2013

Which advanced mathematics courses influence ACT score? A state level analysis of the Iowa class of 2012

Mary L. Grinstead
Iowa State University

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A state level analysis of the Iowa class of 2012

by

Mary L. Grinstead

A dissertation submitted to the graduate faculty

in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Major: Education (Educational Leadership)

Program of Study Committee:
Jeffrey S. Brooks, Co-Major Professor
Joanne Marshall, Co-Major Professor
Mack C. Shelley II
Jan Westerman-Beatty
Frankie Santos Laanan

Iowa State University
Ames, Iowa
2013

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ACKNOWLEDGMENTS

The completion of this degree was accomplished with the support and encouragement of many individuals to whom my appreciation is extended. I would like to thank Drs. Joanne Marshall, Mack Shelley, Jan Westerman-Beatty, and Frankie Santos Laanan for being a part of my committee and providing encouragement and feedback throughout this entire process. Their feedback and guidance has helped me become the educational leader and researcher I have strived to be. A special thank you is owed to Dr. Jeffrey Brooks for being my advisor at the onset of this dissertation process and seeing me through completion from more than 1,000 miles away.

Thanks also to my friends and former co-workers at the Iowa Department of Education who granted me access to the data needed for this study. In particular, thank you to Dr. Xiaoping Wang, a great friend and mentor. Xiaoping molded me into an aspiring educational researcher with lots of help and patience along the way.

Last, and most important, I would like to thank my husband, Jason, for his patience through this entire process and his constant faith that I could get through the program. I am grateful for the support he provided for me to attend classes, study, and write this dissertation. I especially thank my daughter, Abby, who arrived half way through this process and reminded me what is truly important in life—spending time with family. I look forward to the time I will now have to spend with them.

ABSTRACT

This study explores the relationship between specific advanced mathematics courses and college readiness (as determined by ACT score). The ACT organization has found a consistent relationship between taking a minimum core number of mathematics courses and higher ACT scores (mathematics and composite) (ACT, Inc., 2012c). However, the extent to which individual advanced mathematics courses increase ACT scores when prior achievement is controlled is unknown. The relationship between trigonometry, pre-calculus, calculus, advanced placement (AP) calculus, and AP statistics, and ACT composite and mathematics scores are examined using a general linear model. The sample for the study included members of the Iowa high school graduating class of 2012 who took the ACT at any point during high school.

All advanced mathematics courses included in the analysis (trigonometry, pre-calculus, calculus, AP calculus, and AP statistics) had a positive relationship with ACT mathematics score. AP calculus had the largest impact of all advanced mathematics courses on both ACT mathematics and composite scores, with enrollment in the course associated with an average increase of 1.6568 points in ACT mathematics score and an average increase of 1.1821 points in ACT composite score.

The relationship between enrollment in advanced mathematics courses and ACT scores was influenced by race/ethnicity for algebra II, calculus, and AP calculus and by gender for algebra II and calculus. In addition, female students saw less of an increase in ACT mathematics score when taking algebra II than males and less of an increase in ACT mathematics and composite scores when taking algebra II and calculus than male

students. This finding hints at the cultural sensitivity of instructional strategies and materials in the mathematics classroom. To increase college readiness, students must be provided the opportunity to enroll in advanced mathematics courses, including AP courses. These opportunities for exposure to advanced mathematical concepts must exist for all students, including minority and female students. This requires increased exposure to pre-algebra concepts at the middle school grade levels and culturally sensitive instructional methods in which students relate their everyday experiences to mathematical concepts.

CHAPTER 1

INTRODUCTION

Background

Education policymakers and stakeholders have increasingly emphasized college readiness for high school graduates (Bill and Melinda Gates Foundation, 2012; Common Core State Standards Initiative, 2012; United States Department of Education, 2009). In 1973, 27 percent of jobs in the United States required postsecondary education. This increased to 59 percent in 2007 and is predicted to grow to 66 percent by 2018 (Symonds, Schwartz, & Ferguson, 2011). With the current job market requiring postsecondary education for the majority of careers, the Obama administration stresses the importance of preparing every United States student for college (The White House, 2009). A commonly accepted indicator of college readiness is performance on college entrance examinations, such as the SAT and ACT. Colleges and universities use these scores as student admission criteria and for course placement (Beale, 2012; Camilli, 2006). Districts and states are also using college entrance examination scores to assess the effectiveness of educational systems in preparing students for college.

ACT (along with the SAT) is one of the two major college entrance examinations used by colleges and universities in the United States. ACT is used more commonly among Midwestern colleges, while the SAT is used predominantly on the east and west coasts. The ACT organization has found a consistent relationship between taking at least three mathematics courses and a higher ACT (mathematics and composite) score (ACT, Inc., 2012b). However, it cannot be determined that advanced mathematics courses increase ACT scores as prior achievement is not controlled. It is not known if higher-achieving students take more advanced mathematics courses and also score higher on the ACT or if advanced mathematics courses actually increase test scores.

Predictors of College Readiness/Academic Achievement

The strongest predictor of academic achievement on standardized tests is previous achievement (Aubrey, Dahl, & Godfrey, 2006; Kyttälä & Björn, 2010). Student background characteristics have also been found to impact student achievement. Socioeconomic status and academic achievement have a consistently negative relationship (Parke & Kanyongo, 2012; Siegler et al., 2012). Achievement gaps also exist between African Americans and whites and between Hispanics and whites (Bali & Alvarez, 2004; Wolk, 2011). Among the national graduating class of 2012 who took the ACT, the scores of African Americans and Hispanics were significantly lower than the scores of whites. Whites had an average composite score of 22.4, African Americans 17.0, and Hispanics 18.9 (ACT, Inc., 2012b). English language learners also underperform native English speakers in both reading and mathematics (Garcia, Lawton, & De Figueiredo, 2012; Guglielmi, 2012). Examining National Assessment of Educational Progress (NAEP) data, McGraw, Lubienski, and Strutchens (2006) found males to have consistently higher mathematics test scores than females from 1990 to 2003.

