UNDERSTANDING THE CONNECTION BETWEEN HIGH SCHOOL EXIT EXAMS AND COLLEGE PERFORMANCE

by

Adriana Diane Cimetta

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As member of the Dissertation Committee, we certify that we have read the dissertation prepared by Adriana Diane Cimetta entitled Understanding the Connection between High School Exit Exams and College Performance and recommend that it be accepted as fulfilling the dissertation requirement for the Degree of Doctor of Philosophy

____ Date: 4/22/09
Jerome V. D'Agostino

____ Date: 4/22/09
Joel R. Levin

____ Date: 4/22/09
Ronald W. Marx

Final approval and acceptance of this dissertation is contingent upon the candidate's submission of the final copies of the dissertation to the Graduate College.
I hereby certify that I have read this dissertation prepared under my direction and recommend that it be accepted as fulfilling the dissertation requirement.

____ Date: 4/22/09
Dissertation Director: Jerome V. D'Agostino

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SIGNED:________________________

Adriana Diane Cimetta

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DEDICATION

To Brett – I wish you were here to see me finish. Love always.

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ABSTRACT

This study examines the messages and accuracy of the messages sent to students from the Arizona Instrument to Measure Standards (AIMS) math test regarding academic preparedness for postsecondary education. Previous studies investigating messages sent to students, derived from information such as educational standards, grades, course taking policies, test material, and college admissions requirements, focused on content alignment of secondary and postsecondary content standards. However, a dearth of research exists on messages from high school performance, as measured by exit exams and college performance measured by grades, major selection, or graduation. This study addresses the need to understand and interpret messages students receive based on academic performance. Specifically, this study aims to answer three questions. First, what is the relationship between AIMS math scores and college math performance defined by the University of Arizona math requirement and college graduation? Second, to what degree do AIMS math scores predict college math performance? Third, what is the average AIMS math score and performance level for students who choose certain majors?

To answer the research questions posed in this study, various statistical analyses were employed. To answer the first question, a one-way ANOVA and logistic regression analyses were used. A linear regression analysis served to analyze the second and third questions. Results indicate that the messages sent to students regarding college readiness

are, in fact, well aligned and clear and consistent. Also, there is evidence that the messages vary by gender and ethnicity.

CHAPTER 1

INTRODUCTION

Many students are entering college academically unprepared and must take remediation courses in math and/or English. This is a serious problem as remediation is costly for students and institutions both financially and in terms of degree completion. Obtaining the exact number of students needing remediation is difficult, yet research commonly indicates that forty percent of college students take at least one remediation course (Attewell, Lavin, Domina, & Levey, 2007; NCES, 2004). A major concern with remediation is that students needing remediation are less likely to graduate (Adelman, 1999). This concern is due in part to the increased time it takes students to complete their degree. In fact, only 17% – 20% of students who take remedial courses go on to complete a bachelor's or higher degree (NCES, 2004). Jepsen (2006) found that younger students taking math remediation courses at two-year institutions were negatively associated with degree attainment or transfer to a four-your institution. A previous study found that students in nine California community colleges took, on average, five years of courses before transferring to a four-year university. After five years of course taking, with 50% of the courses being remedial, only one year of credit-bearing courses could be transferred (Melguizo, Hagedorn, & Cypers, 2008).

Mathematic skills are of particular interest when discussing postsecondary remediation because research suggests that more students require remedial assistance in math than any other subject area (Bahr, 2007, Adelman, 2004). Parsad, Lewis and

Greene (2003) found that 22% of first-time college freshman took remedial math coursework compared with 14% taking writing remedial courses and 11% enrolled in remedial reading courses. Adelman (2004) found that 34% of students earned credits in remedial math courses while only 18% of students earned credits in remedial writing. The numbers of students requiring remediation in different subject areas varies from study to study. However, postsecondary math remediation always tends to serve the greatest number of students and is considered the “gate-keeper” of higher education.

Another indicator suggesting a lack of academic preparedness for postsecondary education can be gleaned from college retention data. Are entering college freshman graduating in four years? The national averages for graduation rates at four-year institutions in 2008 were 36.2%, 52.6%, and 57.3% for graduation in 4, 5, and 6 years, respectively (Knapp, Kelly-Reid, & Ginder, 2009). Basically, the traditional four-year bachelor’s degree actually takes 5 to 6 years for most students to achieve. These numbers are similar to the rates reported by the University of Arizona (UA) (2007) where the four and six year graduation rates in 2006 were 32% and 59%, respectively. The UA does not track a 5-year graduation rate. The national and UA graduation rates suggest the majority of incoming college freshmen do not receive the appropriate messages in high school regarding the academic knowledge and skills necessary to succeed in college.

Research Questions

This study proposes to build on the previous work of D’Agostino and Cimetta (2008) by examining the relationship between the Arizona Instrument to Measure

Standards (AIMS) and college performance more closely. Specifically, what can be inferred about high school students' future college success from the messages they receive from the AIMS math test scores? Messages consist of multiple sources of information such as educational standards, test material, grades, high school course requirements and college admissions requirements that a student receives regarding the necessary knowledge and skills for college success. These messages, in turn, act as signals that influence important life decisions regarding postsecondary options. The key components of this study are the AIMS math test, college math performance, college majors grouped by students' college math performance. This research provides insightful information to determine what messages related to future college success are sent to students and educators from students' performance on the AIMS math test. There are three primary research questions to explore the meaning of the AIMS math test messages and the accuracy of those messages. Gender and minority status will also be examined for research questions when appropriate.

Research Question 1

What is the relationship between AIMS math scores and college performance defined by the UA math requirement and college graduation?

Research Question 2

To what degree do AIMS math scores predict college math performance?

Research Question 3

What is the average AIMS math score and performance level for students who choose certain college majors?

CHAPTER 2

LITERATURE REVIEW

Students, parents, and the public generally view completing high school as a signal of academic competence indicating a student is prepared to enter college. Although the notion of college readiness is not officially linked to current high school academic standards and assessments in most states (CEP, 2007; Gayler, Chudowsky, Hamiton, Kober, & Yeager, 2004), the public and students often infer that high school prepares students for college. For this study, college readiness is defined as "the level of preparation a student needs in order to enroll and succeed, without remediation, in a credit-bearing, general education course at a postsecondary institution that offers a baccalaureate degree or transfer to a baccalaureate program" (Conley, 2007). To promote college readiness during the K-12 years, students need to receive and understand clear messages regarding the necessary steps to ensure appropriate academic preparation for postsecondary success. Kirst (2004) suggests a disconnect between secondary experiences and postsecondary academic expectations results in unclear messages regarding social and academic skills making it difficult for students to know when they truly ready for college.

Theoretical Framework

Signaling theory serves as the theoretical framework for this study. Admissions policies, placement standards, assessments, and academic standards all send signals to students and parents. Signals communicate the knowledge (what students need to know) and the skills necessary (what students need be able to do) in order to succeed in postsecondary education. Students' ability to interpret the signals regarding their level of preparedness for college is based on the clarity and consistency of the signal. Researchers (Brown & Conley, 2007; Kirst & Reeves Braco, 2004) use signaling theory to argue that academic content standards and performance in high school send erroneous signals to students, parents, and the public as to the degree of preparedness needed to pursue postsecondary education. For example, passing tests, completing required high school courses, and graduating high school sends the signal that students must be ready for the next academic step, college. However, since high school standards on which curriculum and assessments are built are not directly or intentionally tied to college standards. Thus, a student may successfully complete high school courses, even math courses, and graduate high school only to find out that he/she is unprepared to handle the social and academic rigor of college. These confusing signals negatively impact students' learning by causing obstructions and delays in navigating their postsecondary educational aspirations. Ideally, a connected K-16 educational system should provide simple, clear and consistent messages about what material is important to teach, learn, and know in high school that will prepare students for postsecondary success (Kirst & Reeves Braco 2004). Signaling theory suggests that streamlined, well aligned, and appropriate content messages have a positive impact on students' learning and achievement.

Since signals regarding college readiness are often unclear or contradictory, causing the intended signals to be misinterpreted or ignored, it becomes increasingly difficult for students, teachers, administrators, and parents to determine what the next steps in a student's education should be (Venezia & Kirst, 2005). Unclear and contradictory signals, coupled with the fact that many two-year and four-year postsecondary institutions have lenient admission policies creates an environment in which students, parents, teachers, and administrators simply do not try to decipher the signals indicating college readiness. Instead, signals regarding college readiness are taken at face value and often interpreted as students need only to complete high school, regardless of the amount of effort or type of courses taken, to gain entry to postsecondary education (Bishop, Bishop, Gelbwasser, Green, & Zuckerman, 2003). Many initiatives such as the Standards for Success Project, Bridge Project, American Diploma Project, and, most recently, the Common Core State Standards Initiative are working toward improving the educational system to academically prepare students for college and workplace success. Their main message is that high school students, parents, and educators need to focus on more than just completing high school and going to college and become more concerned with being academically prepared to succeed in college and the workplace.

There is mounting interest and concern among students, parents, educational researchers, K-12 representatives, and institutions of higher education regarding the signals of college readiness received in high school. Since students' postsecondary choices are impacted by messages (grades, test scores, course taking policies, and postsecondary admissions policies) received in high school, how these messages are interpreted signal students to make decisions regarding their social and academic competence. These decisions directly influence students' postsecondary decisions to not attend college, attend a two-year institution, or attend a four-year institution. Again, the concern is that these decisions are predicated on unclear and inconsistent messages. The signals received in high school most likely influence students' selection of a college major. The primary problem with students making such important life altering decisions based on, what in many cases, are unclear or inaccurate signals regarding postsecondary success, leads to high rates of students not graduating college and a considerable drain on the financial resources of individuals, families, and academic institutions.

Disconnect Research

Over the past decade, researchers (Achieve, 2007; Conley, 2003b & 2007; Kirst, 2004) have collected evidence indicating mismatched and disconnected messages between high school achievements and college performance. Projects such as Standards for Success, the Bridge Project, and the American Diploma Project have attempted to understand the conflicting messages between high school preparation and outcomes in relation to college expectations and performance. Most recently, a state-led effort supported the need for aligned standards across the academic lifetime, pre-kindergarten through postsecondary education, resulted in the establishment of the Common Core State Standards (NGA & CCSSO, 2010). The primary focus of these projects is on the alignment of academic content taught and tested in high school with the knowledge and skills necessary for college success.

The Center for Educational Policy Research (CEPR) at the University of Oregon initiated the Standards for Success program to identify a set of standards for college success and then analyzed the alignment of the standards with high school expectations for college success. The program developed the Knowledge and Skills for University Success (KSUS) standards (Conley, 2003b). The KSUS standards resulted from an extensive review of national academic content standards by more than four-hundred faculty and staff members from twenty research universities associated with the Association of American Universities. The KSUS standards define what students should know and be able to do well enough to meet the general education requirements in entry-level postsecondary courses. During the development of the KSUS standards, special attention was given to the mental capabilities students should possess when entering postsecondary education. Broader cognitive skills such as critical thinking, analytic thinking and problem solving, willingness to accept critical feedback, openness to occasional failure, an inquisitive nature, and good written and oral communication were essential components for understanding and mastering the specific content knowledge in the standards. The KSUS standards were endorsed by twenty-eight of the leading research universities in the country and are licensed to The College Board (CEPR, 2008).

In addition to developing the KSUS standards, the Standards for Success program also analyzed the alignment between high school exit exams and end-of-year exams from twenty states to the KSUS standards. Conley (2003a) rated twenty states on how well their high school exams (31 math and 35 English) aligned to the KSUS standards using Webb's (1997, 1999) established alignment methodology with some minor modifications. Alignment was based on four areas: categorical concurrence, depth of knowledge, range of knowledge, and balance of representation. Categorical concurrence is the match between the objectives and assessment items in the KSUS standards. Depth of knowledge represents the match between the cognitive complexity of the KSUS standards and the assessment item. Range of knowledge represents the number of objectives in the KSUS standards that were addressed by one or more assessment item. Balance of representation looks at the distribution of assessment items across and within the KSUS standards. Overall alignment ratings, based on combined averages of categorical concurrence and depth of knowledge indices, were developed to categorize state tests (Conley, 2003a). Level A exams (≥ 80% alignment) showed the best potential to provide college readiness information. Level B exams (70%-80% alignment) needed to be examined more closely to determine if they could provide useful college readiness information. Level C exams (< 70% alignment) had limited potential to provide college readiness information. In math, no states tests received an alignment rating of A, twenty-nine state tests received a B, and two state tests received a C. Alignment ratings for the English tests were more disperse with three state tests receiving an A, eighteen state tests a B, and fourteen state tests a C. Since most state tests received a rating of B or C, more research is need to determine if state tests provide useful messages regarding college readiness. It is important to note that current research is focused on content alignment and does not use performance data to examine the signals sent to students regarding college readiness.

