>
<td>0.154</td>
<td>0.115</td>
<td>0.180</td>
</tr>
<tr>
<td>Discipline emphasized at this school</td>
<td>-0.150</td>
<td>-0.219</td>
<td>-0.509</td>
</tr>
</tbody>
</table>

Notes: MIL mean=0.000 with range 7.386 [-2.563,4.823] and weighted N=1,319,828. Wilks’ Lambda=0.895 and cases correctly classified 64.2%.
Table 19

Overview of Each Step During MIL Construction for Adelman’s Universe of NELS Participants Excluding Standardized Math Score

<table>
<thead>
<tr>
<th>Step</th>
<th>Variable removed</th>
<th>Structure Matrix</th>
<th>New Wilks’ Lambda</th>
<th>Cases correctly classified</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>0.893</td>
<td></td>
<td>65.3%</td>
</tr>
<tr>
<td>1</td>
<td>Time spent of math HW outside school 10th</td>
<td>-0.103</td>
<td>0.895</td>
<td>64.6%</td>
</tr>
<tr>
<td>2</td>
<td>Teachers encourage academic achievement 12th</td>
<td>0.140</td>
<td>0.895</td>
<td>64.2%</td>
</tr>
</tbody>
</table>

Block Entry of Covariates

Table 20 reflects the results of the analysis using the MIL variable without the inclusion of the standardized NELS mathematics score for all of the NELS participants with secondary and postsecondary transcripts. The results are similar to the analysis in part 2 and will be discussed in chapter 5. Table 20 concludes the presentation of results for chapter 4. The Nagelkerke R-Square 0.389 indicates a very high association with the dependent variable for social science data analysis.
Table 20

Block Entry of Covariates for Adelman’s Universe of NELS Participants Without Standardized Math Score in MIL

<table>
<thead>
<tr>
<th>Variables Included</th>
<th>B (SE)</th>
<th>Lower</th>
<th>Exp(B)</th>
<th>Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.432*** (0.045)</td>
<td>1.541</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SES in 12th grade</td>
<td>0.797*** (0.003)</td>
<td>2.205 2.220 2.235</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8th grade NELS math score</td>
<td>0.021*** (0.000)</td>
<td>1.021 1.021 1.022</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highest math course completed in HS</td>
<td>0.319*** (0.003)</td>
<td>1.375 1.375 1.382</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall academic intensity</td>
<td>0.063*** (0.000)</td>
<td>1.065 1.065 1.066</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous enrollment in secondary math</td>
<td>-0.206*** (0.055)</td>
<td>0.731 0.814 0.906</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Early entry to algebra</td>
<td>-0.624*** (0.045)</td>
<td>0.491 0.536 0.585</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mathematics intensity level (MIL)</td>
<td>0.228*** (0.003)</td>
<td>1.247 1.256 1.265</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous enrollment in math * MIL</td>
<td>-0.431*** (0.029)</td>
<td>0.614 0.650 0.688</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Early entry to algebra * Continuous enrollment in math</td>
<td>0.157** (0.055)</td>
<td>1.051 1.170 1.304</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MIL * Early entry to algebra * Continuous enrollment in math</td>
<td>0.433*** (0.029)</td>
<td>1.456 1.541 1.632</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: R²=.291 (Cox & Snell), .389 (Nagelkerke), χ²(11)=386706.5, ***p<0.001, **p<0.01, cases correctly classified=73.2%, and N=1,030,400
CHAPTER 5: EXPLANATION AND SYNOPSIS

Interpretations, Discussions, Summary, Conclusions, and Recommendations Resulting from this Study

This study was conducted in an effort to continue the discourse regarding secondary mathematics graduation and college admissions requirements for the prototypical college bound student attending public four-year institutions. This study was driven by the research findings of Clifford Adelman (1999, 2006), and its intent was to strengthen, clarify, and extend his findings. More specifically, this study aimed to support Adelman by focusing on the more typical or traditional group of college bound students referred to in this research as the prototypical college bound student.

The students comprising the universe of participants in this study are arguably more likely to struggle or avoid mathematics in secondary schools. Hypothetically, the group of students comprising this study’s universe, under some states’ current policies and higher education admission requirements, may avoid challenging secondary mathematics while preparing for college. Further, this study removed the high academic achievers (those attending highly
selective institutions), two-year-only college participants, and part-time students from Adelman’s universe of analysis. The removal of these participants allowed this study to analyze, more specifically, the prototypical universe of high school graduates who seek four-year degrees under the traditional path to a bachelor’s degree. The direction of this study was to focus on the prototypical high school students seeking a four-year degree full-time by removing some of Adelman’s universe of study, which then allowed this research to focus on the standard traditional bachelor degree-seeking student. Focusing on this particular group of participants created an environment that centered on the students who are more likely to be affected by state secondary mathematics educational mandates and college admissions standards for four-year degree seeking students.

Overview of Chapter 5

The results of this study are presented first by summarizing and interpreting the results of part 1 in chapter 4. Part 1 of chapter 4 was the primary focus of this study. Further, the results of part 1 are compared to part 2 as an effort to differentiate the importance of secondary mathematics for prototypical college bound
students without a statistical influence from elite college students, non-bachelor degree seeking students, and transient or part-time students included in Adelman’s research universe. In addition, a discussion is presented regarding part 3 and part 4 from chapter 4 where the MIL variable omitted the standardized mathematics achievement measure. Chapter 5 closes with conclusions resulting from this study and makes recommendations in light of its results.

Interpretation of the Results

MIL Discussion and Interpretation

There are a few important notes regarding the MIL variable in table 7. First, the third most important variable contributing to the MIL was whether discipline was emphasized at the school. One interpretation may be if schools must enforce or emphasize discipline, then students may misbehave and consequently lose academic focus. Thus, students fail to be model students and achieve at lower levels. A second interpretation may be that schools that emphasize discipline may run smoothly, and consequently, students have an environment to focus on academics. Thus, students achieve at higher levels. A third interpretation
might be that the link between discipline and achievement is indirect. That is, in schools where students are more academically oriented, discipline is less of an issue and, therefore, is not emphasized. However, in schools where students are less conscientious or academically oriented (and their resultant academic achievement is lower), discipline may be a larger issue. The unstandardized coefficient was negative, which arguably leans towards the first or third suppositions. If more discipline is required, then students may not be acting appropriately in the classroom; students may be behaving at a level requiring secondary schools to focus more on discipline than academics. Alternatively, students in schools that devote a significant amount of time on discipline may lose academic focus. In either case, this study indicates these students are less likely to finish a bachelor’s degree after high school if their secondary schools dedicated and emphasized discipline to a point where academic focus is lost.