The context in which students receive their education also impacts student achievement. Students attending high schools with class sizes of more than 400 students had lower student achievement than students in smaller high schools (Weiss, Carolan, &

Baker-Smith, 2010). Another contextual variable impacting student achievement is consistency. A negative relationship exists between both low attendance and mobility and student achievement (Lamdin, 1996; Parke & Kanyongo, 2012; Parke & Keener, 2011; Roby, 2004). The content of courses also impacts achievement. Ma and Wilkins (2007) found upper-level mathematics courses (trigonometry, pre-calculus, and calculus) to increase student growth as measured by mathematics tests.

Purpose

The purpose of this study was to explore the relationship between students' enrollment in specific advanced mathematics courses and college readiness. This study addresses the following questions: Is taking advanced mathematics courses related to an increase in ACT score? Specifically, which advanced mathematics courses contribute to an increase in ACT score? Advanced mathematics courses are defined in this study as courses beyond the algebra I, geometry, and algebra II sequence in high school. Algebra I, geometry, and algebra II is the typical course sequence for high school mathematics courses (Common Core State Standards Initiative, 2010). Advanced mathematics courses include trigonometry, pre-calculus, calculus, AP calculus, and AP statistics. The state of Iowa high school graduating class of 2012 who took the ACT at any point during high school constitute the sample in this study. Matched student cohort data from ninth grade (2008-2009 school year) to twelfth grade (2011-2012 school year) collected by the Iowa Department of Education (IDE) will be analyzed to examine ninth grade academic achievement, mathematics course-taking patterns, background characteristics, and ACT scores.

Data were analyzed using a general linear model (GLM). The purpose of a GLM is to quantify the relationship between several independent variables and a dependent variable. The dependent variable of interest was ACT score (mathematics or composite). The independent variables in the model included: enrollment in trigonometry, enrollment in pre-calculus, enrollment in calculus, enrollment in AP calculus, enrollment in AP statistics, prior achievement, attendance rate, student mobility, district size, and a number of student demographic variables.

Hypotheses

Given the literature on mathematics courses and college readiness, ten hypotheses will be tested in the study.

1. H_O: There is no relationship between enrollment in trigonometry in high school and ACT mathematics score.

   H_A: There is a positive relationship between enrollment in trigonometry in high school and ACT mathematics score.

2. H_O: There is no relationship between enrollment in pre-calculus in high school and ACT mathematics score.

   H_A: There is a positive relationship between enrollment in pre-calculus in high school and ACT mathematics score.

3. H_O: There is no relationship between enrollment in calculus in high school and ACT mathematics score.

   H_A: There is a positive relationship between enrollment in calculus in high school and ACT mathematics score.

4. H_O: There is no relationship between enrollment in AP calculus in high school and ACT mathematics score.

   H_A: There is a positive relationship between enrollment in AP calculus in high school and ACT mathematics score.

5. H_O: There is no relationship between enrollment in AP statistics in high school and ACT mathematics score.

   H_A: There is a positive relationship between enrollment in AP statistics in high school and ACT mathematics score.

6. H_O: There is no relationship between enrollment in trigonometry in high school and ACT composite score.

   H_A: There is a positive relationship between enrollment in trigonometry in high school and ACT composite score.

7. H_O: There is no relationship between enrollment in pre-calculus in high school and ACT composite score.

   H_A: There is a positive relationship between enrollment in pre-calculus in high school and ACT composite score.

8. H_O: There is no relationship between enrollment in calculus in high school and ACT composite score.

   H_A: There is a positive relationship between enrollment in calculus in high school and ACT composite score.

9. H_O: There is no relationship between enrollment in AP calculus in high school and ACT composite score.

H_A: There is a positive relationship between enrollment in AP calculus in high school and ACT composite score.

10. H_O: There is no relationship between enrollment in AP statistics in high school and ACT composite score.

    H_A: There is a positive relationship between enrollment in AP statistics in high school and ACT composite score.

Rationale

To maximize student learning by exposing students to the content most likely to increase student knowledge it is important to isolate the contributions of the high school curriculum (administered through mathematics courses) on student college readiness. By controlling for previous academic achievement, the relationship between mathematics courses and ACT scores is measured more accurately. Students who enroll in advanced mathematics courses also score higher on the ACT and other measures of college readiness (ACT, Inc., 2012b; Noble, Davenport, Schiel, & Pommerich, 1999; Noble, Roberts, & Sawyer, 2006). However, it has not been widely determined if higher-achieving students enroll in more advanced mathematics courses and also score higher on the ACT or if advanced mathematics courses increase test scores.

Significance of the Study

This study informs the placement of high school students in advanced course-taking patterns. The Common Core State Standards (Common Core State Standards Initiative, 2012) push for four years of mathematics course taking for students at all achievement levels. These standards were adopted by the Iowa Board of Education on July 29, 2010 (Iowa Department of Education, 2010). This study informs the effect of advanced course enrollment, along with the importance of high expectations for students at all performance levels.

This study contributes to the existing literature by exploring the effect of enrollment in advanced mathematics courses on ACT scores while controlling for previous achievement and by exploring the effect of enrollment in specific individual courses (trigonometry, pre-calculus, calculus, AP calculus, and AP statistics) on ACT scores. Other studies (Noble, Davenport, Schiel, & Pommerich, 1999; Noble, Roberts, & Sawyer, 2006) have explored the impact of mathematics coursework on ACT score using course enrollment that was self-reported by students at the time of the ACT test administration. The present study used student course enrollment reported by school for state data reporting, giving a more accurate representation of course enrollment. In addition, no previous study has explored the impact of AP courses on ACT scores. This study explored the impact of AP calculus and AP statistics (individually) on ACT scores.

Definition of Terms

ACT composite score: The ACT composite score is the average of the four ACT test scores: English, mathematics, science, and reading. The score ranges from 1 (low) to 36 (high) (ACT, Inc., 2012c).

ACT mathematics score: The ACT mathematics score is based on 60 multiple-choice questions covering pre-algebra/elementary algebra, intermediate algebra/coordinate geometry, and plane geometry/trigonometry. The score ranges from 1 (low) to 36 (high) (ACT, Inc., 2012c).

Advanced mathematics courses: Courses beyond the algebra I, geometry, and algebra II sequence in high school. Advanced mathematics courses include trigonometry, pre-calculus, calculus, AP calculus, and AP statistics.

College readiness: The level to which students are prepared for college (Arnold, Lu, & Armstrong, 2012; The College Board, 2006; Conley, 2008).