Brown and Conley (2007) compared high school assessments from thirty states with the KSUS standards for success in entry-level math and English college courses. Only one-third of state math assessments were found to have adequate alignment while more than half, 55%, of the English assessments had adequate alignment. This finding supports the notion that math skills are a key barrier to postsecondary success. Since the majority of high school math tests studied were not aligned with college expectations for math performance, students entering college were likely academically unprepared in the area of math. The degree of alignment was based on Brown and Conley's (2000) new summary alignment index value (SAIV). The SAIV consists of a new combination of acceptable alignment categories and values from Webb's (1997, 1999) alignment methodology. Only the categories of depth of knowledge, range of knowledge, and balance of representation are used to an alignment judgment. Brown and Conley (2007) found that two-thirds of high school math assessments were not aligned with standards for entry-level math college courses. These findings support the position that when the content on high school exit exams is not aligned with college performance expectations, confusing messages regarding high school experiences and college expectations are sent to students.

The Bridge Project, housed at Stanford University, conducted research focused on strengthening K-16 transition policies. The project examined the policies, perceptions, and practices surrounding the transition from high school to postsecondary education in six states: California, Georgia, Illinois, Maryland, Oregon, and Texas (Venezia, Kirst, & Antonio, 2003). The goal of the project was to strengthen the alignment between postsecondary education admissions requirements and K-12 curriculum frameworks, standards, and assessments. With such alignment, improved opportunities for students to enter and succeed in postsecondary education would be expected.

The underlying philosophy of the project was that system level change must occur for reforms affecting K-12 and postsecondary education to achieve the desired outcomes. System level reforms needed to establish an aligned and consistent educational pipeline creating a seamless pathway for students through a K-16 education system. Educational reforms occurring in isolation, only at the K-12 level or postsecondary level, create mismatched policies and educational stakeholders (students, parents, teachers, administrators, and counselors) receive confusing messages.

Venezia and Kirst (2005) found the cause of confusing messages to be rooted in a lack of information, resources, and disconnected expectations. Teachers and counselors often lacked accurate information regarding college admissions and placement policies. Many schools had limited counseling resources, which made it difficult to create an environment where students could begin to realistically consider a college bound future. Distribution of college preparation materials to parents varied based on socioeconomic status with lower socioeconomic parents receiving less information. Lastly, high school assessments contained different academic knowledge and skill levels than seen on college placement tests, specifically in the area of math. High school math assessments commonly emphasized algebra and geometry where as college placement tests typically emphasize algebra II or above.

The American Diploma Project (ADP) is an Achieve, Inc. initiative that works with state education officials, governors, institutes of higher education, and business leaders to ensure all high school graduates are prepared to succeed in college and the workplace (Achieve, 2007). ADP focuses on four areas to prepare students for success after high school: (1) aligning high school standards with college and career-ready standards, (2) developing and implementing requirements for student to take courses necessary for college and the workplace, (3) develop an assessment system that allows high school tests to serve as placement tests for college and hiring in the workplace, and (4) developing an accountability system for high schools and postsecondary institutions to ensure the success of students. Currently, 35 states, including Arizona, are participating in ADP (Achieve, 2011).

ADP reviewed items from six state English and math exit exams for content and cognitive demand expectations (Achieve, 2004). The skills necessary to reach a passing score on the exit exams were also examined. The test demands were then compared to college and workplace knowledge and skill benchmarks in English and mathematics that ADP had previously developed. Items on the exit exams, taken together, were found to measure only a small portion of the knowledge and skills expected from colleges and employers. The math pass scores on most exit exams reflected what students in other countries learned in seventh or eighth grade, and the pass scores on English tests represented the knowledge and skill often tested in the eighth and ninth grades (Achieve, 2004)

In 2009, a state-directed effort to establish a shared set of clear educational standards for English language arts and mathematics began, known as the Common Core State Standards (CCSS) Initiative. The CCSS initiative is being jointly led by the National Governors Association Center for Best Practices and the Council of Chief State School Officers in partnership with Achieve, Inc., ACT, and the College Board. It built directly on previous efforts of leading organizations and states that focused on developing college and career ready standards and ensured that the standards were internationally benchmarked to top-performing countries around the world. The mission statement of the CCSS initiative explicitly states the standards developed will inform students of the skills and knowledge needed for success in college and the workplace. The CCSS initiative's mission statement (2012) is as follows,

> The Common Core State Standards provide a consistent, clear understanding of what students are expected to learn, so teachers and parents know what they need to do to help them. The standards are designed to be robust and relevant to the real world, reflecting the knowledge and skills that our young people need for success in college and careers. With American students fully prepared for the future, our communities will be best positioned to compete successfully in the global economy.

The process to develop the CCSS initiative included collaboration with representatives from 48 states, 2 territories, the District of Columbia, educators, content experts, researchers, national organizations, and community groups. These stakeholders participated in one of three groups during the development the CCSS. The Standards Development Work Group was responsible for determining and writing the CCSS. The Feedback Group provided researched-based information to inform draft standards documents throughout the standards development process. The Validation Committee, comprised of independent, national education experts, reviewed the CCSS to ensure they met the development criteria. The standards were developed based on the following criteria. The CCSS needed to be: (1) aligned with college and work expectations, (2) clear and interpretable, for educators and parents to know what they need to do to help students learn, (3) consistent across all states, (4) inclusive of both content and application of knowledge through high-order skills, (5) constructed upon the strengths of current state standards and standards of top-performing nations, (6) realistic, for effective use in the classroom, and (7) informed by other top performing countries.

The final K-12 Common Core State Standards were release in English language arts and mathematics in June 2010. The participating states and territories will voluntarily adopt the CCSS based on the individual timelines established by their state. The goal of the CCSS initiative is that the standards will provide more clarity about and consistency regarding what is expected of student learning across the country instead of each state having its own set of academic standards. This initiative will help to ensure students from school-to-school and state-to-state are held to the same expectation of academic achievement at every grade level. The CCSS do not dictate how local teachers present the content of the standards in the classroom.

Lastly, the CCSS initiative includes a component to develop and implement a comprehensive assessment system to measure student performance against CCSS that will eventually replace existing state testing systems. Two multistate consortia have formed to develop assessments for the CCSS: the Smarter Balanced Assessment Consortium (SBAC) and the Partnership for the Assessment of Readiness for College and Career (PARCC). The Consortia are funded by the U.S. Department of Education's Race to the Top assessment funding (U.S. Department of Education, 2010). In 2010, the U.S. Department of Education awarded $330 million to PARCC and SBAC to develop assessments for the CCSS. States participating in the CCSS initiative chose to join one Consortium and were involved in the development of assessments for the CCSS. Arizona joined the PARCC Consortium. The SBAC is designing a computer-adaptive testing structure to maximize accuracy in assessing individual student's abilities across the CCSS. Assessments types in the SBAC include summative assessment, interim benchmarks assessments, and formative assessments (SBAC, 2012). The PARCC consortium is developing computer-based testing to monitor if students are on track for postsecondary and workplace success, identify achievement and knowledge gaps, and provide information on how the gaps can be addressed. The PARCC consortium's assessment framework consists of five assessments: early formative assessment, mid-year formative assessment, performance assessments associated with courses, end of year summative assessment, and a speaking/listening assessment of English language arts (Educational Testing Services, 2011). The adoption of SBAC and PARCC consortia assessments are scheduled to be operational in the 2014-2015 academic year. States will implement their respective assessments based on their internal timeline for the adoption of the CCSS.

High School Performance and College Performance Research

The reviewed projects, Standards for Success, The Bridge Project, ADP, and CCSS initiative provide important, yet incomplete, information regarding the knowledge and skills tested on high school exit exams in relation to college expectation and performance. Although examining content alignment is a necessary first step, examining students' performance in high school and how that translates to performance in college is needed to fully understand the clarity and accuracy of college readiness signals received in high school. The alignment information produced in the reviewed studies is insufficient for two main reasons. First, their evidence is solely based content analysis, which is rarely considered sufficient evidence to draw valid inferences from test scores (AERA, APA, & NCME, 1999). To thoroughly evaluate the degree to which exit exam scores indicate college readiness, multiple methodological approaches are needed. These methods ought to include both analysis of content alignment and the analysis of actual exam scores and the relationship between the scores and desired postsecondary outcomes. Second, the college standards developed by Brown and Conley (2007) and Achieve (2004) represent the ideal educational expectations, not the enacted curriculum at universities. The standards were derived from university syllabi, curricular materials, and faculty's knowledge of the skills required for college success. It is unknown if the ideal expectations reported by university faculty actually match the rigor of their teaching and grading practices found in the classroom. If the expected standards are more rigorous than the enacted classroom practices, previous studies may have underestimated the alignment between high school exit exams and the knowledge and skills necessary to succeed in college.

As state standards and high school curriculum are restructured to prepare students for the demands of postsecondary education, revisions to high school exit exams are occurring to account for these changes (Achieve, 2008; CCSS, 2012). With the current efforts focused on content alignment between the CCSS or individual state standards and college expectations, many high school exams will soon be a test of high school standards, CCSS or state level, and an indicator of college readiness. Little research exists on what signals are communicated from performance on high school exit exams and the accuracy of those signals. With 22 states having mandatory exit exams in the 2006-2007 school year, 31 states having or planning to have required exit exams as of December 2011 (Center on Education Policy, 2007 & 2011), and the CCSS assessments operational in the 2014-2015 school year, understating the meaning and accuracy of the messages these exams send to students, parents, and educators is crucial to developing a K-16 education system that sends clear signals to students and educators regarding college and career readiness.

D’Agostino and Cimetta (2008) preliminarily examined actual test scores and college performance. The study examined the alignment between performance on Arizona’s high school exit exam, Arizona Instrument to Measure Standards (AIMS), and college performance measured by first year college GPA. The study found that high school signals might not be as inflated as past studies have indicated. A passing score on the AIMS writing test was aligned with a first year college GPA of “B- or above” while a passing score on the AIMS math test aligned with a college GPA in the “B or above” range. The AIMS reading test did not provide useful information in understanding students’ likely success at the University of Arizona. While this study provided a necessary first step for understanding how high school performance translates into college performance, it was limited. First, the college GPA includes many different courses with varying difficulty. Thus, a student’s college GPA may not accurately reflect his/her ability in a given subject area. Second, the study did not attempt to account for college major paths chosen by students. It is reasonable to assume that different majors have varying levels of course difficulty. Students may be selecting majors based on the types of required courses.

This dissertation attempts to begin to investigate some of the issues confronting the D’Agostino and Cimetta (2008) research. Specifically, only performance on the AIMS math test and college math courses and major selection were examined. It is hoped that this research clarifies the signals high school students receive from the AIMS math test regarding the likelihood of college success.

CHAPTER 3

METHODS

Data Collection

Data for this study came from the Arizona Department of Education and the Department of Student Enrollment and Management at the University of Arizona (UA). Scores for all high school sophomores completing the 2000 AIMS Mathematics test were obtained from the Arizona Department of Education. A unique identifier was created for students completing the 2000 AIMS test. This unique identifier was used to search the UA student database to identify students who took the 2000 AIMS test and enrolled in courses at the UA. Identified students were assigned a UA student identification number. Math courses, grades, and chosen major for each student were also retrieved from the UA database based on the student identification number.

Sample Characteristics

The sample was composed of those in-state members of the 2002-2003 freshman class at the UA for whom AIMS results were available. Most of the 2002-2003 UA freshmen took the AIMS exams while they were enrolled as sophomores in Arizona high schools during the spring of 2000. Only those students with valid AIMS math scores and who entered the UA as freshman in the fall of 2002 were included in the analyses, amounting to 2,734 students. In-state students would not have taken AIMS during their sophomore year of high school if they moved to Arizona during their junior or senior year of high school, attended a private high school, or were absent on AIMS testing days.