A second observation to note is the interpretation of the variables regarding time spent on math homework inside and outside of school. Time spent on mathematics homework inside school (in both 10th and 12th grades) negatively
impacts students’ MIL. An interpretation is that teachers in the secondary mathematics classroom who use class time for students to do homework arguably may not cover as much material or may not cover topics as deeply. Still another possibility is that teachers who feel the need to have students practice choose to have them do some of the homework in class because some/many of the students may not be willing to do the work at home. An additional interpretation may be students will learn a behavior in high school that negatively impacts study habits in college. That is to say, students completing more of their homework in school during the high school years may arguably fall into an academic trap; students may perceive that learning and academic coursework is isolated or exclusively inside the classroom rather than outside the classroom, and consequently, students may erroneously believe that homework is unnecessary, which results in their spending less time outside of school studying course content. In other words, once the student reaches college, he or she may tend to do very little work outside of the classroom. This conclusion may perhaps be supported even further with the next MIL result.
Time spent on mathematics homework outside of school (in 12th grade) positively impacts MIL and bachelor degree completion. Hence, students hypothetically doing more math homework in school and less homework out of school are dually lowering their MIL. This, of course, presumes that the work is done here or there. Alternatively, more homework may simply mean more total work. On the other hand, homework may be an indicator of a student’s desire to learn. Moreover, if a secondary mathematics teacher uses class time for students to complete homework and, as a consequence, then requires less time outside the classroom to complete homework, the teacher is dually lowering students’ MIL.

A final note for the MIL is that the number of mathematics credits to graduate from high school is a significant contributor to the MIL. However, caution must be applied here. This NELS variable must be distinguished from the secondary mathematics credits required to enter college; the two are not identical. The variable in the NELS data is the number of credits for all students (not necessarily college bound) to graduate from their respective high school in 1992. In 1992, the number of credits to graduate from most public high schools was three
or two and most postsecondary institutions (non-highly selective four-year schools) required no more than three secondary mathematics credits for admission. Therefore, NELS participants with postsecondary records must have completed at least two, but more likely, three secondary mathematics credits at a minimum. The interpretation from the MIL statistic is that students who exceeded the standard two or three credits were more likely to be a bachelor degree recipient. Hence, students increasing this variable above three mathematics credits would more likely be grouped as a bachelor degree recipient than not. This result supports the increase of secondary mathematics credits required to enter four-year public institutions from three to four but cannot be at the expense of lowering other MIL variables. Otherwise, the lowering of other MIL variables would negate the increased graduation requirements.

Logistic Regression Results

The results of the logistic regression analysis produced a significant model in predicting bachelor degree completion. Each block entry of covariates resulted in a stronger model being generated. Three results support this conclusion. First, all of the variables analyzed in part 1
of this study (except for Adelman’s overall academic intensity variable) were significant contributors towards predicting bachelor degree completion. Second, the R-square values from block 1 through block 3 increased at each block entry step. The Cox & Snell R-square term increased from 0.047 to 0.058 to 0.084 while the Nagelkerke R-square term increased from 0.063 to 0.078 to 0.113. The Nagelkerke R-square jumped most dramatically when the variables of this study were included in the model. Third, the percentage of cases correctly classified by the model increased modestly from 60.9% to 61.0% to 62.2%. The largest increase in the R-square statistics and percentage of cases correctly classified occurred from block 2 to block 3. These statistics indicate the block 3 variables of this study are important in predicting and associating bachelor degree completion above and beyond block 1 and block 2 variables.

Reference student definition.

The reference student referred to in the next three subheadings is a student with: (a) A mean SES in twelfth grade; (b) A mean eighth grade NELS math score; (c) The highest math course completed in high school as algebra-2, (d) A mean MIL; (e) Did not enter algebra-1 prior to grade nine; and (f) Did not remain continuously enrolled in
secondary mathematics throughout high school. The reference student has an odds ratio of 1. That is to say, the reference student’s odds of completing a bachelor’s degree are the baseline for referral.

**Block 1 variables: Discussion & interpretation.**

The first block entry of covariates was to establish controlling variables known in educational research to predict future academic achievement. SES and prior mathematics achievement were both significant in predicting bachelor degree completion. The SES of a student in twelfth grade seems to show some evidence whether a student can afford to attend college, or it signifies government financial aid will be required. Additionally, a student with lower mathematics achievement prior to high school will likely achieve less mathematically in high school, thus lowering the odds of bachelor degree completion.

The SES mean-centered scale cuts up into quartiles at SES values of -0.464, -0.076, and 0.494. Consider the reference student who moves up the SES scale from the mean (0.000) to the 75th percentile (0.494). A student at this level would complete a bachelor’s degree 1.24 times more often (about 25% more often). The eighth grade NELS mathematics test score breaks up into quartiles at the
values of -6.8, -0.19, and 7.27. Consider the reference student who increases their eighth grade math test score from the mean (0.000) to about a half a quartile (3.50). A student at this level would complete a bachelor’s degree only a small percentage (about 4%) of the time less often, because the beta-value for this variable is negative but small. The interpretation of block 1 covariates in the final model is that a higher SES greatly impacts the odds of bachelor degree completion and that prior mathematics achievement contributes very little either way. Secondary classrooms typically cannot change or influence these two distal variables. Thus, discussions that follow hold SES and prior achievement constant at the mean.

Block 2 variables: Discussion & interpretation.

The highest mathematics course completed in high school was significant in predicting bachelor degree completion as suspected. However, Adelman’s overall academic intensity variable (after block three covariates were entered into the model) was not significant for the universe of participants for which this study focused. These two results can be interpreted to imply moving up the secondary mathematics ladder qualitatively greatly improves the odds of completing a bachelor’s degree as Adelman
(1999, 2006) demonstrated in his research. However, for the prototypical high school graduate (this study’s universe), quantity, or the simple accumulation of Carnegie credits (moving up Adelman’s academic intensity scale), was not significant in predicting bachelor’s degree completion.

The Exp(B) or odds ratio for each rung of the mathematics ladder (above algebra-2) increased the odds of bachelor degree completion to 1.35 times, 1.83 times, and 2.48 times (trigonometry to pre-calculus to calculus, respectively) for the universe of participants in this study. For example, suppose we compare the reference student to a student equal in nature with the exception of completing pre-calculus in high school. The second student completed two additional rungs (units) of the mathematics ladder than the reference student. The second student is 83% more likely (1.83 odds ratio) to complete a bachelor’s degree than the reference student.