CHAPTER 2

LITERATURE REVIEW

The purpose of this study was to explore the relationship between students' enrollment in specific advanced mathematics courses and college readiness. Specifically, the impact of enrollment in advanced mathematics courses on ACT scores was explored. In order to frame the study within the context of the current literature, a review of literature encompassing the state of mathematics education in the United States and Iowa, high school mathematics courses, and college readiness (including the ACT) was performed. In conclusion, a theoretical framework for exploring the relationship between enrollment in advanced mathematics courses and ACT composite and mathematics scores is presented.

Mathematics Achievement in the United States and Iowa

The mathematics achievement of students in the United States on international and national benchmarks paints a picture of mediocrity. Of the 56 countries and other education systems that administered the Trends in International Mathematics and Science Study (TIMSS) at grade eight in 2011, the United States average score in mathematics at grade eight was higher than 32 other countries but lagged behind Korea, Singapore, Chinese Taipei, Hong Kong, Japan, the Russian Federation, and Quebec. The United States eighth grade TIMSS average mathematics score (509) was slightly higher than the international TIMSS scale average (500) in 2011. However, mathematics achievement in the United States appears stagnant, as there was no measurable difference between the

United States average mathematics score at grade eight in 2007 (508) and in 2011 (509) (Institute of Education Sciences, 2012).

The Programme for International Student Assessment (PISA) has a different emphasis than TIMSS or NAEP, assessing mathematics literacy (i.e., application) rather than content knowledge. It also tests a different selection of countries than does TIMSS. Among the 65 education systems testing 15-year-olds in 2009, the United States ranked 32nd. The United States had a lower average mathematics score (487) than the international Organisation for Economic Co-operation and Development (OECD) PISA average (496) (OECD, 2010).

As for national achievement measures, the mathematics achievement of United States eighth graders is slowly climbing on the NAEP, with the national average score increasing from 262 to 284 between 1990 and 2011. However, 65 percent of eighth graders failed to score in the proficient or above range, meaning that approximately two-thirds of United States eighth graders enter high school unprepared for higher levels of mathematics (National Center for Education Statistics, 2011).

Until lately, students in Iowa have been achieving at higher levels on mathematics assessments than the rest of the nation. However, Iowa has not mirrored the positive trends of increased achievement that the nation has seen over the past 20 years. In 1990, Iowa ranked in the top three states on the eighth grade mathematics NAEP with an average score of 278, 16 points above the average score for the nation (262). Since 1990, other states have seen large increases in NAEP scores, while scores in Iowa have increased moderately. According to the latest eighth grade mathematics NAEP assessment, mathematics achievement in Iowa is relatively similar to that of the nation.

The average mathematics score for Iowa eighth graders was 285, while the eighth grade mathematics national average was 284 in 2011. Iowa now ranks 24th on the eighth grade mathematics NAEP (National Center for Education Statistics, 2011). This lack of growth in academic achievement is a major point of concern for Iowa's educational system.

High School Mathematics Curriculum

History of Standards in Iowa

The state of Iowa highly values local control of school districts. Until 2008, standards were developed by local school districts, creating 371 (as of 2008) different sets of standards across the state. Iowa was the last state in the nation to adopt state-wide standards (Public Broadcasting System, 2012). This adoption of state standards was brought about by federal No Child Left Behind (NCLB) requirements, which requires a test aligned to the standards taught in the classroom to be administered state-wide (Iowa Department of Education, 2010; U.S. Department of Education, 2001). In 2005, Iowa passed legislation to develop a core curriculum for Iowa high schools in mathematics, science, and literacy (Iowa Department of Education, n.d.). The Iowa legislature passed state standards and expanded Iowa's core curriculum in 2007 by including kindergarten through eighth grade and adding social studies and 21st Century learning skills subject areas (Iowa Department of Education, n.d.).

Iowa Core

The Iowa Core (originally known as the Iowa Core Curriculum) was signed into law in 2007 (Iowa Department of Education, 2010). This initiative was the first attempt in the state of Iowa for common state-wide standards. The Iowa Core identified the most important curricula in literacy, mathematics, and science based on best practice research and information from Iowa Testing Programs (the provider of Iowa's state accountability test), the National Assessment of Educational Progress, ACT, and the College Board (Iowa Department of Education, n.d.). Iowa high schools were required to fully implement the Iowa Core by July 1, 2012. Schools with kindergarten through eighth grade are required by Iowa Code to implement the Iowa Core by the 2014-2015 school year (Iowa Department of Education, n.d.).

Common Core State Standards

In an effort to increase the academic achievement of students, the Iowa State Board of Education adopted the Common Core State Standards as part of the Iowa Core in 2010 (Iowa Department of Education, 2010). When adopting the Common Core, the State Board of Education required all Iowa school districts and accredited non-public schools to implement the Iowa Core, including the Common Core by 2014-2015 (Iowa Department of Education, 2010). The Common Core State Standards are more rigorous than the state standards previously implemented in many states, by introducing concepts at early ages and making room for more advanced coursework in high school (Schmidt, 2012). These standards for high school mathematics include content that all high school students should learn to be college- and career-ready (Common Core State Standards Initiative, 2010; Jones & King, 2012). In addition, standards are also listed for students pursuing advanced mathematics (such as calculus or advanced statistics) that go beyond what is expected for all students. The expected standards for all students focus on number and quantity, algebra, functions, modeling, geometry, and statistics and probability. These categories cross the boundaries of courses, providing a complete view of what students should know by the end of their high school careers. The Common Core State Standards do not dictate a sequence for high school mathematics courses (Common Core State Standards Initiative, 2010); however, students who master the Common Core State Standards in mathematics should be prepared for entry-level credit-bearing mathematics courses in college (Jones & King, 2012).