The degree to which sampled students differed from high school students statewide on the 2000 AIMS math test appears in Table 1. As can be seen from the table, 17% of high school students in Arizona “met” or “exceeded” the standard on the 2000 high school AIMS math test. Among sampled students who enrolled at the UA in the fall of 2002, 51% “met” or “exceeded” the math standard on the AIMS math test. To pass the test, a student must “meet” or “exceed” the math standard. UA students were more proficient on AIMS relative to students statewide even though the university did not have highly selective admission standards in 2002-2003.

Table 1. Mean AIMS Math Scores and Proficiency Levels for the Sample and 1999-2000 Arizona High School Sophomores

	1999-2000 AZ HS Sophomores N=55,609			Sample N = 2,734		
AIMS Proficiency Levels	Mean	SD	Percent	Mean	SD	Percent
	453	46.3		500	37.0	
Falls Far Below the Standard			73%			30%
Approaches the Standard			11%			19%
Meets the Standard			16%			48%
Exceeds the Standard			<1%			3%

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Measures

The 2000 AIMS mathematics test consisted of eighty-one multiple-choice and eight short answer items that represented performance objectives from six academic standard strands: (1) Number Sense, (2) Data Analysis and Probability, (3) Patterns, Algebra, and Functions, (4) Geometry, (5) Measurement and Discrete Mathematics, and (6) Mathematical Structure/Logic. Possible scaled scores ranged from 200 to 800. A committee of Arizona educators determined three cut scores (Approaches, Meets, and Exceeds), which defined four performance levels: “falls far below the standard”, “approaches the “standard, “meets the standard”, and “exceeds the standard”. The Arizona Department of Education (2008) defines the high school AIMS math performance level descriptors as follows. Students who score at the “falls far below the standard” level may have significant gaps in the knowledge and skills that are necessary to satisfactorily meet the Math standard. Students will typically require a considerable amount of additional instruction and remediation in order to achieve a satisfactory level of understanding. Students who score at the “approaches the standard” level show partial understanding of the knowledge and application of the skills that are fundamental for proficient work. Students show some understanding of the math standard’s concepts and procedures by being able to solve problems involving similar and congruent figures, organize and display data, and solve and graph linear equations or inequalities. Some gaps in knowledge and skills are evident and may require additional instruction and remediation in order to achieve a satisfactory level of understanding. Students who score at the “meets the standard” level demonstrate a solid academic performance on subject matter as reflected by the math standard. Students who perform at this level are able to justify the relationships among subsets of the real numbers, solve problems using a system of linear equations, and write the equation of a line. They can calculate surface area and volume of 3-dimensional objects and determine probability in contextual situations. They can solve and factor quadratic equations. Students who score at the "exceeds the standard" level illustrate a superior academic performance as evidenced by performing substantially beyond the achievement goal for all students. Students who perform at this level demonstrate knowledge, skills, and abilities in fulfillment of the math standard. They can create and analyze inductive and deductive arguments and solve problems that contain trigonometric ratios or algebraic concepts.

A one-parameter item response theory model was used to scale the AIMS math test. Thus, there was a one-to-one correspondence between raw scores and scale scores. The Bookmark method was used to set the performance standards for the exam by a committee of Arizona educators in 1999 (Mitzel, Lewis, Patz, and Green, 2001). Possible scaled scores ranged from 200 to 800 and 500 denoted a passing score (i.e., "met the standard"). Specific cut scores were set for the 1999 and 2000 AIMS math tests to indicate four performance levels: a scaled score $\leq$ 480 was at the "falls far below the standard" level, a scaled score $\geq$ 481 and $\leq$ 499 was at the "approaches the standard" level, a scaled score $\geq$ 500 and $\leq$ 573 was at the "meets the standard" level, and a scaled score $\geq$ 574 was at the "exceeds the standard" level. Although the performance level score ranges applied to the AIMS test used in this study, the performance levels were modified in 2005 with lowered scores necessary in the "meets the standard" performance level. The performance level scores also changed from this point forward with each administration of the AIMS test. An alignment analysis between the AIMS test items and the Arizona Academic Standards, based on the Webb (1999) alignment method, revealed sufficient congruence between test items and the performance objectives that comprised the standards (D'Agostino, Welsh, & Cimetta, 2005).

Arizona is one of 31 states currently administering a high school exit exam (CEP, 2011). Arizona began administering a high school exit exam, AIMS, to tenth grade students in 1999 as a test administration without the high stakes of it being a graduation requirement attached. In 2000, tenth grade students took the AIMS with the knowledge that passing the test was necessary for graduation. However, after test results were received, Arizona legislators repealed the graduation requirement (the 2006 graduating class was the first cohort for whom the requirement applied). This chain of events created an ideal opportunity to examine the AIMS math scores and college performance because students took the exam believing they had to pass it to graduate. Ultimately, their scores had no influence on their graduation from high school or their chances of attending the UA.

Data Analysis

Research Question 1

To examine the relationship between performance on the AIMS math test and college performance defined by the UA math requirement and college graduation, a series of analyses were taken. A threshold for college math performance was established based on passing the required basic math course for all majors. There are three math courses that fulfill the UA basic math requirement. These three courses can be divided into two categories: (1) real life math (Math 105 – Mathematics in Modern Society) and (2) college algebra (Math 110 – College Algebra and Math 112 – College Algebra Concepts and Applications). Entering UA students must take the UA Math Readiness Test and obtain a score that places them in one of three basic math courses or allows them to enter directly into a higher math course. If students do not test into college algebra, they must take remedial math courses at a community college before entering the basic math requirement course or higher math at the UA. Students would not have taken any UA math course if they (1) transferred in eligible math units from another university or community college meeting the basic math requirement or higher, (2) transferred out of the university before completing a math course, or (3) dropped out of the university before completing a math course. Table 2 shows the UA math courses that constitute the basic math requirement and percentage of students in the sample completing each course.

Table 2. Percent of Students in the UA Basic Math Requirement Courses (N=2734)

Course Number	Name	Percent	N
Math 105	Mathematic in Modern Society	1.8	48
Math 110	College Algebra	29.4	803
Math 112	College Algebra Concepts and Applications	3.4	92
Higher Math	Entered math course other than 105 or 110/112	36.6	1002
No Math	Competed no UA math courses	28.8	789

To better understand the signal sent to students from passing the AIMS math test regarding college performance, AIMS math scores were further examined in relation to meeting the basic UA math requirement and likelihood of graduation in six years. A 6-year graduation indicator was used based on the fact that 30% more students were captured using the 6-year graduation rate instead of the 4-year graduation rate. At the time of this study, a 6-year graduation indicator was not available from the Office of Institutional Planning and Research at the UA. Thus, a likelihood of graduation variable was created based on the following: known graduation in four years, was still taking classes in years five or six, GPA, major, and change in status from undergraduate to graduate student. If a student had graduated in four years, was still taking courses in their fifth or sixth year and had a GPA of a C or better, had his/her major switched from a preliminary major (i.e., pre-education) to the actual major (i.e., education), or had entered a graduate degree program, the student was considered to have graduated in six years or was likely to graduate. Table 3 shows that the calculated graduation rates for the sample and the UA graduation rates were similar, with a slightly lower 4-year graduation rate and a slightly higher 6-year graduation rate observed in the sample.

Table 3. 2006 and 2008 Graduation Rates for the Sample and the University of Arizona

	Graduation Rates	
	4-Year	6-Year
University of Arizona (N=5603)	32.2%	57.2%
Sample (N=2734)	29.6%	61.6%

Note: Numbers reported are based on entering freshman in 2002. The study sample of high school sophomores taking the AIMS test in 2000 were eligible to graduate in 2006 after four years of college and in 2008 after six years.

A one-way ANOVA was performed with the AIMS math test score as the dependent variable and four groupings of the UA math requirement coupled with the likely graduation as the independent (factor) variable. The four groups in the model were (1) UA math requirement met and graduated, (2) UA math requirement met and did not graduate, (3) UA math requirement unmet and graduated, (4) UA math requirement unmet and did not graduation. Tukey's Honestly Significant Differences (HSD) post-hoc tests were also conducted to examine the differences between groups.

To determine the degree of accuracy of the AIMS math test pass score, 500, a series of logistic regression analyses were performed based on two hypothetical cut scores indicating passing the AIMS math test: (1) half a standard deviation above the current pass score, 519 and (2) half a standard deviation below the current pass score. Logistic regression provides an odds ratio for the likelihood of college graduation for a group of interest. The odds ratio compares whether the probability of a certain event, college graduation, is the same for two groups, passing or failing the AIMS test. An odds ratio of 1 implies that the event, college graduation, is equally likely in both groups. An odds ratio that is greater than one implies that the event is more likely in the target group, passed the AIMS test. An odds ratio that is less than one implies that the event is less likely in the target group. All variables included in the analyses are presented in Table 4.

Table 4. Logistic Regression Analysis Variables

Dependent Variable	Definition
College Graduate	Graduation likely in 6 years coded "1" and "0" for no graduation likely
Independent Variables *AIMS cut scores*	
AIMS established cut	Performance on the 2000 AIMS math test coded "1" for pass (scale score of $\geq$ 500) and "0" for fail (scale score of $\leq$ 499)
AIMS ½ SD above established cut	Performance on the 2000 AIMS math test coded "1" for pass (scale score of $\geq$ 519) and "0" for fail (scale score of $\leq$ 518)
AIMS ½ SD below established cut	Performance on the 2000 AIMS math test coded "1" for pass (scale score of $\geq$ 482) and "0" for fail (scale score of $\leq$ 481)

Note: Standard deviation is abbreviated as SD.

Research Question 2

To determine if high school math achievement can predict college math performance, a linear regression analysis was performed. The college math performance variable was created based on the math courses a student took at the UA. Math course grades were recoded from letter grades to numerical values: A = 4, B = 3, C = 2, D = 1, F = 0 (Young, 1990). Rasch analysis in *Winsteps* was conducted on the math course grades and produced an estimated math difficulty value, referred to as a logit value, for each student. The logit, is the natural log odds of obtaining an average grade (likely a "C") in a math course that is of average difficulty (Bond & Fox, 2001). Refer to the item map created for the college math performance variable in Appendix A to see which math courses have a logit at zero or near zero. Math courses with a logit at zero or near zero are considered being of average difficulty.

The Rasch model equation is

$$P = (e\text{^ } B - D) / [(1 + \mathrm{e}\text{^ } B) - D] \qquad (1.1)$$

In the Rasch model equation, "*e*" is the natural number, 2.71828, and "*B*" is the person ability, and "*D*" is the item difficulty. Because the scale is centered around the average difficulty item and average grade (the 0 point), then *D* = 0. So, the person's "*B*" value, the logit, indicates the natural log odds of getting the average course grade in the average course. To calculate the probability, "*P*", a student has of getting at least the average grade in the average course, take the student's logit as the exponent in the Rasch formula and divide that value by 1 + that value.

The created math difficulty variable represented a student's college math performance. So, for a student with a 2 logit score, first square the natural number (*e*^2), equaling 7.39. Then divide 7.39 by 8.39 (1 + *e*^2), which results in 0.88 or an 88% chance of getting the average grade in the average class. In contrast, a student with a -1 logit has a 27% change of getting the average grade in the average class (*e*^-1 = .37, then .37/1.37 = 0.27).

The linear regression analysis used the created college math performance variable for the dependent variable and the AIMS math test score as the predictor variable. Appendix B lists the fit statistics for the students' college math performance variable.

Prior to conducting the linear regression, a correlation analysis was run to determine the relationship between the AIMS math test and the created college math performance variable.

Research Question 3

This research question sought to determine if high school math achievement impacts students' selection of a college major based on students' math performance by major. The mean college math performance logit value for students in each major was computed, which represented the math difficulty level of each major. The mean college math performance variable was separated into four levels, which would become the math performance by major variable. A frequency distribution of the mean college math performance variable was obtained. Quartiles of the frequency distribution were used to classify the students' performance in math courses by college majors into four categories:

low (coded as 0), low-medium (coded as 1), medium-high (coded as 2), and high math performance by major (coded as 3).

Although the mean college performance logit values were computed for every college major present in the sample, it was decided to only include majors with at least ten students to have a more representative average difficulty level of the major. The excluded majors are listed in Appendix C. This decision reduced the number of college majors in the sample from 102 to 48 and the sample size from N = 1322 to N = 1168. Reference tables were developed to show the mean college math performance, college major math performance level, mean AIMS math score, and AIMS performance level for each major.