**Block 3 variables: Discussion & interpretation.**

This study resulted in demonstrating that all three variables were statistically significant in predicting bachelor degree completion above and beyond block 1 and block 2 variables. Some of the results were not as expected, while other results were as expected. For
example, the beta-value for early entry to algebra-1 was negative. This result implies that early entry to algebra-1 decreases the odds of bachelor degree completion. However, a reasonable interpolation may be that by removing the highest achievers (highly selective college goers) many high school calculus-completing students are missing from this analysis. This was an unexpected result and rejects the third hypothesis (H₃) of this study. The continuous enrollment and MIL variables of this study were both significant, and both variables increase the odds of bachelor degree completion. These two results confirm the remaining two study hypotheses (H₁ and H₂). The rejection of the third hypothesis (H₃) warrants further discussion.

The rejection of the early algebra entry hypothesis was investigated further after the results were obtained. Further examination of NELS participants who entered algebra-1 prior to grade nine was conducted. As presented in chapter 4, roughly 1% of NELS participants fit into this category. However, more than 80% of these participants completed a bachelor’s degree. This result was blurry at first, but there are two important interpretations to discuss. First, consider a student who decides to enroll in algebra-1 in eighth grade. If this student holds all other
variables constant at the mean, then this student will be about 50% less likely to complete a bachelor’s degree. Recall, the reference student only completes algebra-2 and does not remain continuously enrolled in secondary mathematics. Assume the example student does not fail algebra-1, geometry, or algebra-2 at any point in high school. Thus, the example student would end up without mathematics their junior and senior years of high school. Recall from chapter 4 descriptive data that only 1% of this study’s universe enrolled in algebra in eighth grade. Very few students, if any at all, would fall into this category of enrollment. Hence, the early entry to algebra-1 variable having a negative beta means the odds of bachelor degree completion are seriously deflated if the student does not persist continuously up the mathematics ladder through high school graduation. In other words, to counteract the negative beta value for the early entry to algebra variable, a student would need to remain continuously enrolled in secondary mathematics climbing up the mathematics ladder through the end of grade 12.

Second, the interaction term between early algebra-1 enrollment and the MIL was significant. This result partially explains the negative beta for the early entry to
algebra-1 variable. The interpretation of the negative beta for this interaction term is a student with a below average MIL (negative MIL) will increase their odds of bachelor degree completion by enrolling in algebra-1 early. This interaction also indicates students who experience higher MILs do not necessarily need to enroll in algebra-1 prior to grade nine. Students with an above average MIL will be challenged enough in high school mathematically to account for the late start in college preparatory mathematics (algebra-1). Thus, students expecting to attend a high school where the classroom variables constructing the MIL result in a below average MIL might consider enrolling in algebra-1 in grade eight to get an extra year of secondary mathematics coursework.

The continuous enrollment variable (the primary focus of this study) is significant: students increase their odds (1.31 odds ratio, 31% more likely) of bachelor’s degree completion by remaining continuously enrolled in secondary mathematics regardless of whether the student repeats a course in high school or not. For the universe of participants in this study, 55% of students remained continuously enrolled in secondary mathematics. For the same universe, 45% earned credits continuously. Thus, at
least 10% of the universe of analysis failed a mathematics course(s) in high school yet still increased their odds of bachelor degree completion by repeating a course and continuing in secondary mathematics. Further, the interaction between continuous enrollment and the MIL was significant even with a negative beta-value. This result is an indication signifying a high MIL (above average) means continuous enrollment is less important. On the other hand, weak MIL classrooms (below average) when coupled with continuous enrollment tend to increase the odds of bachelor degree completion.

Finally, the MIL variable (1 unit of MIL = 2.70 odds ratio) increases the odds of bachelor degree completion. The MIL was significant and has a large effect size compared to other variables in part 1. The MIL variable was determined to be the greatest contributor to increasing the odds of bachelor degree completion. The results presented in table 10 indicate that if secondary mathematics classrooms are intense and students achieve mathematically, then the MIL variable will overshadow taking high levels of mathematics continuously in high school. Based on the results of this study, there is not a single approach to
increasing the likelihood of completing a bachelor’s degree.

Summary of Main Analysis

The results of the main analysis present strong evidence that supports and extends Adelman’s 1999 and 2006 Toolbox findings. Secondary mathematics debatably remains an influential subject area impacting bachelor degree completion. The odds of bachelor degree completion are greatly influenced by secondary mathematics enrollment factors and the intensity of students’ secondary mathematics (MIL).

Three distinct paths through secondary mathematics have been hypothesized as possible course of studies for the prototypical college bound student. Typically, the prototypical student attending a state four-year college or university will not have completed calculus in high school. This study does not promote the notion that all college bound students take calculus in high school. However, this study does promote the notion that students are to be calculus or at the least, pre-calculus ready upon entering college.
Path 1

First, holding SES and prior achievement constant, one path for prototypical students is: (a) Enter algebra-1 in grade nine; (b) Remain continuously enrolled in secondary mathematics (completing trigonometry as highest mathematics); (c) Take four years of challenging mathematics courses in a school that require 4-6 hours of homework a week outside of the classroom setting and less than 1 hour each week of coursework inside the classroom where discipline is semi-emphasized; (d) Achieve at the mean on standardized mathematics tests; and (e) Place a high priority on learning their senior year in a school where homework is expected to be completed by all students (see figure in appendix G). This scenario generates an MIL of 2.42 units above the mean and increases the odds of bachelor degree completion about 13.5 times than that of the reference student. This scenario applies to a high school where academics are emphasized highly and students are active in their studies but only achieve at the mean on standardized mathematics assessments. This result indicates study habits are important when considering bachelor degree completion odds.
Path 2

Second, holding SES and prior achievement constant, another path for the prototypical student is: (a) Enter algebra-1 in grade eight because the student/parents anticipate a secondary school with minimal demands (MIL below average); (b) Remain continuously enrolled in mathematics; (c) Achieve at the 40th percentile on standardized mathematics tests; (d) Complete pre-calculus in the senior year; and (e) Complete 2-3 hours of math homework per week in the classroom and complete 2-3 hours of math homework out of school (see figure in appendix H). This scenario produces the odds of bachelor degree completion only about 3% (1.03 odds ratio) more often than the reference student does. Further, this scenario sets the stage for a high school that fails to establish the academic demands where students become active and engaged in their studies mathematically. Additionally, this scenario gives an example of a student who completes high levels of mathematics but fails to achieve at levels typical of students completing high levels of mathematics in high school.
Path 3

Holding SES and prior achievement constant at the mean, another path for the prototypical student is: (a) A student takes algebra-1A and algebra-1B in grades eight and nine respectively; (b) The student remains continuously enrolled in secondary mathematics; and (c) The student completes trigonometry and pre-calculus during the senior year of high school with a mean MIL (see figure in appendix I). The odds for this student to complete a bachelor’s degree are 1.12 than that of the reference student. This scenario represents a student who may have average mathematical ability in grade eight and needs two years to complete algebra-1. Further, the scenario illustrates the importance of remaining continuously enrolled; otherwise, the odds ratio drops to 0.47 (53% less likely to complete than reference student) if algebra-2 ends up being completed in grade eleven and no math is taken in grade twelve. This pattern is evident in many prototypical students attending four-year institutions today. Additionally, if this student along with their high school mathematics teachers increased this student’s MIL an additional unit above the mean, the student’s odds of bachelor degree completion increases to 2.60 from 1.12.
This result signifies a massive change in the odds of bachelor degree completion.