Content of Advanced Mathematics Courses

Neither the Iowa Core nor the Common Core mandates requirements for standards taught in individual classes. Instead, they list all standards students need to master in order to be college ready by the end of their high school careers (Common Core State Standards Initiative, 2010; Iowa Department of Education, 2010). Qualifiers for taking advanced mathematics courses typically include algebra I, geometry, and algebra II (Common Core State Standards Initiative, 2010), but sequencing may differ among high schools. Advanced mathematics courses may differ greatly in content among high schools and even classrooms, though they may be titled the same. However, all Iowa high school courses are coded according to the Secondary School Course Classification System: School Codes for the Exchange of Data (SCED) system. The SCED system allows for a standardized coding of courses that is consistent across districts and states (Bradby, Pedroso, & Rogers, 2007). All advanced mathematics courses coded meet the following definitions (as determined by individual high schools):

Trigonometry

Trigonometry courses typically include the following topics: "trigonometric and circular functions; their inverses and graphs; relations among the parts of a triangle;

trigonometric identities and equations; solutions of right and oblique triangles; and complex numbers" (Bradby, Pedroso, & Rogers, 2007, p. 25) and prepare students for calculus (Bradby, Pedroso, & Rogers, 2007).

Pre-calculus

Pre-calculus topics typically include **"**complex numbers; polynomial, logarithmic, exponential, rational, right trigonometric, and circular functions, and their relations, inverses and graphs; trigonometric identities and equations; solutions of right and oblique triangles; vectors; the polar coordinate system; conic sections; Boolean algebra and symbolic logic; mathematical induction; matrix algebra; sequences and series; and limits and continuity" (Bradby, Pedroso, & Rogers, 2007, p. 26) and combine elementary functions, analytic geometry, trigonometric, and mathematical analysis (Bradby, Pedroso, & Rogers, 2007).

Calculus

"Derivatives, differentiation, integration, the definite and indefinite integral, and applications of calculus" (Bradby, Pedroso, & Rogers, 2007, p. 27) are topics typically covered in calculus courses (Bradby, Pedroso, & Rogers, 2007).

AP Calculus

Advanced placement (AP) calculus courses have a suggested curriculum set by the College Board. This curriculum parallels college-level calculus courses (The College Board, 2012). Topics covered in the course include "elementary functions, properties of functions and their graphs, limits and continuity, differential calculus (including definition of the derivative, derivative formulas, theorems about derivatives, geometric applications, optimization problems, and rate-of-change problems), and integral calculus (including antiderivatives and the definite integral)" (Bradby, Pedroso, & Rogers, 2007, p. 27). Before teaching AP calculus, teachers are required to attend a four-day institute conducted by the College Board covering the AP calculus exam (offered at the end of the course for college credit) and the curriculum framework of the course.

AP Statistics

Using the College Board's suggested curriculum paralleling college-level statistics courses, AP statistics courses cover the following topics: "exploring data, sampling and experimentation, anticipating patterns, and statistical inference" (Bradby, Pedroso, & Rogers, 2007, p. 30). Before teaching AP statistics, teachers are required to attend a four-day institute conducted by the College Board covering the AP statistics exam (offered at the end of the course for college credit) and the curriculum framework of the course.

College Entrance Exams

Colleges and universities use entrance exams to measure academic achievement of potential students. These standardized tests are used to uniformly measure the level of knowledge and compare students from all over the nation. The two predominant college entrance examinations used by colleges and universities in the United States are the ACT and the SAT. The ACT is a curriculum-based achievement test that measures what a student has learned, while the SAT is more of an aptitude test that measures reasoning and verbal abilities (ACT, Inc., 2012d).

The ACT is used more commonly among Midwestern colleges, while the SAT is used predominantly on the east and west coasts. Among the Iowa graduating class of 2012, 63 percent took the ACT and 3 percent took the SAT (Iowa Department of

Education, 2012). Therefore, the ACT is used as the college entrance exam of interest when examining the Iowa graduating class of 2012.

The ACT

The ACT is a curriculum-based measure of college readiness that includes multiple choice tests of academic achievement in English, math, reading, and science (ACT, Inc., 2012d). The ACT test requires college academic skills by reproducing college-level work. The ACT is designed to "determine how skillfully students solve problems, grasp implied meanings, draw inferences, evaluate ideas, and make judgments in subject-matter areas important to success in college" (ACT, Inc., 2007, p. 3). Test questions require students to integrate skills in major curriculum areas with the information on the test. As a result, ACT scores are related to the students' academic achievement in curriculum areas (ACT, Inc., 2007).

The mathematics test is timed for 60 minutes with 60 questions covering mathematics skills typically acquired by the end of eleventh grade. The mathematics test covers six content areas: pre-algebra, elementary algebra, intermediate algebra, coordinate geometry, plane geometry, and trigonometry. The ACT English test is timed for 45 minutes with 75 questions covering standard written English and rhetorical skills. The ACT reading test is timed for 35 minutes with 40 questions involving reading comprehension. The ACT science test is timed for 35 minutes with 40 questions covering skills required in the natural sciences: interpretation, analysis, evaluation, reasoning, and problem solving (ACT, Inc., 2012a). Each test (English, mathematics, reading, and science) is scored in a range of 1 (low) to 36 (high). A composite score is also calculated by averaging the scores from all four tests (ACT, Inc., 2012a).

Most students take the ACT during their junior year of high school (ACT, Inc., 2007), as ACT recommends taking the test late in the high school career, to ensure that coursework corresponding to the test is completed, and at least two months before college applications are due (ACT, Inc., 2012d). In 2006, 65 percent of ACT test takers were juniors and 34 percent were seniors in high school (ACT, Inc., 2007).

History

E. F. Lindquist founded ACT in 1959 with the purpose of testing broad competencies with a college entrance exam. Lindquist viewed the current college admission test at the time (known as the College Board Examination) as an instrument that excluded all students except the most qualified. The essay format of the test was subjective and time-intensive to score. During the 1920's, the SAT was developed with the intention of providing a measure of intelligence instead of academic achievement. Many schools used the SAT for scholarships and the College Board Examination as the entrance exam (Lemann, 2000). The influence of the SAT was limited to highly selective institutions (mostly private and in the northeastern United States) and was not marketed across the United States. This created a need to be addressed by the ACT (ACT, Inc., 2009a).

The majority of colleges and state university systems used a wide assortment of admission tests that did not produce standard results in the 1950s. Lindquist's goal was to create a measure of academic preparation (not of intelligence) to address academic deficiencies. The ACT was first administered in November of 1959 (ACT, Inc., 2009a).

Intent of the Test

The ACT is designed not only to measure student learning for college planning, but also to help colleges and universities address the needs of their students by providing information about the achievement level of students (ACT, Inc., 2007). Since the ACT is curriculum-based, the best preparation is learning through high school coursework. The ACT may serve as a coursework motivator to students, as high test scores represent a commitment to high school coursework (ACT, Inc., 2007).