Linear regression was used to determine if the AIMS math score can be used to predict students' major selection based on their college math performance. The linear regression analysis used students' math performance by major as the dependent variable and the AIMS math test score as the predictor variable.

Prior to conducting the linear regression, a correlation analysis was run to determine the relationship between the AIMS math test and the created students' math performance by major variable.

To further understand the signal sent to students from the AIMS math test regarding college major selection, the proportion of students selecting majors with different levels of student math performance by majors was examined. A closer look at the selection of majors based on performance in math courses was reviewed by gender and minority status for the sample, those passing the AIMS math test and by AIMS performance level.

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CHAPTER 4

RESULTS

This chapter presents the results of the analyses conducted for the three research questions. Results for each research question are structured in the same format. Reporting of the results begins by addressing the descriptive statistics and intercorrelations (when appropriate) for all measures. It is important to examine these statistics prior to running any analysis to understand the sample characteristics and composition to determine whether enough variation exists among variables and to gauge the extent to which factors such as range restriction and multicollinearity might diffuse estimates. Then the statistical analyses used to answer each research question are presented.

Research Question 1

Descriptive Results

The sample for this research question contained students who took the AIMS math test in 2000 and then entered the UA as freshmen in the Fall of 2002 (N = 2734). It was decided to only include students entering as freshman because the UA does not keep detailed records of why the student was delayed in starting at the UA or previous courses that may have been taken at other institutions. For example, students may have spent a year or two taking courses at a community college and then transferred credits to the UA or a student may have attended another four-year university and transferred to the UA.

Since the focus of this dissertation is to examine the signals regarding college performance sent to students from the AIMS math test, having detailed information on math courses taken and graduation in six years is imperative to gauge signal accuracy. Complete information regarding math courses and the likely graduation was only available for students entering the UA as freshmen.

Table 5 presents the demographic characteristics of the sample compared to the total entering 2002-2003 UA freshman class. The sample is predominately white, 67%, with Hispanic students being the next largest group, 17%. Asian and Unknown/Other/Non-resident alien students each comprise 5% of the sample. The population of African American and American Indian students combined equal roughly 6% of the sample. Females outnumbered males in the sample 57.5% to 42.5%. The study sample closely matches the total entering 2002-2003 UA freshman class.

Performance on the AIMS math test was examined for the sample. Table 6 presents the mean AIMS math scores by ethnicity and gender. AIMS math scores were found to vary across ethnicity and gender. In general, minority students, African American, American Indian, and Hispanic, showed lower mean AIMS math scores compared to their White and Asian peers and to the overall sample. In fact, the mean AIMS score was below passing for all three groups with African American and Hispanic students' mean score at the "approaches the standards" performance level while American Indian students' mean score was in the "falls far below the standard" performance level. White, Asian, and Unknown/Other/Non-resident alien students all had mean AIMS math scores above 500, a passing score.

Table 5. Ethnicity and Gender for the Sample and the 2002-2003 UA Freshman Class

	Sample N=2734		2002-2003 UA Freshman Class N=6836	
Ethnicity	N	Percent	N	Percent
African American	100	3.7	229	3.3
American Indian	59	2.2	120	1.8
Asian	137	5.0	300	4.4
Hispanic	462	16.9	935	13.7
Unknown/Other/ Non-Resident Alien	139	5.0	541	7.9
White	1837	67.2	4711	68.9
Gender				
Males	1161	42.5	3272	47.9
Females	1573	57.5	3564	52.1

Note. Source of 2002-2003 UA Freshman data: 2002-03 UA Fact Book produced by the Office of Institutional Research and Planning.

Table 6. Mean AIMS Math Score and Standard Deviation by Ethnicity and Gender

	AIMS Math Score		
	Mean	Standard Deviation	N
Sample	500	37.0	2734
Ethnicity			
African American	482	38.0	100
American Indian	475	35.4	59
Asian	509	41.5	137
Hispanic	484	36.9	462
Unknown/Other/Non-Resident Alien	502	34.6	139
White	505	35.0	1837
Gender			
Males	507	36.7	1161
Females	495	36.3	1573

It was important to understand the characteristics of the sample in terms of passing or failing the AIMS math test in relation to taking UA math courses and graduating in six years. Table 7 presents the frequency and percent of students in the sample passing and failing the AIMS math test with respect to graduation status. While the mean AIMS math score for the sample was 500, about half the sample failed the AIMS math test. Approximately 62% of students in the sample graduated in six years. The percentage of students passing and failing the AIMS math test differed based on graduation status. Students who passed the AIMS math test had a higher percentage of students who graduated from college. Students who failed the AIMS math test were most likely to not graduate college, 60.3%. The Chi-square (χ^2) test results indicate there was a significant relationship between the college graduation and performance (pass/fail) on the AIMS math test (χ^2 with one degree of freedom = 74.911, $p < 0.001$).The mean passing and failing AIMS math scores and standard deviations for the sample with respect to graduation status are shown in Table 8. Table 9 presents the frequency and percent of students with no math courses or courses below the UA math requirement passing or failing the AIMS math test by graduation status. Students who did not take any math courses and failed to graduate had the highest percentage failing the AIMS math test. The χ^2 test results indicate there was a significant relationship between the college graduation and performance (pass/fail) on the AIMS math test for students with no math courses or courses below the UA math requirement (χ^2 with one degree of freedom = 23.398, $p < 0.001$).The mean passing and failing AIMS math scores and standard deviations for students without any math courses or courses below the UA math requirement appear in Table 10. There was a small group of students, roughly fourteen percent, who did not take any math courses at the UA yet graduated. Students in this group most likely took courses elsewhere, probably Pima Community College, to fulfill the math requirement for their major while attending the UA.

Table 7. Frequency and Percent of Sample Passing/Failing the AIMS Math Test by Graduation Status

	Graduate College						
	Yes		No		χ^2	Total	
	N	%	N	%		N	%
Pass AIMS	955	56.7	416	39.7	74.911***	1371	50.1
Fail AIMS	730	43.3	633	60.3		1363	49.9
Total	1685		1049			2734	

Note: ****p* < 0.001.

Table 8. Mean Passing/Failing AIMS Math Scores for the Sample by Graduation Status

	Graduate College					
	Yes			No		
	M	SD	N	M	SD	N
Pass AIMS	531	23.3	955	525	20.9	416
Fail AIMS	473	21.7	730	468	22.7	633

Table 9. Frequency and Percent of Sample with No Math or Below the Math Requirement Passing/Failing AIMS Math Test by Graduation Status

	Graduate College						
	Yes		No		χ^2	Total	
	N	%	N	%		N	%
Pass AIMS	157	41.9	109	25.7	23.398***	266	33.3
Fail AIMS	218	58.1	315	74.3		533	66.7
	375		424			799	

Note: ****p* < 0.001.

Table 10. Mean Passing/Failing AIMS Math Scores for Students with No Math or Below the Math Requirement by Graduation Status

	Graduate College					
	Yes			No		
	M	SD	N	M	SD	N
Pass AIMS	534	24.1	157	520	18.7	109
Fail AIMS	462	25.0	218	462	23.9	315

Statistical Analyses

Exploration of the mean AIMS math scores by likely graduation prompted the need for further analysis to understand the signals sent to students from the AIMS math scores regarding math performance and the impact college math has on the likelihood of graduation. Groups were created for all the possible combinations of math performance and graduation in six years: (1) UA math requirement met and graduation, (2) UA math requirement met and no graduation, (3) UA math requirement not met and graduation, and (4) UA math requirement not met and no graduation. A one-way ANOVA was calculated to reveal if significant differences among the groups existed. An alpha level of .05 was used and eta squared, η^2, was calculated. The analysis was significant, $F_{(3,2730)} = 109.97$, $p < .05$ ($\eta^2 = 0.11$). Table 11 presents the results of the one-way ANOVA analysis. Significant differences were found among all group pairwise comparisons using the Tukey's HSD post-hoc test. Cohen's *d* was used to calculate the effect size for each pairwise comparison. The Cohen's *d* values ranged from 0.0062 to 0.0265, which are considered "small" effect sizes. Table 12 presents the Cohen's *d* value for each pairwise comparison.

Table 11. One-Way ANOVA Result of AIMS Scores by UA Math Requirement and Graduation

	AIMS			F	η^2
Groups	Mean	SD	N		
Math met/Graduate Yes[a]	510[bcd]***	33.7	1302		
Math met/Graduate No[b]	502 [acd]***	32.8	555		
Math unmet/ Graduate Yes[c]	492 [abd]***	42.8	385	109.97	0.11
Math unmet/Graduate No[d]	478 [abc]***	33.8	492		

Note. *** = $p < 0.001$. Means with differing superscripts within rows are significantly different based on Tukey's HSD post hoc pairwise comparisons with $\alpha = .05$.

Table 12. Cohen's d Effect Size for all Tukey's HSD Post Hoc Comparisons

Groups	Cohen's d
Math met/Graduate Yes[a] x Math met/Graduate No[b]	0.0062
Math met/Graduate Yes[a] x Math unmet/ Graduate Yes[c]	0.0146
Math met/Graduate Yes[a] x Math unmet/Graduate No[d]	0.0265
Math met/Graduate No[b] x Math unmet/ Graduate Yes[c]	0.0085
Math met/Graduate No[b] x Math unmet/Graduate No[d]	0.0203
Math unmet/ Graduate Yes[c] x Math unmet/Graduate No[d]	0.0118

Note. Cohen's d effect size of 0 to 0.2 = small effect.

Descriptive Results

To determine the degree of accuracy of the AIMS math test pass score in signaling graduation from college in six years, logistic regression analysis was used for the established AIMS math test pass score and the two revised pass scores. An explanation of the predictor variables appears in Table 4 in the methods section. A total of three similar logistic regressions were performed. The basic model included the selected AIMS math test pass score as the independent variable predicting the dependent variable, college graduation in six years. Model 1 used the established AIMS math test pass score, 500, was entered as the independent variable. For Model 2, a half standard deviation above the established AIMS math test pass score, 519, was entered as the independent variable. For Model 3, a half standard deviation below the established AIMS math test pass score, 482, was entered as the independent variable. Tables 13, 14, and 15 present the mean AIMS math scores for each logistic regression model by graduation status.

Table 13. Mean AIMS Math Scores for AIMS Passing Score of 500 by Graduation Status

	Graduate College							
	Yes				No			
	N	%	M	SD	N	%	M	SD
Pass AIMS	955	56.7	531	23.3	416	39.7	525	20.9
Fail AIMS	730	43.3	473	21.7	633	60.3	468	22.7

Table 14. Mean AIMS Math Scores for AIMS Passing Score of 519 by Graduation Status

	Graduate College							
	Yes				No			
	N	%	M	SD	N	%	M	SD
Pass AIMS	616	36.6	543	20.3	222	21.1	540	17.5
Fail AIMS	1069	63.4	484	24.8	827	78.9	477	26.1

Table 15. Mean AIMS Math Scores for AIMS Passing Score of 482 by Graduation Status

	Graduate							
	Yes				No			
	N	%	M	SD	N	%	M	SD
Pass AIMS	1275	75.7	521	26.8	627	59.8	514	23.6
Fail AIMS	410	24.3	458	18.7	422	40.2	457	19.1

Statistical Results

The logistic regression analysis revealed that the three AIMS pass scores predicted the 6-year college graduation with the similar degrees of accuracy. Table 16 reports the logistic regression model for the likelihood of graduating college. With the hypothetical AIMS math test pass scores set at 482 and 519, students who passed the AIMS math test at these cut points were roughly two times more likely to graduate college, with odds ratios of 2.093 and 2.147, respectively. These findings support the concept that one magic cut score for predicting graduation may not exist. However, ranges of scores, such as performance levels, can provide accurate messages to students regarding their likelihood of college graduation. Students scoring slightly below the established AIMS math test pass score of 500 may have received an erroneous signal regarding their preparedness for college success. The message sent to students failing the AIMS math test with a score between 482 and 499 may have been interpreted as a signal that they were not prepared for college. The results of the logistic regression with the lower AIMS math test pass score indicate that success in college is equal to that of an AIMS math score in the 500 to 519 range, the established and half a standard deviation above the established AIMS math test pass score.