Part 1 Results Compared to Part 2 Results

Using the same methodology, this section compares the results between the universe of participants for this study and Adelman’s universe of participants. The MIL was constructed using the same method in part 1 and in part 2. Logistic regression was used in the same fashion as well. A number of different results are discussed next.

MIL Differences

The universe of participants for this study resulted with a MIL consisting of nine variables (see table 7). Using the NELS population as Adelman used, the MIL consisted of eight variables (see table 12). The MIL in part 1 lost three contributors when compared to the MIL in part 2. The variables lost were: (a) Discipline emphasized at the school; (b) Time spent on math homework inside school in 10th grade; and (c) Graduation requirements for mathematics. The MIL for Adelman’s universe picked up two additional variables not in the MIL in part 1. The variables gained included: (a) Teachers press students to
achieve in the 10th grade; and (b) Time spent on math homework outside school in the 10th grade.

Comparing the two MIL variables indicate similar findings. Time devoted to completing math homework inside school deflates the MIL, while time devoted to completing math homework outside school increases the MIL. The MIL for Adelman’s universe was more predictive due to the population of analysis. The MIL for Adelman’s universe had a Wilkes’ Lambda of 0.779 compared to a value of 0.951 for this study’s universe (lower Wilkes’ Lambda indicates a stronger classification model). Additionally, the percentage of cases correctly classified were 69.7% (part 2) and 61.0% (part 1). These results indicate a strong MIL in part 2; the results were not unexpected. The universe of participants in part 1 and part 2 are fairly different. However, the important result is secondary mathematics intensity level is rather predictive of bachelor degree completion. Hence, the MIL is especially important at maintaining bachelor degree momentum.

Logistic Regression Comparison

This section compares the variables of interest in this study for the two universes (this study and Adelman’s). Table 10 and table 14 present the results of
the logistic regression for each universe of participants. There are a number of differences. Part 2 in table 14 indicates a stronger logistic model. This was expected based on the two different universes of study. In both models, the results indicate secondary mathematics is important for bachelor degree completion. The differences between table 10 and table 14 are discussed next.

First, Adelman’s overall academic intensity (OAI) variable was significant for the universe in which Adelman studied. The OAI variable was not significant in the model for this study’s universe. Second, prior mathematics achievement barely contributes to bachelor degree completion. The results indicate mathematics achievement prior to high school is not as important as the mathematics achievement and enrollment in high school when predicting bachelor degree completion. This statement applies to all four parts of chapter 4 for both this study’s and Adelman’s universes.

Third, SES remained significant as expected. However, the odds ratio for this study’s universe for one unit of SES is 1.54 while the SES odds ratio for Adelman’s universe is 2.23 for one unit of SES. This result was expected and is important to note. Students often attend their
particular higher education institutions based on financial means. That is to say, poorer students may be more likely to attend trade or two-year schools after high school graduation. Many low SES students do not attend any postsecondary institutions because they lack the financial means to do so. Additionally, students with a higher SES are more likely to attend four-year schools or highly selective schools. Hence, the higher SES odds ratio for Adelman’s universe than this study’s universe is not unexpected. The results of part 1 and part 2 signify these results regarding the SES variable. Further, the range of SES is much greater for Adelman’s (see table 4 and table 11) universe than this study’s universe. Associations between variables may well be reduced in part 1 because of the deletion of the tails of Adelman’s universe. Thus, part 2 may seem to demonstrate SES is much more important to the tails (high achievers and non-full-time, non-bachelor degree seeking students) of Adelman’s universe.

Fourth, the highest mathematics course completed in high school ended up nearly identical when comparing Adelman’s universe to this study’s universe. The odds ratio for each rung of the mathematics ladder in Adelman’s universe was 1.32. The odds ratio for each rung for this
Fifth, the beta-value for the early entry to algebra variable changed from negative to positive when comparing part 1 to part 2. This result would seem to solidify Ma’s (2005a, 2005b) contention that early entry to algebra for the weakest mathematics students produces higher overall mathematics achievement in the long run because the different universes of study in part 1 and part 2 differ most by including the large number of non-bachelor degree seeking students who attended only two-year schools and also differ by the deletion of students attending highly selective four-year schools. This top-end student would have been more likely to take calculus in high school.

Sixth, the most notable changes occurred in the block 3 covariates. The continuous enrollment variable for this study’s universe had an odds ratio of 1.31, while the odds ratio was 2.96 for Adelman’s universe of study. This result indicates a strong predictive nature for this variable regardless of the universe of study. This result could set the stage for reexamination of many high school graduation and college admission standards regardless of the type of postsecondary institution a student plans to attend. Further, the MIL variable was highly significant at
increasing bachelor degree completion odds. This study’s universe had an odds ratio of 2.70 for the MIL variable. Likewise, the MIL odds ratio for Adelman’s universe of study turned out to be 3.86. Both results indicate students’ MIL is the single most predictive variable of bachelor degree completion if a standardized measure of mathematics achievement is included in the MIL model.

Finally, two additional interaction terms were significant in block 3 for Adelman’s universe. The two-way interaction between early entry to algebra and continuous enrollment was significant with a negative beta of -1.128. However, the result is similar in nature to the part 1 discussions and interpretations. That is to say, as long as students’ MIL is above the mean, then early entry to algebra-1 and continuous enrollment are not necessarily needed. Further, the negative beta-values for each two-way interaction coupled with the three-way interaction term (beta-value=0.636) signifies that all three block 3 covariates outweigh the detriments of each variable. Continuous enrollment, early algebra-1 entry, and an above average MIL outweigh the detriment of each variable.

Comparing the results from part 1 and part 2 solidify secondary mathematics as a foundation of bachelor degree
momentum. Without this foundation, the likelihood a student will complete a four-year degree diminishes greatly.