Bias of College Entrance Exams

College entrance exams were designed to identify students' knowledge and skills regardless of socioeconomic status, gender, or race (Lemann, 2000). However, Freedle (2003) found both cultural and statistical test bias on the SAT against minorities (African Americans, Hispanics, and Asians) and students from low socioeconomic backgrounds, particularly in the verbal section of the test, using Differential Item Functioning (DIF). The DIF statistical procedure (Dorans & Kulick, 1986) examines minority and white responses to each test item. Santelices and Wilson (2010) confirmed Freedle's finding of test bias against African Americans in the SAT using updated data in 2010. Similarly, Wainer and Steinberg (1992) found statistical bias against females in the mathematics section of the SAT.

Coursework and ACT Scores

Several studies have found advanced mathematics coursework to have a positive relationship with ACT score (Noble, Davenport, Schiel, & Pommerich, 1999; Noble, Roberts, & Sawyer, 2006). Noble, Davenport, Schiel, and Pommerich (1999) used a national sample of 5,489 students who took the ACT in either April or October 1996 to examine the relationships among high school courses, GPA, background characteristics, and ACT scores. They found algebra II to increase ACT mathematics score by 0.95 and ACT composite score by 0.86. Geometry increased ACT mathematics and composite scores by 1.13 and 0.79, respectively. Trigonometry increased ACT mathematics score by 1.97 and ACT composite score by 1.38. Calculus increased ACT mathematics and composite scores by 3.48 and 2.39, respectively. This study did not control for students' prior achievement (Noble et al., 1999). Noble and Schnelker (2007) controlled for prior achievement when examining high school coursework and ACT scores with a national sample of 403,381 students from the graduating class of 2003. Taking algebra I, geometry, and algebra II was associated with an ACT mathematics score increase of about 1.1 points (compared with taking none, one, or two of these three courses). In addition to algebra I, geometry, and algebra II, taking either trigonometry or other advanced mathematics was associated with an average increase in ACT mathematics score of 1.0 to 1.5 points. Taking other advanced mathematics and trigonometry, or trigonometry and calculus, was associated with an increased ACT mathematics score of over 2.0 points. The greatest mathematics coursework score increase (3.2 points) resulted from taking other advanced mathematics, trigonometry, and calculus in addition to algebra I, geometry, and algebra II (Noble & Schnelker, 2007). Both studies (Noble et al. 1999; Noble & Schnelker, 2007) used coursework data that was self-reported by students at the time of the ACT test administration.

Mo, Yang, Hu, Calaway, and Nickey (2011) found Memphis high school students who took AP mathematics courses (calculus or statistics) to be six times more likely to pass the ACT's college readiness benchmark in mathematics (a score of at least 19) than their peers who did not take AP mathematics courses, when controlling for prior achievement as measured by Tennessee's state accountability test (Mo, Yang, Hu, Calaway, & Nickey, 2011).

College Entrance Exams as a Measure of College Readiness

Preparing students for postsecondary education is essential to improved educational attainments for students (Education Trust, 1999; Somerville & Yi, 2002). A commonly accepted definition of college readiness does not currently exist (Olson, 2006). Many researchers choose not to define college readiness, but operationalize it as academic performance (Porter & Polikoff, 2012). The College Board's standards for college readiness define the skills and knowledge students need to master to succeed in college-level language arts, mathematics, and science courses. These standards are limited to academic knowledge (The College Board, 2006). ACT, Inc. (2007) defines college readiness as preparation for credit-bearing postsecondary coursework without remediation.

With researchers operationalizing college readiness as academic preparation (or achievement), the term *college readiness* is often confused with academic preparation (Barnes, Slate, & Rojas-LeBouef, 2010). This academic definition of college readiness neglects factors that contribute toward success in college such as creativity, critical thinking, and self-regulation (Amrein-Beardsley, 2009; Conley, 2005, 2008; Ravitch

2009, 2010). College entrance exams measure only the academic preparation definition of college readiness. Conley (2008) defines college readiness as "the degree to which previous educational and personal experiences have equipped them [students] for the expectations and demands they will encounter in college" (p. 3). Similarly, Arnold, Lu, and Armstrong (2012) define college readiness as an "umbrella term that refers to the multidimensional set of skills, traits, habits, and knowledge that students need to enter college with the capacity to succeed once they are enrolled" (p. 2). The definition of college readiness is increasingly expanding beyond academic preparation.

Using SAT scores as a measure of college readiness, Moore et al. (2010) found African American and Hispanic students to have lower rates of college readiness in both reading and mathematics than whites during the 2006-2007 school year. College readiness gaps also appear between African Americans and whites, Hispanics and whites, and students from low socioeconomic and high socioeconomic backgrounds when examining coursework and grade point averages (Roderick, Nagaoka, & Coca, 2009).

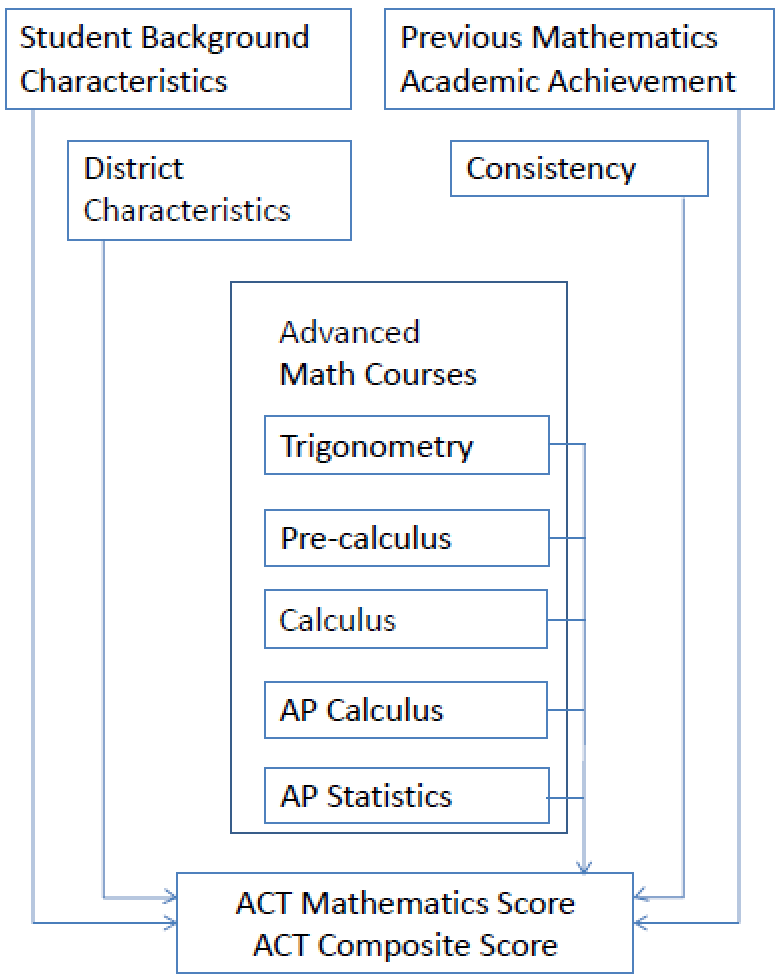
Combs, Slate, Moore, Bustamante, Onwuegbuzie, and Edmonson (2010) found males to be more likely to score at or above college-ready benchmark scores on the ACT and SAT, using state-wide data from Texas. However, females were more likely to take the ACT or SAT than males (Combs et al., 2010).