Table 16. Logistic Regression Output for the Likelihood of College Graduation by AIMS Math Test Passing Scores

AIMS Pass Score	Odds Ratio	CI 95%	x^2	*df*
Established (500)	1.991***	1.702 to 2.329	75.326	1
½ SD above (519)	2.147***	1.796 to 2.566	74.416	1
½ SD below (482)	2.093***	1.773 to 2.471	76.169	1

Note: *** = $p < 0.001$

Research Question 2

Descriptive Results

To determine if the AIMS math score can predict college math performance, only students who were likely to graduate in six-years and who took UA math courses were included in the sample. It was reasoned that including students in the sample who were not likely to graduate could potentially confound the indicator of college math performance due to various circumstances such as: (1) students may drop out after unsuccessfully taking UA math courses; (2) staying enrolled and taking multiple courses without an intended path of graduation allows students the opportunity take more classes, which may include math courses; and (3) students may transfer to another university without completing UA math courses. Table 17 reports the AIMS math scores by ethnicity and gender for this sub-sample compared to those who were excluded from the analysis. When looking at ethnicity, the population of both samples was similar. The excluded students had a greater gender discrepancy with slightly more females and fewer males present in the excluded group compared to the sample. Mean AIMS math scores were lower in the excluded sample. Since it was not likely that the students in the excluded group graduated in six years, this supports the notion that higher AIMS math scores signal improved chances for college success defined as college graduation.

Table 17. Mean AIMS Math Score by Ethnicity and Gender for Likely Graduates and Students Excluded from the Analysis

	AIMS Math Scores					
	Likely Graduates			Excluded Students		
	Mean	SD	N	Mean	SD	N
Sample	509	33.9	1322	491	37.6	1412
Ethnicity						
African American	496	30.6	53	466	39.6	47
American Indian	497	18.8	14	468	36.6	45
Asian	515	38.6	69	502	43.4	68
Hispanic	485	34.6	229	473	35.9	233
Unknown/Other/ Non-Resident Alien	508	32.0	69	497	36.4	70
White	514	32.6	888	497	35.2	949
Gender						
Males	517	34.0	596	497	36.8	565
Females	503	32.7	726	487	37.6	847

Statistical Analyses

A correlation analysis for variables included in the linear regression analysis was run. The relationship between the AIMS math score and college math performance was significant, $r = 0.60$, $p < 0.01$. This moderate relationship indicates that higher AIMS math scores are associated with better college math performance.

A linear regression analysis revealed that the AIMS math score was a highly significant predictor of college math performance, $\beta = 0.604$, $p < 0.001$. This finding supports the alignment between high school math performance and college math performance. Table 18 reports the linear regression results.

Table 18. Summary of Linear Regression Analysis for AIMS Math Score Predicting College Math Performance (N = 1322)

	College Math Performance		
Variable	B	SE B	β
AIMS Math Score	0.069	0.003	0.604***

Note. ****p* < 0.001.

Research Question 3

Descriptive Results

The same sample of likely graduates explained in research question 2 was used for analyses concerning performance in math courses by students and selection of college major. However, as explained in the methods chapter, majors with less than ten students were not included in the analyses concerning students' math performance by college major. Based on this rule, 154 students representing 54 majors were excluded from these analyses. Appendix A contains a list of excluded majors. Basically, the excluded majors had an average of three students. Therefore, the eligible students and college majors totaled 1,168 and 48, respectively.

Statistical Analyses

A correlation analysis for variables included in the linear regression analysis was run. The relationship between the AIMS math score and students' college math performance by major was significant, $r = 0.395$, $p < 0.01$. This moderate relationship indicates that higher AIMS math scores are associated with college majors having higher levels of student math performance.

A linear regression analysis was conducted to determine if AIMS math scores could predict selection of students' college major based on their math performance in college math courses. The analysis revealed that the AIMS math score was a highly significant predictor of students' math performance by major, $\beta = 0.395$, $p < 0.001$. This finding supports claim that adequate alignment between high school math performance and college math performance exists. The linear regression results are reported in Table 19.

Table 19. Summary of Linear Regression Analysis for AIMS Math Score Predicting College Major based on Students' Performance in College Math Courses (N = 1168)

	College Major Math Performance		
Variable	B	SE B	β
AIMS Math Score	0.013	0.001	0.395***

Note. ****p* < 0.001.

The regression analysis revealed that performance on the AIMS math test can provide valuable information to students and educators regarding both selection of and success in a college major based on students' performance in math courses. To clearly interpret the high school math performance signal sent to students regarding college major selection based on performance in college math courses, tables containing the average AIMS math score, AIMS performance level, average college math performance logit, and college major by students' performance levels in college math courses for each of the forty-eight majors was created. Students, counselors, educators and parents can quickly look at these tables to see what AIMS math scores are needed for different types of majors or perhaps a specific major. Table 20 shows majors with lowest student math performance. Table 21 lists the majors with the low to medium levels of performance in math courses by students. Table 22 lists the majors with the medium to high levels of performance in math courses by students. Table 23 lists the majors with highest levels of performance in math courses by students. When reviewing the majors at each level of performance in math courses by students, the performance levels seem consistent with traditional views of the degree of math skills associated with the major.

The mean AIMS math scores for the majors with the lowest level of student math performance, coded as 0, hover at or below the pass score of 500. In fact, two-thirds of the majors with the lowest student math performance were in the "falls far below" or "approaches the standard" AIMS performance level. As math performance increases for majors, so do the average AIMS math scores. Majors with low to medium student performance in math courses, coded as 1, still have a few majors with mean AIMS math scores below passing or in the “approaches the standard” performance level. Majors with medium to high student performance in math courses, coded as 2, all have passing mean AIMS scores and are in the “meets the standard” performance level. Majors in the highest student math performance category, are also still in the “meets the standard” performance level. However, this is the only group in which mean AIMS scores remain above a passing score when going out one standard deviation.

Table 20. Summary of Majors with Low Student Performance in College Math Courses

College Major Math Performance		College Math	AIMS Score			
Low	Major	Mean Logit	Mean	SD	Performance Level	N
0	Sociology	-6.28	480	33.7	FFB	16
0	Retailing & Consumer Sciences	-4.65	482	30.7	APP	18
0	Regional Development	-4.52	505	28.2	Meets	12
0	History	-4.19	500	26.5	APP	17
0	Communication	-4.17	489	28.6	APP	32
0	Spanish	-3.9	495	40.2	APP	20
0	Criminal Justice Admin	-3.89	495	27.7	APP	13
0	Political Science	-3.70	502	31.2	Meets	50
0	Elementary Education	-3.69	491	31.0	APP	71

Note. AIMS performance level abbreviations: FFB = falls far below the standard, APP = approaches the standard, Meets = meets the standard, Exceed = exceeds the standard.

Table 21. Summary of Majors with Low to Medium Student Performance in College Math Courses

College Major Math Performance		College Math	AIMS Score			
Low/Medium	Major	Mean Logit	Mean	SD	Performance Level	N
1	Health Education	-3.55	496	23.4	APP	14
1	Psychology	-3.55	496	33.7	APP	80
1	English	-3.50	501	28.0	Meets	20
1	Family Studies & Human Dev	-3.48	491	25.4	APP	25
1	Studio Art	-3.34	503	39.2	Meets	19
1	Anthropology	-3.13	503	33.3	Meets	17
1	Journalism	-3.04	505	32.3	Meets	20
1	Media Arts	-2.69	508	38.3	Meets	20
1	Marketing	-2.45	496	25.2	APP	46
1	Nutritional Sciences	-2.39	500	33.8	Meets	27
1	Speech/Hearing Sciences	-1.88	492	28.4	APP	14
1	Interdisciplinary Studies	-1.76	516	27.2	Meets	12

Note. AIMS performance level abbreviations: FFB = falls far below the standard, APP = approaches the standard, Meets = meets the standard, Exceed = exceeds the standard.

Table 22. Summary of Majors with Medium to High Student Performance in College Math Courses

College Major Math Performance		College Math	AIMS Score			
Medium/High	Major	Mean Logit	Mean	SD	Performance Level	N
2	Business Mgmt	-1.75	501	32.1	Meets	31
2	Microbiology	-1.72	507	23.9	Meets	18
2	Economics	-1.51	504	49.5	Meets	17
2	Ecology & Evolutionary Bio	-1.50	521	39.6	Meets	14
2	Creative Writing	-1.19	510	43.3	Meets	10
2	Engineering Mgmt	-1.13	512	29.8	Meets	20
2	Mgmt Info Systems	-1.10	516	26.7	Meets	16
2	Architecture	-1.02	518	32.4	Meets	14
2	General Biology	-0.61	510	22.5	Meets	17
2	Nursing	-0.49	506	27.1	Meets	34
2	Veterinary Science	-0.39	507	28.8	Meets	16
2	Finance	-0.13	514	25.2	Meets	39
2	Accounting	-0.04	512	25.0	Meets	32
2	Chemistry	-0.04	523	27.8	Meets	11

Note. AIMS performance level abbreviations: FFB = falls far below the standard, APP = approaches the standard, Meets = meets the standard, Exceed = exceeds the standard.

Table 23. Summary of Majors with High Student Performance in College Math Courses

College Major Math Performance		College Math	AIMS Score			
High	Major	Mean Logit	Mean	SD	Performance Level	N
3	Molecular & Cellular Biology	0.13	525	30.1	Meets	49
3	Business Economics	0.21	518	30.8	Meets	17
3	Physiology	0.24	514	28.2	Meets	59
3	Civil Engineering	0.78	541	30.1	Meets	17
3	Computer Science	0.85	531	34.3	Meets	16
3	Pharmacy	1.09	533	36.2	Meets	13
3	Mechanical Engineering	1.48	539	32.4	Meets	39
3	Bio & Molecular Biophysics	1.72	534	28.6	Meets	17
3	Electrical Engineering	1.98	533	33.2	Meets	19
3	Aerospace Engineering	2.09	526	22.9	Meets	14
3	Computer Engineering	2.24	537	30.8	Meets	25
3	Optical Sciences & Engineering	2.33	536	26.0	Meets	16
3	Mathematics	3.36	544	33.2	Meets	16

Note. AIMS performance level abbreviations: FFB = falls far below the standard, APP = approaches the standard, Meets = meets the standard, Exceed = exceeds the standard.

To further explore the signals sent to students from AIMS math scores regarding the selection of college major based on students' performance in college math courses, the proportions of students selecting majors at the different college math performance levels were analyzed by gender and ethnicity. Table 24 reports the differences in major selection by gender without considering performance on the AIMS math test. A greater proportion of females selected majors in the lower two college math performance levels. The proportion of males selecting majors in the most rigorous math performance level was more than two in half times higher than females. Males and females were equally represented in majors with the second highest math performance. This is not surprising given that males' math skills in this sample were slightly higher on average when entering the UA compared to females. The χ^2 test results indicate there was a significant relationship between the selection of major based on college math performance level and gender for students who took the AIMS math test (χ^2 with three degrees of freedom = 99.909, $p < 0.001$).

Table 24. Proportion of Students in Majors at each College Math Performance Level by Gender (N=1168)

	College Math Performance Level				χ^2
	0	1	2	3	
Across Gender	.21	.27	.25	.27	
Males (n=524)	.14	.20	.25	.41	99.909***
Females (n=644)	.27	.32	.25	.16	

Note. Cell values represent the proportion of students at each math performance level who chose majors in the corresponding math performance level. ***$p < 0.001$.

The distribution of major selection based on college math performance for students of all ethnicities appears in Table 25. The χ^2 test results indicate there was no relationship between the selection of major based on college math performance level and ethnicity for students who took the AIMS math test (χ^2 with fifteen degrees of freedom = 20.881, $p = 0.141$). However, there were descriptive differences in the proportion of students selecting majors based on college math performance level among students with different ethnicities. Hispanic and African American students had the highest proportions in majors at the lowest college math performance level and the lowest proportions at the highest math performance level. The highest proportions of Hispanic and African American students were in majors in the low to middle college math performance level. In general, Hispanic students had the highest proportions in majors in the lower two college math performance levels and slightly lower proportions in majors at the higher two college math performance levels than students of other ethnicities. Hispanic students' AIMS math scores were the lowest compared to students of other ethnicities, as presented previously in Table 17, which might account for the differences in college math performance. American Indian students had the lowest proportion in majors in the low college math performance level with the majority of students in majors in the middle to high college math performance level, 0.37. Asian students were the only group that showed increasing proportions of students in majors at each college math performance level, 0.11, 0.20, 0.31, and 0.38, respectively. Asian students also had the highest level of students in majors at the highest math performance level. The next closest groups of students with majors in the highest level of college math performance were the Other, American Indian, and White with proportions of 0.28, 0.27, and 0.27, respectively.