Path 1 Discussion (Comparing Part 1 and Part 2)

The reference student for comparison purposes in this section is the same as in part 1 with one exception. Adelman’s overall academic intensity variable is set at the mean of 0, which is equivalent to level 15 seen in appendix C (recall this study recoded Adelman’s variable to range from -17 to 14 by mean-centering, with 14 the highest level possible). The odds ratio for the reference student in part 2 is 1.0 as was the same for the reference student in part 1. That is to say, the reference student in part 2 has mean SES, mean eighth grade mathematics achievement, does not take algebra 1 in eighth grade, does not remain continuously enrolled in secondary mathematics, has a mean MIL, and completes algebra-2 in high school on level 15 of Adelman’s overall academic intensity scale.

Recall the student progressing down path 1 as previously discussed in this chapter. Hypothetically, consider the same academic settings and course variables for comparison. The results from Adelman’s universe produce an overall odds ratio for bachelor degree completion of
8.31 as compared to 13.46 for this study’s universe. Hence, the analysis of the same student using the statistics from part 1 and part 2 present expected results. The analyses for both universes indicate an extremely high likelihood of students completing a bachelor’s degree by following the hypothetical path 1. Similar odds result from paths two and three.

Part 3 and Part 4 Discussions

MIL Comparisons

Table 15 and table 18 present the results for the MIL identically as was done in part 1 and part 2 of this study with one exception. The MIL was constructed without a standardized mathematics achievement score. Both universes of study in part 1 and part 2 coincide with part 3 and part 4, respectively. The MIL variable constructed in part 3 is only slightly different from the MIL construction in part 1. Most notably, five variables have negative unstandardized coefficients. The reader may have anticipated these five coefficients ending up positive (see table 15) after examining the results in part 1 and part 2.

The discipline emphasis variable possessing a negative coefficient was discussed earlier in this chapter; however,
the other four variables call for discussion. Two variables indicate that if teachers press for and encourage academic achievement, then students’ MIL is lowered. This result is surprising at first glance. However, by removing the standardized mathematics achievement variable, the possibility exists that teachers can stress achievement, but students fail to take achievement seriously. Thus, student achievement may not be inline or up to par with teacher expectations. The other two variables also indicate such findings. The more math homework completed inside school, the more it negatively impacts the MIL. This result is similar in nature to part 1 results. Finally, if students place a high priority on learning in grade twelve (as asserted by school personnel), then this resulted in a lower MIL. This result can be interpreted similarly to the teacher stressing achievement result. One can say achievement is important but fails to demonstrate achievement on standardized tests. These results possibly speak of a problem in today’s secondary school classrooms. To be precise, we can stress achievement all we want; however, without a standardized measure that positively indicates that achievement is progressing, words mean nothing.
Table 18 in part 4 presents similar findings as in the MIL construction in part 2. The MIL in part 4 had only one significant difference than in part 2. The variable regarding math homework completed in school in grade 12 changed from a negative to positive unstandardized coefficient. However, the positive value was 0.011 indicating very little contribution to the MIL model.

**Part 3 and Part 4 Logistic Regression**

Part 3 logistic regression results (see table 17) indicate that continuous enrollment and MIL are the strongest contributors to increasing the odds of bachelor degree completion. This result solidifies the outcomes found in part 1. To be exact, continuous enrollment in secondary mathematics and a strong MIL are the predominant predictors of bachelor degree completion for the universe of this study. Without the inclusion of the standardized mathematics achievement measure, the results of part 3 arguably indicate even stronger results than part 1. That is to say, the achievement removal from the MIL pumps up the continuous enrollment variable’s contribution to the model. In other words, if we compare the logistic regression results from part 1 (table 10) and part 3 (table 17), we can conclude the greatest change in the odds occurs
with the continuous enrollment variable (1.307 to 2.254). All other variables’ odds contribution remained approximately the same. Hence, by dropping the achievement measure from the construction of the MIL, the shear importance of continuous enrollment becomes significantly greater for the universe of participants in this study.

Part 4 logistic regression results (see table 20) indicate very different results than in part 2. Part 4 was initially presented only as a reference for readers to compare part 2 and part 4 results for Adelman’s universe of study with the inclusion and exclusion of the standardized mathematics score in the MIL. However, the results in part 4 do raise some interesting concerns warranting further interpretation and discussion.

The absence of the standardized mathematics achievement measure from the MIL introduces a concern in today’s society, that SES greatly impacts overall academic achievement and educational opportunity. Recall part 4 is made up of high school graduates with any form of postsecondary education. Thus, by examining table 20, the reader should take note that SES was the greatest contributor to the odds of bachelor degree completion. Moreover, SES has the greatest effect size of whether
students will complete a bachelor’s degree, at least from the odds perspective. This result signifies that low SES students at the time of high school graduation are at a somber disadvantage from earning a bachelor’s degree based on a distal variable that is out of students’ control.

Finally, the model in part 4 has one other significant difference from the first three parts. The continuous enrollment beta-value now appears as a negative value. The block 3 covariates are led (in odds contribution) by the MIL. Thus, a strong MIL is the only block 3 covariate positively increasing the odds of bachelor degree completion. However, the three-way interaction is the greatest contributor (besides SES) to the odds of bachelor degree completion. Hence, if students enroll in algebra-1 in grade eight and remain continuously enrolled, then students must also be exposed to an above average MIL during their secondary mathematics studies. Otherwise, MIL is more important than continuous enrollment or early entry into an algebra course.

Summary

Adelman’s Toolbox results (1999, 2006) indicate students who will be seeking bachelor’s degrees after high school should climb the mathematics ladder as high as
possible when in high school. The results from this study expand Adelman’s research. That is, students need to be enrolled in secondary mathematics throughout high school even if they fail or struggle in mathematics courses along the way. More importantly, the secondary mathematical curriculum needs to ensure that the mathematics classroom remains intense. Teachers and school personnel are in control of all of the variables in the MIL in parts 3 and parts 4 of chapter 4. That is to say, excluding achievement, schools can increase students’ MIL greatly by challenging their students and expecting more out of their prototypical college-bound students. Further, even in parts 1 and 3 of chapter 4, an average mathematics-achieving student can have their MIL increased significantly by school personnel. Mixed results were discovered regarding early entry to algebra-1 in grade eight that might be the result of a low percentage of NELS participants who enrolled in algebra-1 prior to grade nine. The low percentage of participants introduces an additional limitation in this study discussed in chapter 1. However, the early entry to algebra variable was significant and produced interesting interpretations of the results that warrants future research.
Three strengths emerge from this study. First, SES plays a major role in whether students will earn a bachelor’s degree. This can be reasonably inferred by comparing part 2 and part 4. Thus, when considering all high school students who attend any type of postsecondary institutions, SES is a predominant contributor to the odds of bachelor’s degree completion. Second, continuous enrollment in secondary mathematics does improve the odds of bachelor degree completion significantly for this study’s universe of participants. Finally, the MIL variable (with or without standardized mathematics score) is the most significant variable contributing to the odds a student will complete a bachelor’s degree. The rigor or intensity of the secondary mathematics curriculum for students is highly predictive and contributes a great deal to the odds of bachelor degree completion. These findings, even with a limited number of academic and classroom variables available in NELS, strongly indicate that secondary mathematics teachers need to focus on increasing the MIL for all students, especially students with any postsecondary education in their future. This conclusion further strengthens and provides additional research
supporting the rationale behind NCTM’s Equity Principle (NCTM, 2000).