Theoretical Framework

Based on the review of literature, enrollment in advanced mathematics courses is expected to be positively associated with ACT composite and mathematics scores. Advanced mathematics courses will have more of an impact on the ACT mathematics score than on the ACT composite score, as the ACT composite score is an average of ACT English, mathematics, science, and reading scores.

As indicated in the theoretical model below (Figure 1), factors affecting ACT scores in this study can be classified into five areas: student background characteristics, previous mathematics academic achievement, advanced mathematics courses, consistency, and district characteristics.

Figure 1. Theoretical Framework



Student Background Characteristics

Several student background characteristics are expected to affect student achievement. Low socioeconomic status, English language learner status, student disability status, minority race/ethnicity, and female gender have a negative relationship with academic achievement as shown in the literature (ACT, Inc., 2012b; Bali & Alvarez, 2004; Garcia, Lawton, & De Figueiredo, 2012; Guglielmi, 2012; McGraw, Lubienski, & Strutchens, 2006; Parke & Kanyongo, 2012; Siegler et al., 2012; Wolk, 2011). It is expected that students with low socioeconomic status, English language learner status, disability status, minorities, and females will have lower ACT scores than their peers.

Previous Mathematics Achievement

The strongest predictor of academic achievement on standardized tests is previous achievement (Aubrey, Dahl, & Godfrey, 2006; Kyttälä & Björn, 2010). Therefore, a positive relationship between previous mathematics achievement and ACT scores is expected. In addition, high-achieving students take more advanced courses. Previous achievement is expected to affect student advanced mathematics course enrollment. Therefore, previous mathematics achievement must be measured separately from enrollment in advanced mathematics courses to isolate the individual effects of previous achievement and advanced mathematics courses on ACT scores.

District Characteristics

District/school characteristics also affect student achievement. Weiss, Carolan, and Baker-Smith (2010) found that small high schools have higher academic achievement than larger high schools. It is expected that students attending smaller school districts will have higher ACT scores than students attending large districts. District size is the only district characteristic controlled in this study.

Consistency

Another contextual variable impacting student achievement is consistency. Consistency will be measured as student attendance rate and student mobility in this study. A negative relationship exists between attendance and mobility and between attendance and student achievement (Lamdin, 1996; Parke & Kanyongo, 2012; Parke & Keener, 2011; Roby, 2004). It is expected that attendance rate will be positively related with ACT scores, while student mobility will be negatively related with ACT scores.

Advanced Mathematics Courses

Enrollment in advanced mathematics courses is expected to have a positive relationship with ACT scores (Noble, Davenport, Schiel, & Pommerich, 1999; Noble, Roberts, & Sawyer, 2006). The effect of enrollment in each specific mathematics course, trigonometry, pre-calculus, calculus, AP calculus, and AP statistics on ACT mathematics and composite scores may differ by mathematics course. In accordance with previous research (Noble et al., 1999; Noble & Schnelker, 2007), calculus, AP calculus, and AP statistics are expected to have more of an impact on ACT scores than are trigonometry or pre-calculus.

Summary

Mathematics achievement in the United States lags behind many other developed countries (Institute of Education Sciences, 2012; OECD, 2010). In addition, Iowa's rank as one of the highest-achieving states in the nation has slipped over the past 20 years as other states have made large gains in mathematics achievement (National Center for Education Statistics, 2011).

With the adoption of the Common Core State Standards, the state of Iowa aims to increase the number of Iowa high school graduates who are college ready (Iowa Department of Education, 2010). One way to increase college readiness may be to increase student enrollment in advanced mathematics courses. Advanced mathematics courses have been found to have a positive effect on college readiness as measured by ACT mathematics and composite scores (Noble, Davenport, Schiel, & Pommerich, 1999; Noble, Roberts, & Sawyer, 2006). The ACT measures college readiness by assessing the knowledge students need for college coursework. However, college readiness is increasingly defined as preparation for all aspects of college, both academic and non-academic (Amrein-Beardsley, 2009; Conley, 2005, 2008; Ravitch 2009, 2010).

This study explored the effect of enrollment in advanced mathematics courses (trigonometry, pre-calculus, calculus, AP calculus, and AP statistics) on ACT composite and mathematics scores. It is expected that enrollment in advanced mathematics courses will have a positive relationship with ACT scores. Student background characteristics, previous student mathematics academic achievement, district characteristics, and consistency (as measured by student attendance rate and student mobility) were also expected to affect ACT composite and mathematics scores.

CHAPTER 3

METHODOLOGY: GENERAL LINEAR MODELING TO ASSESS COLLEGE READINESS

This study examines the effect of taking advanced mathematics courses on ACT mathematics and composite scores for Iowa high school students in the context of prior achievement (previous test scores), attendance rates, socioeconomic status, gender, race/ethnicity, English language status, disability status, student mobility, and the enrollment size of the school district the student attends. These data are collected yearly for all Iowa students from all Iowa public school districts by the Iowa Department of Education (IDE).