Table 25. Proportion of Students in Majors at each College Math Performance Level by Ethnicity (N=1168)

	College Math Performance Level				χ^2
	0	1	2	3	
African American (n=46)	.26	.28	.22	.24	
American Indian (n=11)	.09	.27	.36	.27	
Asian (n=64)	.11	.20	.31	.38	20.881
Hispanic (n=212)	.27	.31	.19	.23	
Other (n=61)	.18	.28	.26	.28	
White (n=774)	.21	.26	.26	.27	

Note. Cell values represent the proportion of students at each math performance level who chose majors in the corresponding math performance level. The other category is comprised of students with an unknown ethnicity, other ethnicity, and non-resident alien students.

Since these first two examples were not linked to AIMS math scores, the analyses were rerun for students passing the AIMS math test. Table 26 presents the proportion of students in majors at each college math performance level by gender for students who passed the AIMS math test. When passing the AIMS math test was included, females selected majors in the highest two college math performance levels. Males still chose majors with the highest student college math performance twice as much a females. However, females now had a greater proportion than males in majors with the second most difficult student college math performance. It seems passing the AIMS math test gave females the confidence to choose more math intense fields. The χ^2 test results indicate there was a significant relationship between the selection of major based on college math performance level and gender for students who passed the AIMS math test (χ^2 with three degrees of freedom = 53.227, $p < 0.001$).

Table 26. Proportion of Students in Majors at each College Math Performance Level by Gender for Students Who Passed the AIMS Math Test

	College Math Performance Level				χ^2
	0	1	2	3	
Across Gender (N=700)	.14	.22	.27	.37	
Males (n=361)	.09	.17	.24	.50	53.227***
Females (n=339)	.19	.27	.30	.24	

Note. Cell values represent the proportion of students at each math performance level who chose majors in the corresponding math performance level. ***$p < 0.001$.

Table 27 reports the proportion of students in majors at each college math performance level by ethnicity for students who passed the AIMS math test. For ethnicity, the proportions followed similar patterns regardless of passing the AIMS math test. The χ^2 test results indicate there was no relationship between the selection of major based on college math performance level and ethnicity for students who passed the AIMS math test (χ^2 with 15 degrees of freedom = 17.417, p = 0.295). There were some descriptive differences in the proportion of students selecting majors based on college math performance level among students with different ethnicities who passed the AIMS math test. Hispanic and African American students had the highest proportions in majors at the lowest college math performance level and the lowest proportions in majors at the highest college math performance level. The highest proportions of Hispanic and African American students were in majors in the low to middle college math performance level. In general, African American students had the highest proportion of students in majors in the low to middle college math performance levels and the lowest proportions in majors at the higher two college math performance levels compared to students of other ethnicities. American Indian students were not included in this analysis since only three American Indian students in the sample passed the AIMS math test. Again, Asian students were the only group that showed increasing proportions of students in majors at each college math performance level, 0.02, 0.16, 0.34, and 0.48, respectively. Asian students also had the highest level of students in majors at the highest math performance level. The next closest ethnicity was White with 0.37 of students in majors at the highest college math performance level. Overall, passing the AIMS math test resulted in higher proportions of students selecting majors at the highest math performance level across all ethnicities.

Table 27. Proportion of Students in Majors at each College Math Performance Level by Ethnicity for Students Who Passed the AIMS Math Test (N=700)

	Student Math Performance Level				x^2
	0	1	2	3	
African American (n=19)	.16	.37	.21	.26	
Asian (n=44)	.02	.16	.34	.48	
Hispanic (n=85)	.17	.24	.24	.35	17.417
Other (n=40)	.08	.30	.27	.35	
White (n=509)	.15	.21	.27	.37	

Note. Cell values represent the proportion of students at each math performance level who chose majors in the corresponding math performance level. The other category is comprised of students with an unknown ethnicity, other ethnicity, and non-resident alien students. Proportions were not reported for American Indians due to only 3 students in the analysis.

To better understand the impact of AIMS math scores on selecting a college major in one of the four college math performance categories, students' major selection was examined at each AIMS performance level. Table 28 presents the proportion of students' college major math performance level by gender for each AIMS performance level. If students' AIMS math scores were in the "falls far below the standard" AIMS performance level, the majority of students tended to have majors in the two lowest college major math performance levels. More females, 41%, than males, 29%, chose majors in the lowest math performance level. Surprisingly, both male and female students in the "falls far below the standard" AIMS performance level selected majors in the highest math performance category, albeit only for 4% of females, 18 % of males. The χ^2 test results indicate there was a significant relationship between the selection of major based on college math performance level and gender at the "falls far below the standard" AIMS performance level (χ^2 with three degrees of freedom = 14.035, $p = 0.003$). Females with AIMS math scores in the performance levels of "fall far below the standard" and "approaches the standard" tended to select majors in the two lowest college math performance levels compared to their male peers. The χ^2 test results indicate there was a significant relationship between the selection of major based on college math performance level and gender at the "approaches the standard" AIMS performance level (χ^2 with three degrees of freedom = 12.413, $p = 0.006$). When females passed the AIMS math test and scored in the "meets the standard" AIMS performance level, their distribution across the majors became more diffuse. Males in this same category were more likely to have majors in the upper two college math performance levels. The χ^2 test results indicate there was a significant relationship between the selection of major based on college math performance level and gender at the “meets the standard” AIMS performance level (χ^2 with three degrees of freedom = 50.670, $p < 0.001$). However, if a female achieved an AIMS math score in the “exceeds the standard” AIMS performance level, this seemed to signal confidence in selecting majors with the highest college math performance. The χ^2 test results indicate there was no relationship between the selection of major based on college math performance level and gender at the “exceeds the standard” AIMS performance level (χ^2 with three degrees of freedom = 5.612, $p = 0.132$).

Table 28. Proportion of Students' College Major Math Performance Level by Gender for each AIMS Performance Level (N=1168)

AIMS Performance Level	College Major Math Performance Level				x^2
Falls Far Below the Standard (N=228)	0	1	2	3	
Across Gender	.37	.37	.17	.09	
Males (n=72)	.29	.35	.18	.18	14.035**
Females (n=156)	.41	.38	.17	.04	
Approaches the Standard (N=240)					
Across Gender	.28	.32	.25	.15	
Males (n=91)	.24	.22	.32	.22	12.412**
Females (n=149)	.30	.38	.22	.10	
Meets the Standard (N=656)					
Across Gender	.15	.22	.28	.35	
Males (n=327)	.10	.17	.25	.48	50.670***
Females (n=329)	.20	.27	.31	.22	
Exceeds the Standard (N=44)					
Across Gender	.02	.11	.18	.68	
Males (n=34)	.00	.15	.20	.65	5.612
Females (n=10)	.10	.00	.10	.80	

Note. Cell values represent the proportion of students at each performance level who chose majors in the corresponding math performance level. **$p < 0.01$ and ***$p < 0.001$.

Tables 29 and 30 present the proportion of students' college major math performance level by ethnicity for each AIMS performance level. The proportion of students in each college math performance category who scored in the "falls far below the standard" and "approaches the standard" AIMS performance levels on the AIMS math test is shown in Table 29. The χ^2 test results indicate that there was no relationship between the selection of major based on college math performance level and ethnicity at the "falls far below the standard" AIMS performance level (χ^2 with fifteen degrees of freedom = 11.139, p = 0.743). Descriptively, in the "falls far below the standard" AIMS performance level for all ethnicities, the majority of students chose majors in the two lowest college math performance categories. However, all ethnicities in this AIMS performance level had a small percent, 6% to 13%, of students selecting majors in the highest college math performance category. Proportions were not reported for American Indian students since only 3 students were in the analysis. The distribution of major selection across the college math performance levels at the "approaches the standard" AIMS performance level was more diffuse. The χ^2 test results indicate that there was no relationship between the selection of major based on college math performance level and ethnicity at the "approaches the standard" AIMS performance level (χ^2 with fifteen degrees of freedom = 14.651, p = 0.477). There were a few descriptive differences in the proportion of students selecting majors across the college math performance categories by ethnicity. Although there were still many students selecting majors in the two lowest college math performance categories, a similar amount of students across ethnicities also selected majors in the two highest college math performance categories. African

American students with AIMS math scores in the “approaches the standard” AIMS performance level had the highest percent, 36%, of students selecting majors in the highest math performance category.

Table 29. Proportion of Students' College Major Math Performance Level by Ethnicity for AIMS "Falls Far Below the Standard" and "Approaches the Standard" Performance Levels (N=468)

AIMS Performance Level	College Major Math Performance Level				x^2
Falls Far Below (N=228)	0	1	2	3	
African American (n=13)	.54	.23	.15	.08	
Asian (n=9)	.45	.22	.22	.11	
Hispanic (n=71)	.41	.33	.13	.13	11.139
Other (n=11)	.37	.27	.27	.09	
White (n=121)	.34	.42	.18	.06	
Approaches (N=240)					
African American (n=19)	.14	.21	.29	.36	
American Indian (n=5)	.00	.20	.60	.20	
Asian (n=11)	.18	.36	.27	.18	14.651
Hispanic (n=56)	.25	.39	.20	.16	
Other (n=10)	.40	.20	.20	.20	
White (n=144)	.31	.31	.26	.12	

Note. Cell values represent the proportion of students at each performance level who chose majors in the corresponding math performance level. Proportions were not reported for American Indians at the "falls far below the standard" due to only 3 students in the analysis.

Table 30 presents the proportion of students in each college major math performance category who scored in the “meets the standard” and “exceeds the standard” AIMS performance levels on the AIMS math test. The majority of students at the “meets the standard” AIMS performance level selected majors in the two highest college math performance categories. The χ^2 test results indicate that there was no relationship between the selection of major based on college math performance level and ethnicity at the “meets the standard” AIMS performance level (χ^2 with fifteen degrees of freedom = 16.863, $p = 0.327$). Descriptively, Asian students had the highest percent of students selecting majors in the two highest math performance levels, 39% in the middle to high level and 44% in the highest level. African American students had the lowest percent of students selecting majors in the two highest math performance levels, 21% in the middle to high level and 26% in the highest level. Overall, the “exceeds the standard” AIMS performance level contained the fewest students. Only Asian, Hispanic, Other, and White students had scores in the “exceeds the standard” AIMS performance level. The χ^2 test results indicate that there was no relationship between the selection of major based on college math performance level and ethnicity at the “exceeds the standard” AIMS performance level (χ^2 with fifteen degrees of freedom = 3.96, $p = 0.947$). At the “exceeds the standard” AIMS performance level, the majority of students, 50% to 80%, selected majors in the highest college math performance level.

Table 30. Proportion of Students' College Major Math Performance Level by Ethnicity for AIMS "Meets the Standard" and "Exceeds the Standard" Performance Levels (N=700)

AIMS Performance Level	College Major Math Performance Level				x^2
Meets (N=656)	0	1	2	3	
African American (n=19)	.16	.37	.21	.26	
Asian (n=39)	.02	.15	.39	.44	
Hispanic (n=81)	.19	.25	.23	.33	16.863
Other (n=36)	.08	.31	.28	.33	
White (n=478)	.16	.21	.28	.35	
Exceeds (N=44)					
Asian (n=5)	.00	.20	.00	.80	
Hispanic (n=4)	.00	.00	.25	.75	3.396
Other (n=4)	.00	.25	.25	.50	
White (n=31)	.03	.10	.19	.68	

Note. Cell values represent the proportion of students at each performance level who chose majors in the corresponding math performance level. Proportions were not reported for American Indians at the "falls far below the standard" due to only 3 students in the analysis. No African American and American Indian students had an AIMS math score in the "exceeds the standard" AIMS performance level.