Conclusions

The results from this study coupled with Adelman’s 1999 and 2006 results solidify secondary mathematics as a most important subject area for students preparing for college in the midst of seeking a bachelor’s degree. If America wishes to increase the adult population possessing a bachelor’s degree, then we as a country need to focus on improving the intensity of America’s secondary mathematics curricula for students by raising classroom demands and expectations. Additionally, secondary mathematics requirements need to be discussed and researched further. This research should not be interpreted to mean that other subject areas should receive less attention in high school. English, science, and other subjects are important as well. Further, the relative importance of subject areas likely varies with the individual student. Too often, students enroll in the minimum number of secondary mathematics courses and fail to remain continuously enrolled in secondary mathematics. Additionally, NAEP data indicate secondary mathematics is failing to make progress. Secondary mathematics programs of high MIL are not only
associated with degree completion but are likely to better prepare students for the rigors of higher education than will secondary mathematics programs of low MIL.

Recommendations

This research makes a number of recommendations based on the findings of the study. First, the secondary mathematics education community (school administrators, teachers, policy makers, professional organizations, higher education persons, and researchers) must enter into a rigorous discourse regarding setting high school graduation requirements for college bound students with different postsecondary goals. The discussions should consider instituting secondary mathematics as required every year of high school such as we do for English. Additionally, higher education should consider revisiting the requirements for admission to four-year public institutions. That is, public four-year schools should consider requiring four years of continuous secondary mathematics rather than four credits. Further, teachers should discuss classroom practices that will increase the MIL in their schools. Researchers should collaborate and extend existing research as an effort to inform policy makers. Students and parents alike must be made aware that secondary mathematics has become a
separator of bachelor degree recipients and those who do not earn the degree.

This research indicates that further research regarding the link between secondary mathematics and bachelor's degree completion is warranted. Moreover, it calls for the education and policy research community to expand the results of this research and Adelman’s research to incorporate other subject areas. The calls for future research are made in lieu of the fact that many public four-year institutions are seeing remedial and service-level mathematics course enrollments soar coupled with simultaneous poor success in those courses. Additionally, many public four-year institutions have yet to see significant increases in graduation rates or freshmen retention rates. Finally, this researcher recommends four-year institutions further research the links between mathematics coursework and overall college success in an effort to increase student retention and bachelor degree completion. Institutions can be served well by their institutional researchers using transcript and registrar data to expand the connection between mathematics and overall college success. The results of this research, as well as research noted in chapter 2, indicate that
mathematics success or failure may well impact, or be related to, non-mathematics coursework in higher education. Thus, examining the ties between mathematics and non-mathematics coursework successes and failures at a variety of different four-year institutions is an area for still further investigation.


Pro Principal. (2007). Course loads jump over 20 years but rigor doesn’t follow suit (Issue 5). LRP Publications.


Southern Regional Education Board. (2005a). Building transitions from high school to college and careers for West Virginia's youth. 05V77 ed., Atlanta, GA: Author.


### Appendix A

Example of State Graduation and College Admissions for Math

<table>
<thead>
<tr>
<th>STATE</th>
<th>Math Credits**</th>
<th>Language of policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>AL</td>
<td>3</td>
<td>Must include algebra I, algebra II, and one unit of either geometry, trigonometry, or calculus</td>
</tr>
<tr>
<td>GA</td>
<td>4</td>
<td>Completion of algebra I &amp; II and geometry. One math course must be beyond Algebra II</td>
</tr>
<tr>
<td>SC</td>
<td>3</td>
<td>Algebra I and II and geometry are required. (Applied Mathematics I and II may count together as a substitute for Algebra I if a student successfully completes Algebra II). A fourth, higher-level mathematics course is strongly recommended (i.e., Algebra-3/trigonometry, pre-calculus, calculus)</td>
</tr>
<tr>
<td>KY</td>
<td>3</td>
<td>Algebra I, Algebra II and Geometry (or more rigorous courses in mathematics</td>
</tr>
<tr>
<td>WV</td>
<td>4</td>
<td>Three units must be Algebra I and II and Plane Geometry</td>
</tr>
<tr>
<td>CO</td>
<td>3, 4*</td>
<td>*For the graduating class of 2010, the policy increases to 4 credits. Currently, must include Algebra I, Geometry, Algebra II or equivalents.</td>
</tr>
<tr>
<td>MN</td>
<td>3</td>
<td>Three years of math, including two years of algebra, one of which is intermediate or advanced algebra, and one year of geometry</td>
</tr>
<tr>
<td>OR</td>
<td>3</td>
<td>First-year algebra and two additional years of college preparatory mathematics selected from geometry; advanced topics in algebra (through Algebra-2), trigonometry, analytical geometry, finite mathematics, advanced applications, calculus, and probability &amp; statistics, or courses that integrate topics from two or more of these areas. One unit is strongly recommended in the senior year. (Algebra &amp; geometry taken prior to 9th grade will be accepted.)</td>
</tr>
<tr>
<td>NC</td>
<td>4</td>
<td>Four course units including Algebra I, Geometry, Algebra II AND a higher-level mathematics course for which Algebra II is a prerequisite.</td>
</tr>
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</table>
Appendix B

Concept Map for Theoretical Position

Initial Enrollment Year in Algebra
Early  Avg  Late

Intense Secondary Mathematics (MIL)

Continuous Enrollment in Secondary Mathematics

Secondary Mathematics Achievement Level
HIGH  MEDIUM  LOW

Remedial Math in College

College Service Level Math Courses

College Calculus

College Graduation
## Appendix C

Curriculum components of the 31 gradations of the high school academic intensity measure of the NELS:88/2000, by Carnegie unit minimums

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<th>Math</th>
<th>Science</th>
<th>Foreign</th>
<th>Hist and Soc Stu</th>
<th>Highest Math</th>
<th>Remed Math</th>
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<th>APs</th>
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</table>
NOTE: For this study, Adelman’s overall academic intensity was recoded by taking the absolute value of the level above minus 32*. This puts the scale at 0 to 31 so that an increase in intensity level should yield an increase in the odds of bachelor degree completion. *Additionally, Adelman coded a level of 32 as the lowest not appearing in the table above.