Methodology

Data were analyzed using a general linear model (GLM). The purpose of GLM is to quantify the relationship among several independent variables and a dependent variable (StatSoft, Inc., 2013). The GLM used in this study predicts a continuous dependent variable (ACT score with a range of 1 to 36) with both continuous and categorical independent variables. GLM is a flexible version of linear regression that allows for categorical or binary independent variables. GLM differs from linear regression by allowing the linear model to be related to the outcome variable through a relationship between the linear predictor and the mean of the distribution function. GLM also allows the magnitude of the variance of each measurement to be a function of its predicted value. The equation is written as:

$$Y = b_0 + b_1X_1 + b_2X_2 + \ldots + b_nX_n + \epsilon$$

where Y is the dependent variable, X_1 through X_n are the independent variables, b_0 is the intercept, b_1 through b_n are the coefficients for the independent variables, and ϵ is the error term.

A coefficient for a given independent variable is the predicted difference in the dependent variable for a one-unit increase on the given independent variable, holding all other independent variables constant. If the dependent and independent variables have a positive relationship, the ACT score of a student increases as the value of the independent variable increases (StatSoft, Inc., 2013; Tabachnick & Fidell, 2013).

Prior to estimating the GLM, a correlation matrix was calculated using all variables in the study. Through the use of the correlation matrix, some independent variables may be excluded from the analysis. If the correlation between two variables was greater than 0.90, one of the two variables was eliminated from the analysis to reduce multicollinearity. Multicollinearity occurs when variables are so highly correlated that it is difficult to determine accurate estimates of individual regression coefficients, because the two variables are measuring the same construct.

The analysis was conducted using SPSS Statistics version 20 (IBM Corp., 2011) statistical software. SPSS is a data analysis tool used frequently by quantitative social science researchers.

Sample

The sample includes all Iowa high school students who graduated in the 2012 school year who also took the ACT at any point in their high school careers and took the

Iowa Test of Educational Development (ITED) test at ninth grade. There were 33,293 students who graduated from Iowa high schools in 2012. However, only 15,661 of those graduates took both the ACT and ITED—the sample included in this study. This does not include any students who dropped out of high school. In the 2010-2011 school year, 3.4 percent of Iowa high school students dropped out (Iowa Department of Education, 2011). Sixty-three percent of the Iowa graduating class of 2012 took the ACT (Iowa Department of Education, 2012). Most ACT test takers in Iowa elect to take the ACT; however, all students in the Des Moines and Clinton school districts take the ACT because those districts administer the test to all eleventh grade students in the school setting.

Access to the data was gained through an agreement with the IDE. The IDE collects demographic, enrollment, course (classes), and achievement data on all Iowa students in public schools, grades kindergarten through twelve.

This data was collected by the IDE from Iowa public school districts through Electronic Access to Student Information and Records (EASIER), a required student-level data collection. Data are collected through EASIER three times per year: in fall (October), winter (January), and spring (June). Student level data has been collected from Iowa school districts through EASIER since the 2004-2005 school year with the use of state student identification numbers. Through the use of unique student identification numbers, the IDE has been able to track the progress of students through the educational system over time. Information collected through EASIER includes student enrollments, attendance, demographic information (such as race/ethnicity, gender, and free or reduced-price lunch eligibility), and student course enrollment. All courses are coded according to the Secondary School Course Classification System: School Codes for the Exchange of Data (SCED) system. The SCED system allows for a standardized coding of courses that is consistent across districts and states. For more information on the SCED system, see Bradby, Pedroso, and Rogers (2007).

In order to control for district size, district enrollment numbers were taken from the October 2011 certified enrollment. These numbers are a count of students enrolled in Iowa school districts as of October 1, 2011, submitted by public school districts to the IDE for funding purposes.

ITED assessment data are shared directly from Iowa Testing Programs (ITP) to the IDE. Iowa school districts submit student demographic information to ITP on the ITED. ITP provides this information along with test scores to the IDE for the completion of the Adequate Yearly Progress (AYP) report—the yearly evaluation of schools and districts using assessment data—required by No Child Left Behind.

ACT data are also shared directly from ACT to the IDE for all Iowa public school students. ITED and ACT data are also linked with unique student identification numbers.

Variables

The dependent variables of interest are ACT mathematics score (range of 1 to 36) and ACT composite score (range of 1 to 36). The ACT mathematics test covers six content areas: pre-algebra, elementary algebra, intermediate algebra, coordinate geometry, plane geometry, and trigonometry. The ACT composite score is the average of a student's score on the four tests of the ACT: English, mathematics, reading, and science. Independent variables include:

- Gender. Gender was taken from spring 2012 EASIER, the latest student data collection point.
- Race/ethnicity. Race/ethnicity was taken from spring 2012 EASIER, the latest student data collection point. Students in Iowa are identified according to seven race/ethnicity categories: African American, Asian American, Hispanic/Latino, Native American, Multi-racial, Hawaiian/Pacific Islander, and white. The data set included only 29 Native American students and 15 Hawaiian/Pacific Islander students. These counts are not large enough to draw statistically significant conclusions. Therefore, the Native American and Hawaiian/Pacific Islander students are excluded from the analysis.
- Low socioeconomic status (determined by free or reduced-price lunch eligibility). Free or reduced-price lunch eligibility was taken from spring 2012 EASIER, the latest student data collection point.
- English language learner (ELL). ELL status is determined by a student's score on the state of Iowa's English language proficiency assessment. ELL status was taken from spring 2012 EASIER, the latest student data collection point.
- Student disability status (determined by presence of an Individual Education Plan [IEP]). IEP status was taken from spring 2012 EASIER, the latest student data collection point.
- Ninth grade ITED score in mathematics (2008-2009 school year). School districts in Iowa retain local control of when they administer the ITED assessment. Based on when students were tested during the year, their test

scores may be standardized to fall, midyear, or spring norms. These three norm groups are not directly comparable with one another; therefore, all national standard scores were converted to z-scores with mean of zero and standard deviation of one for direct comparison among all norm groups.