CHAPTER 5

DISCUSSION

This study sought to add to the research on the alignment of secondary and postsecondary expectations and performance by understanding the signals sent to high school students regarding their preparedness for college. Prior studies of alignment were based solely on content analyses by experts, and yielded results that showed high school grades, test material, and course taking policies and college admissions requirements tended to send signals that lead students to overestimate their level of college readiness. The goal of this study was to decipher the signals sent to high school students from the AIMS math test regarding performance in college math and the selection of a college major based on students' college math performance. It was expected that by examining the accuracy of the signals sent to students regarding college performance in math courses and major selection from a high school standards-based achievement test, the AIMS math test, students can make informed decisions when assessing their preparedness for college that improve their chances of avoiding remediation and graduating.

For educators and students to turn college aspirations into college attainment, clear and consistent indicators of performance that signal college readiness must be available (Venezia & Kirst, 2005; Roderick, Nagaoka, & Coca, 2009). High school coursework, grades, performance on achievement exams, class rank, and grade point average typically serve as indicators of college readiness. If signals sent from performance on these indicators do not accurately predict college performance, students may find themselves unprepared to handle the academic demands of college and end up stuck in numerous remediation courses or selecting college majors that do not match students' academic abilities. Either outcome results in less likely degree completion and widens the gap between college and career aspirations and achievement.

The findings in this dissertation repeatedly showed that signals sent to students by the AIMS math test can provide useful information regarding college readiness. Thus, high school signals might not be as inflated as past studies have indicated (Adelman, 2006; Brown & Conley, 2007). Higher AIMS math scores increased students' chances of meeting the UA math requirement and graduating college within six years. Students meeting the UA math requirement had mean AIMS math scores above the passing level, 500, for the test while a greater number of students who failed the AIMS math test did not meet the UA math requirement. Therefore, signals sent to students who passed the AIMS math test indicate high school and college performance expectations were well aligned. Passing the AIMS math test was a good indicator of college success defined as meeting the UA math requirement and college graduation in six years.

Performance on the AIMS math test was also found to be a good predictor of college math performance and the selection of college major in relation to the number and difficulty of required math courses for a given major. The signals regarding major selection differed by gender and ethnicity. Discrepancies in the signals sent to students from the AIMS math test concerning college major selection were greater for gender than ethnicity. Females tended to need a strong signal, such as scoring in the "exceeds the standard" AIMS performance level, before choosing a major with the highest student college math performance, whereas males just need to pass the AIMS math test to chose majors with the highest student college math performance.

Although this study found discrepant results from previous content alignment studies based on expert opinions, the studies complement each other because they provide different perspectives on the debate concerning the accuracy of signals sent to students regarding college readiness. Research initiatives such as Standards for Success (Brown & Conley, 2007; Conley & Venezia, 2003) the American Diploma Project (Achieve, 2004), and the Common Core State Standards Initiative (CCSS, 2012) focus on idealized college expectations, but they serve a needed purpose to get secondary and postsecondary education systems to work together to prepare students for college and workplace demands. The benefit of examining the alignment of high school performance and college performance, as this study did, was that it provided tangible interpretations of the signals sent to students from performance on a required standards-based achievement exam. The table of majors linked to AIMS math scores and performance levels can serve as a quick guide to understanding the academic demands of a major based on students' math abilities and performance. This knowledge can aid students, parents, and educators in making decisions that promote college success.

A limitation of this study is the weakened generalizability of the findings due to data coming from only one university and one state. Future research could provide more convincing and widely applicable results if other universities in the state were included. Expansion of the study and its implications would be further enhanced if this study could be conducted in multiple states. Also, this study only examined the signal sent to students regarding college readiness from one of three subjects on the AIMS test. The importance of this issue is mitigated based on the research supporting math as a key barrier to college success (Bahr, 2007; Schneider, Kirst, & Hess, 2003). Nonetheless, understanding and clarifying all the signals received by students from their performance on standards-based high school exit exams regarding college readiness is necessary for students to make informed life decisions.

A unique opportunity in the near future exists to address the limitations of this study. With the development and adoption of the CCSS and the CCSS assessment program by 48 states, a comprehensive study examining the accuracy of signals from a major standards-based educational reform can be conducted since common education standards and assessments of the standards will soon be used across multiple states. Standards-based reform became prominent in the early 1990s (Smith & O'Day, 1990). After two decades, the basic principles of establishing a clear and common vision for what is expected of students and how school, teachers, and parents can support that vision is still very much at the heart of the current standards-based reform, the CCSS initiative. The state-led CCSS initiative successfully created a shared vision of students' learning and knowledge expectations with CCSS among 48 states. The CCSS were developed on a content alignment framework to promote college and career readiness, which is the first step in understanding the accuracy of college preparedness signals sent to student, parents, and educators. However, examination of students' performance on the CCSS assessments, PARCC consortium and SBAC, and their subsequent college performance will be needed to ensure the signals of college readiness are accurate.

Replicating the research questions and analyses conducted in this dissertation could be conducted with high school students who take the CCSS assessments and who enroll in various postsecondary institutions (type and size) in different states. Another potential performance-based examination of the CCSS assessments is related to the area of college admissions, specifically in the postsecondary institutions' selection of students. Cimetta, D'Agostino, and Levin (2010) found that a measure of standards-based achievement, the 2000 AIMS test, performed similarly well to the conventional measures of college readiness, the SAT and ACT, in predicting college performance defined as first year college grade point average (GPA) and cumulative college GPA. Thus, this standards-based achievement test was found to provide accurate college readiness information. Although it was not the researchers' suggestions to replace conventional college selection measures with state-level achievement tests, the study showed that standards-based achievement tests could serve as useful indicators of college readiness, at least in the state of Arizona. As the CCSS have been purposely aligned, based on content review, with college readiness skills and expectations and will be taken by students in most states, the CCSS assessments could also serve as a tool for selecting students with likely college success by postsecondary institutions. Therefore, understanding the accuracy of signals regarding college performance based on students' performance on the CCSS assessments (a standards-based achievement test) will be useful to students college and career decisions and postsecondary institutions student selection process.

APPENDIX A – ITEM MAP FOR STUDENTS' COLLEGE MATH PERFORMANCE VARIABLE

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INPUT: 1322 PERSONS  86 ITEMS  MEASURED: 1315 PERSONS  56 ITEMS  222 CATS 3.67.0
--------------------------------------------------------------------------------