<table>
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<th>1.0</th>
<th>0.5</th>
<th>Net 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>29</td>
<td>2.5</td>
<td>1.5</td>
<td>1.0</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>2.0</td>
<td>1.0</td>
<td>0.5</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>≥6</td>
</tr>
</tbody>
</table>

NOTES: (1) Net 1 means the sum of total mathematics credits minus remedial mathematics credits was 0.5 or less, i.e., if remedial math appeared at all on a student’s transcript, it was a major presence; Net 0 means the sum of total mathematics credits minus remedial mathematics credits was more than 0.5, i.e., if remedial math appeared at all on a student’s transcript, it was a minor presence.
(2) The figures in the cells for English, math, science, foreign languages, and history and social studies represent the minimum rounded number of Carnegie units required for the gradation on a given row. Where a box is empty, there are no minimum requirements.
(3) An asterisk in a cell for science credits indicates core laboratory science (biology, chemistry, and physics).
(4) The reference points for highest level of mathematics studied in high school are higher than Algebra 2 (≥Alg2), Algebra 2 (Alg2), and less than Algebra 2 (<Alg2). Where there is no entry in the cell, there is no highest mathematics requirement for that row.
(5) Minimum requirements for total high school academic Carnegie units, e.g., ≥12 and ≤6, come into play only in the very lowest gradations of the curriculum distribution.
(6) When the distribution of students across these 31 levels is weighted and then aggregated to quintiles, the quintile breaks are as follows: 1–8 (highest quintile), 9–15 (2nd quintile), 16–20 (3rd quintile), 21–25 (4th quintile), and 26–31 (lowest quintile).
Appendix D

Name: WTS000  Type: Weight
Label: Postsecondary and high school transcript weight
(BaseYear, Follow-up1, Follow-up2, Follow-up3, Follow-up4)
Description: Postsecondary education (PSE) participation weight for full longitudinal panel members (BY, F1, F2, F3, and F4) with high school transcripts and complete postsecondary records. This postsecondary education weight applies to the full fourth follow-up study longitudinal panel respondents (BY, F1, F2, F3, and F4) with high school transcript information who have complete postsecondary transcript records). Qualification for the weight was based on values of NELSSTAT = 1 and COMPLETE = 1 or 2. (See also the description for NELSSTAT and COMPLETE.) In other words, F4PHP3WT is a postsecondary education transcript weight for the NELS:88/2000 respondent population with high school transcript records and with complete postsecondary transcript documentation. These are cases where the fourth follow-up respondent received (a) one or more PSE transcripts, at least one of which was NOT either a GED-level/all-basic skills transcript or a 1-course transcript and (b) where the PSE transcript record was complete or likely complete (i.e., what was missing was deemed incidental). Respondents with imputed PSE transcripts are excluded. The target population for this weight is the population of 1988 eighth-graders who subsequently participated in some form of postsecondary education, excluding those who attended only a single course or attempted fewer than 5 credits. The decision was made to exclude these cases since a single-course record is not adequate for analyses of attendance patterns, time, curriculum, or performance variables, the algorithms for which assume more than one course entry. Also excluded from the target population are individuals who were ineligible for any of the follow-up studies (e.g., individuals who were deceased, incapacitated, or no longer resided in the United States or who had missing data for BY, F1, F2, or F3). CAUTION: Analyses of curriculum and academic performance (e.g., course credits and GPA) with NELS:88 respondents with incomplete records may distort or bias analyses. Since F4PHP3WT includes students with complete records only, it is the recommended weight for these types of analyses, including questions relating to undergraduate credit production, credit aggregates in course configurations (e.g., CRSAGGRT), or GPA. Applies to: Panel members with reported postsecondary experience.
### Appendix E

#### Correlation Matrix for Variables Used in Analysis for the Universe of Participants of this Study

<table>
<thead>
<tr>
<th>Variable</th>
<th>12th grade SES</th>
<th>8th grade NELS math test score</th>
<th>Highest math in H.S.</th>
<th>Overall academic intensity</th>
<th>Continuous math enrollment</th>
<th>Early algebra entry</th>
<th>MIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>12th grade SES</td>
<td>-</td>
<td>0.194***</td>
<td>0.087***</td>
<td>0.090***</td>
<td>0.033***</td>
<td>0.030***</td>
<td>0.121***</td>
</tr>
<tr>
<td>8th grade NELS math test score</td>
<td>-</td>
<td>0.524***</td>
<td>0.362***</td>
<td>0.053***</td>
<td>0.101***</td>
<td>0.544***</td>
<td></td>
</tr>
<tr>
<td>Highest math in H.S.</td>
<td>-</td>
<td>#0.716***</td>
<td>0.397***</td>
<td>0.106***</td>
<td>0.567***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall academic intensity</td>
<td>-</td>
<td>0.447***</td>
<td>0.118***</td>
<td>0.456***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous math enrollment</td>
<td>-</td>
<td>0.009***</td>
<td>0.353***</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Early algebra entry</td>
<td>-</td>
<td>0.107***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MIL</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: ***p<0.001, #Too high to allow interaction term in block 2 during analysis
### Appendix F

#### Correlation Matrix for Variables Used in Analysis for Adelman’s Universe of NELS Participants

<table>
<thead>
<tr>
<th>Variable</th>
<th>12&lt;sup&gt;th&lt;/sup&gt; grade SES</th>
<th>8&lt;sup&gt;th&lt;/sup&gt; grade NELS math test score</th>
<th>Highest math in H.S.</th>
<th>Overall academic intensity</th>
<th>Continuous math enrollment</th>
<th>Early algebra entry</th>
<th>MIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>12&lt;sup&gt;th&lt;/sup&gt; grade SES</td>
<td>-</td>
<td>0.335***</td>
<td>0.322***</td>
<td>0.297***</td>
<td>0.154***</td>
<td>0.050***</td>
<td>0.372***</td>
</tr>
<tr>
<td>8&lt;sup&gt;th&lt;/sup&gt; grade NELS math test score</td>
<td>-</td>
<td>0.625***</td>
<td>0.478***</td>
<td>0.201***</td>
<td>0.125***</td>
<td>0.725***</td>
<td></td>
</tr>
<tr>
<td>Highest math in H.S.</td>
<td>-</td>
<td>#0.782***</td>
<td></td>
<td>0.461***</td>
<td>0.140***</td>
<td>0.713***</td>
<td></td>
</tr>
<tr>
<td>Overall academic intensity</td>
<td>-</td>
<td></td>
<td>0.515***</td>
<td>0.136***</td>
<td>0.609***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous math enrollment</td>
<td>-</td>
<td></td>
<td></td>
<td>0.023***</td>
<td>0.418***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Early algebra entry</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.097***</td>
<td></td>
</tr>
<tr>
<td>MIL</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: ***p<0.001, #Too high to allow interaction term in block 2 during analysis
Figure 3. Hypothetical Path 1 Odds Calculation
Figure 4. Hypothetical Path 2 Odds Calculation