         PERSONS - MAP - ITEMS
              <more>|<rare>
   6 .############  +
                    |T
   5              . T+
                  . |
   4             .# +  RMATH447
                 .# |  RMATH404  RMATH424
   3             .# +  RM415A    RMATH434  RMATH445  RMATH456  RMATH468
                .## |S RM425B    RMATH355  RMATH413  RMATH464  RMATH479
   2           .### +  RM250A    RM250B    RM415B    RM425A    RMATH315
               .### S|  RMATH323  RMATH330  RMATH422  RMATH454  RMATH461
                       RMATH466
   1         .##### +  RM475B    RMATH215  RMATH362  RMATH485
             .##### |  RM475A    RMATH322  RMATH402  RMATH421  RMATH443
   0          .#### +M RMATH223  RMATH368  RMATH410
              .#### |  RMATH129  RMATH243
  -1    .########## +  RMATH125  RMATH254
               .### |  RM120R
  -2            .## M+  RMATH124
             .##### |S RM120S    RMATH263
  -3            .## +  RM115A    RM509C
              .#### |  RMATH105  RMATH111  RMATH113  RMATH160
  -4           .### +  RM302B    RMATH112
                 .# |
  -5      .######## +  RM115B
                 .# S|T RM197A
  -6             .# +  RMATH110
                  . |  RM302A
  -7              . +
                  . |
  -8              # +
                  . T|
  -9              . +
                    |
 -10                +
                    |
 -11            .## +
                  . |
 -12              . +
                    |
 -13                +
                    |
 -14                +
                    |
 -15                +
                    |
 -16            .## +
              <less>|<frequ>
 EACH '#' IS 13.
```

APPENDIX B – STUDENTS' COLLEGE MATH PERFORMANCE VARIABLE FIT STATISTICS

INPUT: 1322 PERSONS 86 ITEMS MEASURED: 1315 PERSONS 56 ITEMS 222 CATS 3.67.0

PERSON: REAL SEP.: 1.58 REL.: .71 ... ITEM: REAL SEP.: 2.12 REL.: .82

ITEM STATISTICS: MEASURE ORDER

ENTRY NUMBER	TOTAL SCORE	COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PT-MEASURE CORR.	PT-MEASURE EXP.	EXACT MATCH OBS%	EXACT MATCH EXP%	ITEM	G
61	7	2	4.13	1.42	.89	-1.4	.89	-1.4	1.00	.06	100.0	53.0	RMATH447	0
53	29	9	3.41	.55	1.69	1.6	1.64	1.5	.42	.59	28.6	46.1	RMATH424	0
42	28	8	3.38	1.02	1.32	.7	1.12	.4	.61	.64	66.7	78.4	RMATH404	0
57	10	3	3.13	.64	.96	.1	.84	.0	.38	.28	33.3	28.4	RMATH434	0
67	7	2	3.12	1.55	.41	-1.0	.41	-1.0	1.00	.41	100.0	70.7	RMATH468	0
63	13	5	3.11	.64	.85	.0	.85	.0	.80	.72	60.0	55.8	RMATH456	0
59	21	7	3.09	.50	.68	-.8	.54	-.5	.73	.56	57.1	44.9	RMATH445	0
49	34	10	2.83	.36	.43	-.7	.27	-.5	.50	.44	62.5	56.9	RM415A	0
55	33	9	2.57	.59	1.68	1.1	1.57	.9	.23	.39	42.9	63.6	RM425B	0
65	24	9	2.45	.44	1.16	.5	1.02	.2	.67	.69	33.3	48.5	RMATH464	0
70	6	2	2.41	.71	1.11	1.5	1.11	1.5	-1.00	.05	.0	.0	RMATH479	0
34	29	9	2.27	.49	1.16	.5	.97	.2	.71	.74	66.7	60.6	RMATH355	0
48	46	16	2.27	.37	.59	-1.4	.57	-1.4	.80	.66	60.0	49.5	RMATH413	0
23	35	11	2.17	.65	.80	-.4	.85	-.2	.79	.74	55.6	64.6	RM250B	0
50	25	8	2.12	1.11	1.10	.4	1.16	.5	-.15	.14	83.3	83.4	RM415B	0
22	32	11	1.96	.55	.60	-.9	.49	-1.1	.86	.76	55.6	59.2	RM250A	0
54	50	16	1.77	.33	.40	-1.7	.43	-1.3	.74	.65	57.1	50.3	RM425A	0
30	14	4	1.75	1.29	.06	-.8	.04	-.9	.98	.88	100.0	96.0	RMATH315	0
66	23	8	1.69	.41	.54	-.7	.33	-.2	.86	.80	62.5	56.4	RMATH466	0
33	16	5	1.48	.75	.63	-.6	.55	-.6	.81	.61	80.0	61.4	RMATH330	0
64	32	11	1.41	.36	1.20	.6	1.16	.5	.56	.65	36.4	49.6	RMATH461	0
52	31	9	1.36	.54	1.14	.4	.83	.0	.68	.72	55.6	69.7	RMATH422	0
62	27	7	1.33	1.12	1.21	.5	1.26	.6	.01	.24	85.7	85.8	RMATH454	0
32	79	28	1.26	.28	1.22	.9	1.45	1.4	.70	.75	44.0	49.8	RMATH323	0
69	19	5	1.20	1.23	.47	-.7	.30	-.5	.88	.41	100.0	80.6	RM475B	0
19	173	61	1.09	.19	1.03	.2	1.11	.6	.79	.80	45.6	56.4	RMATH215	0
72	36	10	1.01	.51	.70	-.3	.42	-.1	.61	.57	66.7	74.2	RMATH485	0
35	59	19	1.01	.31	.76	-.6	.75	-.6	.70	.67	64.7	53.9	RMATH362	0
40	10	4	.69	.83	.14	-.7	.10	-.7	.98	.93	100.0	89.7	RMATH402	0
68	21	7	.61	.66	.24	-1.2	.19	-.5	.99	.91	100.0	73.8	RM475A	0
31	234	85	.49	.16	1.06	.4	.99	.0	.80	.79	46.1	53.6	RMATH322	0
51	26	9	.43	.60	.70	-.3	.59	-.2	.90	.87	42.9	57.7	RMATH421	0
58	2	2	.25	6.93	.00	-1.4	.00	-1.4	1.00	.99	100.0	99.7	RMATH443	0
36	92	25	.14	.45	.55	-1.0	.46	-.1	.70	.64	78.3	76.8	RMATH368	0
20	681	254	-.05	.11	1.05	.6	1.04	.5	.80	.79	58.6	57.8	RMATH223	0
47	161	54	-.25	.22	1.53	2.2	1.58	2.3	.62	.75	46.2	60.4	RMATH410	0
21	34	13	-.56	.53	.20	-1.5	.19	-.9	.80	.66	90.9	69.4	RMATH243	0
14	960	361	-.74	.09	.88	-1.5	.90	-1.3	.84	.81	58.7	57.7	RMATH129	0
13	206	72	-.89	.20	.86	-.7	.91	-.4	.79	.76	60.9	60.2	RMATH125	0
24	552	182	-.95	.13	1.16	1.4	1.06	.6	.74	.76	56.0	60.2	RMATH254	0
5	246	98	-1.71	.20	.90	-.6	.88	-.8	.86	.82	70.6	66.4	RM120R	0
12	812	310	-2.13	.11	1.06	.7	1.03	.3	.82	.82	66.9	64.0	RMATH124	0
6	28	12	-2.56	.69	.98	.1	.71	.1	.81	.74	75.0	67.8	RM120S	0
25	287	105	-2.61	.19	1.03	.3	1.02	.2	.89	.87	68.7	64.2	RMATH263	0
76	7	2	-2.83	2.31	.12	-.6	.12	-.6	1.00	.79	100.0	89.6	RM509C	0
10	700	255	-2.87	.14	1.09	1.0	1.05	.5	.84	.83	66.7	70.6	RM115A	0
8	176	76	-3.44	.21	.76	-1.4	.74	-1.3	.91	.87	73.9	62.6	RMATH113	0
1	110	40	-3.53	.50	1.04	.2	9.07	4.6	.78	.77	78.3	75.0	RMATH105	0
15	184	59	-3.56	.30	.75	-1.2	.72	-1.4	.89	.81	76.6	69.3	RMATH160	0
7	286	129	-3.58	.17	1.04	.3	1.01	.1	.86	.86	67.2	65.7	RMATH111	0
3	153	62	-3.76	.26	.86	-.7	.85	-.7	.90	.87	75.9	67.6	RMATH112	0
29	239	77	-4.09	.26	1.30	1.8	1.65	2.1	.77	.82	69.1	69.7	RM302B	0
11	618	212	-4.98	.15	.99	-.1	.96	-.3	.85	.84	68.4	68.3	RM115B	0
18	169	46	-5.47	.35	.73	-.5	.75	.2	.65	.65	82.9	82.5	RM197A	0
4	1072	453	-6.15	.11	.93	-.9	.87	-1.3	.89	.86	77.7	74.0	RMATH110	0
28	238	78	-6.67	.22	.92	-.4	.99	.0	.80	.78	63.8	65.5	RM302A	0
MEAN	165.0	60.5	.00	.64	.85	-.2	.95	-.1			66.5	64.1		
S.D.	250.2	96.7	2.71	.95	.38	.9	1.17	1.1			20.8	15.8		

APPENDIX C: LIST OF EXCLUDED COLLEGE MAJORS WITH LESS THAN 10 STUDENTS

Major Abbreviation	Major Name
ABE	Agriculture & Biosystems Engineering
AGEM	Agriculture Economics & Management
AGTE	Agriculture Tech Management & Education
ARED	Art Education
ARH	Art History
ASC	Animal Sciences
ASTR	Astronomy
BE	Biosystems Engineering
CHE	Chemical Engineering
CLAS	Classics
CROP	Crop Production
EAS	East Asian Studies
EMA	Engineering Mathematics
ENGR	Engineering
ENTR	Entrepreneurship
EPH	Engineering Physics
FAS	Fine Arts Studies
FREN	French
GEE	Geological Engineering
GEOG	Geography

GEOS	Geosciences
HHS	Health & Human Service Administration
INE	Industrial Engineering
ITAL	Italian
JUS	Judaic Studies
LAS	Latin American Studies
LING	Linguistics
MNE	Mining Engineering
MSE	Materials Sciences & Engineering
MTHR	Musical Theatre
MUED	Music Education
MUS	Music
NES	Near Eastern Studies
PCL	Performance (Clarinet)
PE	Physical Education
PFL	Performance (Flute)
PHIL	Philosophy
PHYS	Physics
PMPC	Public Management & Policy
PSX	Performance (Saxophone)
PTP	Performance (Trumpet)
PVO	Performance (Voice)

RELI	Religious Studies
SCED	Science Education
SER	Special Education & Rehabilitation
SLHS	Speech, Language & Hearing Sciences
SOCL	Social Studies
SYE	Systems Engineering
THED	Theatre Arts Education
THPR	Theatre Production

REFERENCES

Achieve, Inc. (2004). *Do graduation test measure up? A closer look at state high school exit exams.* Washington, DC: Achieve, Inc.

Achieve, Inc. (2007). *Aligned expectations? A closer look at college admissions and placement tests.* Washington, DC: Achieve, Inc.

Achieve, Inc. (2008). *Closing the expectations gap, 2008*. Washington, DC: Achieve, Inc.

Achieve, Inc. (2011). *Achieve & the American diploma project, updated 2011*. Washington, DC: Achieve, Inc.

Adelman C. (1999). *Answers in the toolbox: Academic intensity, attendance patters, and bachelor's degree attainment*. Washington, DC: Office of Educational Research and Improvement, U.S. Department of Education. Retrieved from http://wwwled.gov/pubs/Toolbox/toolbox.html.

Adelman, C. (2004). *The empirical curriculum: Changes in postsecondary course-taking, 1972-2000.* Institute of Education Sciences, Washington, DC.

America Educational Research Association (AERA), American Psychological Association (APA), National Council on Measurement in Education (NCME). (1999). *Standards for educational and psychological testing.* American Psychological Association.

Arizona Department of Education. (2008). Arizona mathematics standard performance level descriptors high school. Retrieved on August 2, 2010 from http://www.azed.gov/wp-content/uploads/PDF/HSMathPLD.pdf

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

Bahr, P.R., (2007). Double jeopardy: Testing the effects of multiple basic skill deficiencies on successful remediation. Research in Higher Education, 48 (6), 695-725.

Bond, T.G., Fox, C.M. (2001). *Applying the Rasch model: Fundamental measurement in the human sciences.* Mahwah, NJ: Lawrence Erlbaum Associates.

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

Callan, P.M., Finney, J.E., Kirst, M.W., Usdan, M.D., Venezia, A. (2006). *Claiming common ground: State policymaking for improving college readiness and success.* San Jose, CA: National Center for Public Policy and Higher Education.

Center for Educational Policy Research. (2008). Standards for Success. Website accessed on April 22, 2008. http://www.s4s.org/cepr.s4s.php

Center on Education Policy. (2007). State high school exit exams: Working to raise test scores. Washington, DC

Center on Education Policy. (2011). State high school tests: Changes in state policies and the impact of the college and career readiness movement. Washington, DC

Cimetta, A.D., D’Agostino, J.V., Levin, J.R. (2010). Can high school achievement tests serve to select college students? *Educational Measurement: Issues and Practice* 29*(2)*, 3-12.

Common Core State Standards Initiative. (2012). Commons core state standards initiative: Preparing America's students for college & career. Website accessed on February 26, 2012. http://www.corestandards.org/

Conley, D.T. (2003a). *Mixed messages: what state high school test communicate about student readiness for college.* Eugene, OR: Center for Educational Policy Research.

Conley, D.T. (2007). *Toward a more comprehensive conception of college readiness*. Eugene. OR: Educational Policy Improvement Center.

Conley, D.T. (2003b). *Understanding university success*. Eugene, OR: Center for Educational Policy Research.

Conley, D.T., & Venezia, A. (April 2003). High school transition: State of the art and views of the future. Paper presented at the annual meeting of the American Educational Research Association, Chicago, IL.

D'Agostino, J.V., Cimetta, A.D., (2008). *The alignment of high school exit exams and college performance.* Paper presented at the annual AERA meeting NY.

D'Agostino, J.V., Welsh, M.E., & Cimetta, A.D. (2005). *Alignment analysis of Arizona academic standards and assessments*. Phoenix, AZ: Arizona Department of Education.

Education Trust (1999). *Ticket to Nowhere*. Thinking K-16. Washington, DC

Educational Testing Services. (2011). Partnership for the Assessment of Readiness for College and Career (PARCC). Center for K-12 Assessment & Performance Management.

Gayler, K., Chudowsky, N., Hamilton, M., Kober, N., & Yeager, M. (2004) *State high school exit exams: A maturing reform.* Washington, DC: Center on Education Policy.

Jaccard, J., Becker, M.A., & Wood, G. (1984). *Pairwise multiple comparison procedures: A review.* Psychological Bulletin, 96, 589-596.

Kirst, M.W. (2004). The high school/college disconnect. *Educational Leadership,* 62*(3),* 51-55.

Kirst, M.W., & Reeves Bracco, K. (2004). Bridging the great divide. How the K-12 and postsecondary split hurts students, and what can be done about it. In M.W. Kirst & A. Venezia (Eds.), *From high school to college: improving opportunities for success in postsecondary education* (pp.1-30). San Fransicso, CA: Jossey-Bass.

Knapp, L.G., Kelly-Reid, J.E., & Ginder, S.A. (2009). *Enrollment in postsecondary institutions, fall 2007; Graduation rates, 2001 & 2004 cohorts; and financial statistics, fiscal year 2007*. National Center for Education Statistics, Institute of Education Sciences. Washington, DC: U.S. Department of Education.

Melguizo, T., Hagedorn, L.S. & Cypers, S. (2008). Remedial/developmental education and the cost of community college transfer: A Los Angeles County sample. *The Review of Higher Education,* 31*(4),* 401–431.

Mitzel, H.C., Lewis, D.M., Patz, R.J., & Green, D.R. (2001). The Bookmark procedure: Psychological perspectives. In G.J. Cizek (Ed.), *Setting performance standards: Concepts, methods, and perspectives* (pp. 249-281). Mahwah, NJ: Lawrence Erlbaum Associates.

National Center for Education Statistics. (2004). *Condition of education 2004*. Washington, DC: U.S. Department of Education.

National Center for Education Statistics (2008). *Enrollment in postsecondary institutions Fall 2006; Graduation rates 2000& 2003 cohorts: and financial statistics, fiscal year 2006*. Washington, DC: U. S. Department of Education.

National Governors Association Center for Best Practices (NGA), Council of Chief State School Officers (CCSSO). (2010). *Common core state standards for mathematics*. National Governors Association Center for Best Practices, Council of Chief State School Officers, Washington D.C.

Parsad, B., Lewis, L., & Greene, B. (2003). *Remedial education at degree-granting postsecondary institutions in fall 2000.* National Center for Education Statistics, Washington, DC.

Roderick, M., Nagaoka, J., Coca, V. (2009). College readiness for all: The challenge for urban high schools. *The Future of Children*, 19*(1)*, 185-210.

Schneider, B., Kirst, M., & Hess, F.M. (2003). Strategies for success: High school and beyond. Brookings Papers on Education Policy, 6, 55-93

Smarter Balanced Assessment Consortium. (2012). Smarter balanced factsheet. Website accessed on February 26, 2012. http://www.smarterbalanced.org/

Smith, M.S., & O'Day, J. (1990). Systemic school reform. *Journal of Education Policy,* 5*(5)*, 233-267.

Webb, N.L. (1997). *Criteria for alignment of expectation and assessment in mathematics and science education* (Research Monograph No. 6) Washington, DC: Council of Chief State School Officers.

Webb, N.L. (1999). *Alignment of science and mathematics standards and assessment in four states* (Research Monograph No. 18) Madison: University of Wisconsin, Wisconsin Center for Educational Research.

U.S. Department of Education. (2010). Race to the Top Assessment Program. Website accessed on March 6, 2012. http://www.ed.gov/open/plan/race-top-assessment

University of Arizona. (2007). *Fall 2007 enrollment highlights*. Tucson, Arizona: Office of Institutional Research and Planning Support.

Venezia, A., Kirst, M. & Antonio, A. (2003). *Betraying the college Dream: How disconnected K-12 and postsecondary education systems undermine student aspirations*. San Francisco, CA: Jossey-Bass.

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

Young, J.W. (1990). Adjusting the cumulative GPA using item response theory. *Journal of Educational Measurement*, 27*(2)*, 175-186.