### Appendix H

#### Overall Odds 1.031

<table>
<thead>
<tr>
<th>Variable value</th>
<th>VARIABLE</th>
<th>B</th>
<th>Exp(B)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>constant</td>
<td>0.657</td>
<td>1.929</td>
</tr>
<tr>
<td>Prob Event</td>
<td>0.665387</td>
<td>0.00</td>
<td>0.433</td>
</tr>
<tr>
<td></td>
<td>0.00</td>
<td>0.00</td>
<td>0.989</td>
</tr>
<tr>
<td>Prob No Event</td>
<td>0.334613</td>
<td>2.00</td>
<td>0.303</td>
</tr>
<tr>
<td></td>
<td>0.00</td>
<td>0.00</td>
<td>1.000</td>
</tr>
<tr>
<td>Ratio</td>
<td>1.988526</td>
<td>1.00</td>
<td>0.268</td>
</tr>
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<td>1.00</td>
<td>1.00</td>
<td>1.307</td>
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<td>1.00</td>
<td>0.758</td>
<td>0.469</td>
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<td></td>
<td>-0.47</td>
<td>0.982</td>
<td>2.697</td>
</tr>
<tr>
<td></td>
<td>-0.47</td>
<td>-0.656</td>
<td>0.519</td>
</tr>
<tr>
<td></td>
<td>-0.47</td>
<td>-0.155</td>
<td>0.856</td>
</tr>
</tbody>
</table>

#### MIL - MATH INTENSITY LEVEL above the mean

<table>
<thead>
<tr>
<th>MIL - MATH INTENSITY LEVEL</th>
<th>Unstd C</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>12th grade NELS score</td>
<td>0.101</td>
<td>5.333</td>
</tr>
<tr>
<td>Math HW outside 12th</td>
<td>0.295</td>
<td>0.927</td>
</tr>
<tr>
<td>Discipline emp at school</td>
<td>-0.989</td>
<td>-2.769</td>
</tr>
<tr>
<td>All students expect to do HW 12th</td>
<td>0.488</td>
<td>0.976</td>
</tr>
<tr>
<td>Students expect to do HW 10th</td>
<td>0.119</td>
<td>0.357</td>
</tr>
<tr>
<td>Math HW inside 12th</td>
<td>-0.096</td>
<td>-0.192</td>
</tr>
<tr>
<td>Math HW inside 10th</td>
<td>-0.238</td>
<td>-0.476</td>
</tr>
<tr>
<td>Graduation requirements math credits</td>
<td>0.361</td>
<td>1.805</td>
</tr>
<tr>
<td>Students place high priority on learning 12th</td>
<td>0.206</td>
<td>0.412</td>
</tr>
</tbody>
</table>

NELS score mean=54.61
10percentile 44.04
20percentile 47.05
30percentile 50.42
40percentile 52.80
50percentile 55.12
60percentile 57.89
70percentile 60.46
80percentile 62.05
90percentile 64.03

0=none or not enrolled in math
1=1 hr or less
2=2-3 hrs
3=4-5 hrs
4=7-9 hrs
5=10-12 hrs
6=13-15 hrs
7=over 15 hrs

1=not accurate
2=somewhat accurate
3=very accurate

1=Not accurate
2=between
3=Somewhat accurate
4=between
5=Very accurate

High Math
3=Calculus
2=Pre-Calc
1=Trigonometry
0=Algebra2
-1=Geometry
-2=Algebra1
-3=Below Alg1

1=none
2=less than 1 yr
3=one yr
4=two years
5=three yrs
6=four yrs
Appendix I

Figure 5. Hypothetical Path 3 Odds Calculation
Appendix J

**NELS variables:**

- **F2RSATM** – SAT math score
- **F2RPSATM** – PSAT math score
- **F2RACTM** – ACT math score
- **BY2XMSTD** – NELS administered math assessment score standardized grade 8
- **F12XMSTD** – NELS administered math assessment score standardized grade 10
- **F22XMSTD** – NELS administered math assessment score standardized grade 12
- **F2SES3** – NELS SES variable at time of HS graduation
- **F1C93D** – Teachers press students to achieve (10<sup>th</sup> grade)
- **F1C93E** – Students are expected to do HW (10<sup>th</sup> grade)
- **F1S36B1** – Time spent on math HW in school (10<sup>th</sup> grade)
- **F1S36B2** – Time spent on math HW out of school (10<sup>th</sup> grade)
- **F1C70B** – Graduation requirements for mathematics (10<sup>th</sup> grade)
- **F2C56A** – Discipline emphasized at this school (12<sup>th</sup> grade)
- **F2C56B** – Students place high priority on learning (12<sup>th</sup> grade)
- **F2C56C** – Classroom activities highly structured (12<sup>th</sup> grade)
F2C56D – Teachers encourage academic achievement (12th grade)
F2C56F – All students expected to do HW (12th grade)
F2S25A1 – Time spent on math HW in school (12th grade)
F2S25A2 – Time spent on math HW out of school (12th grade)

PETS (Adelman’s Postsecondary Education Transcript Study):
REFSELTCT – variable indicating selectivity of 1st true institution attended
PSEFIRST – variable indicating full-time, part-time or less
PSEFIRTY – variable indicating public/private sector of first college attended
INSTCOMB – variable indicating attendance of PSE between 2-yr and 4-yr
DELAYTRI – variable indicating time from HS graduation to PSE attendance
BACHTME and BACHTM2 – variables indicating bachelor degree time-to-degree or not
SATM – SAT math score corrected
SATQUAN – SAT converted from PSAT
ACLEVEL – Adelman’s raw academic intensity level variable
HIGHMATH – variable indicating highest completed mathematics course in high school