- District enrollment size. District enrollment size was taken from the fall 2011 certified enrollment file, the official student count file for the senior year of students in the study. District size was divided into six categories of enrollment size used by the Iowa Department of Education (fewer than 300; 300 to 599; 600 to 999; 1,000 to 2,499; 2,500 to 7,499; and 7,500 or more).
- Attendance rate during tenth and eleventh grade year (2009-2010 and 2010-2011). The attendance rate for each student is calculated by dividing the student's total days present during the school year by his or her total days enrolled during the school year.
- Mobility. Students are considered mobile if they change district of attendance between their ninth and twelfth grade years.
- Algebra II enrollment. Algebra II enrollment is included in the model, as it is considered a gatekeeper course for advanced mathematics courses. Enrollment is determined by the use of SCED codes and was taken from winter 2008-2009, winter 2009-2010, winter 2010-2011, or winter 2011-2012 EASIER.
- Trigonometry enrollment. Enrollment is determined by the use of SCED codes and was taken from winter 2008-2009, winter 2009-2010, winter 2010-2011, or winter 2011-2012 EASIER.

- Pre-calculus enrollment. Enrollment is determined by the use of SCED codes and was taken from winter 2008-2009, winter 2009-2010, winter 2010-2011, or winter 2011-2012 EASIER.
- Calculus enrollment. Enrollment is determined by the use of SCED codes and was taken from winter 2008-2009, winter 2009-2010, winter 2010-2011, or winter 2011-2012 EASIER.
- AP calculus enrollment. Enrollment is determined by the use of SCED codes and was taken from winter 2008-2009, winter 2009-2010, winter 2010-2011, or winter 2011-2012 EASIER.
- AP statistics enrollment. Enrollment is determined by the use of SCED codes and was taken from winter 2008-2009, winter 2009-2010, winter 2010-2011, or winter 2011-2012 EASIER.

Further descriptions of variables are located in Table 1.

Ethical Considerations

De-identified data were provided by the IDE. Names and birthdates were not included in the dataset. The dataset includes school district size category, gender, race/ethnicity, disability status (presence of IEP), and socioeconomic status (eligible for free or reduced-price lunch). The dataset was stored on an encrypted flash drive and was not copied onto any computer.

Table 1. Variable Descriptions

Variable name	Frequency or mean (range)	Description
Dependent variables		
ACT mathematics score	21.76 (11 to 36)	Score on the mathematics section of the ACT test.
ACT composite score	22.19 (8 to 36)	Composite score of the ACT test.
Independent variables		
Gender		Gender of the student.
Female	53.78%	
Male	46.22%	
Race/ethnicity		Race/ethnicity of the student.
Asian American	1.87%	
African American	2.20%	
Hispanic/Latino	4.07%	
Multi-racial	1.51%	
White	90.35%	
Low socioeconomic status	16.51%	Student is eligible for free or reduced-priced school meals.
English language learner	0.42%	Student is eligible for English language learner services.
Student with disability	1.46%	Student has an Individual Education Plan (IEP) on file.
Ninth grade mathematics test z-score	0.3558 (-3.5823 to 2.38687)	Ninth grade ITED score in mathematics as converted to a z-score with a mean of zero.

Table 1 continued. Variable Descriptions

Variable name	Frequency or mean (range)	Description
District size		Number of students enrolled at the district which the student attends.
<300	1.57%	
300-599	12.62%	
600-999	16.40%	
1,000-2,499	26.74%	
2,500-7,499	19.02%	
7,500+	23.66%	
Attendance rate	95.77 (46.77 to 100.00)	Aggregate student attendance rate during tenth and eleventh grade.
Mobility	3.73%	Student changed attending districts between their ninth and twelfth grade years.
Algebra II	87.85%	Student enrolled in an algebra II course in high school.
Trigonometry	25.02%	Student enrolled in a trigonometry course in high school.
Pre-calculus	39.70%	Student enrolled in a pre-calculus course in high school.
Calculus	12.50%	Student enrolled in a calculus course in high school.
AP calculus	8.71%	Student enrolled in an AP calculus course in high school.
AP statistics	3.61%	Student enrolled in an AP statistics course in high school.

Limitations

This study has several limitations. Only students attending public school districts in Iowa are included. Students attending private schools or participating in home schooling are not included. In addition, the graduating class of 2012 is the only cohort of students included in the study. Also, the ACT is the only college entrance exam included. Students may elect to take a college entrance exam other than the ACT (such as the SAT); however, only three percent of the class of 2012 took the SAT (The College Board, 2012).

A number of factors that may influence ACT scores are not accounted for, including motivation, extra-curricular activities, student engagement, teacher quality, course quality, and school climate. Although important, these factors are beyond the scope of this study, which focuses on the relationship between advanced mathematics course enrollment and college readiness.

Summary

Through a general linear model (GLM), the relationship between enrollment in advanced mathematics courses (trigonometry, pre-calculus, calculus, AP calculus, and AP statistics) and ACT scores was quantified while controlling for other student variables. Data from the Iowa graduating class of 2012 who took the ACT were used in estimating the model. The dependent variables of interest were ACT mathematics score and ACT composite score, while independent variables included trigonometry enrollment, pre-calculus enrollment, calculus enrollment, AP calculus enrollment, AP statistics enrollment, ninth grade ITED score in mathematics, attendance rate, gender, race/ethnicity, socioeconomic status, English language learner status, student disability status, district size, and mobility.

CHAPTER 4

RESULTS AND FINDINGS

Data for the 15,661 Iowa high school graduates who took both the ACT during high school and ITED in their ninth grade year were analyzed for descriptive purposes by groups of students who enrolled in each advanced mathematics course. Next, a general linear model (GLM) was utilized to predict ACT mathematics score and ACT composite score (individually) using prior achievement (previous test scores), socioeconomic status, gender, race/ethnicity, English language status, disability status, the enrollment size of the school district which the student attends, student attendance rates, and student mobility as independent variables.

Descriptive Analysis

The descriptive analysis involved data for students who graduated from high school in Iowa in 2012, took the ACT during high school, and took the ITED during their ninth grade year. The study used 15 variables to predict ACT mathematics and ACT composite scores.

Table 2 describes the similarities and differences between students who enrolled in each advanced mathematics course and students who did not enroll in at least algebra II. Those who enrolled in algebra II and those who did not enroll in algebra II constitute mutually exclusive groups. However, the algebra II, trigonometry, pre-calculus, calculus, AP calculus, and AP statistics groups are not mutually exclusive.

Table 2. Description of Students by Enrollment in Advanced Mathematics Courses

	Did not enroll in algebra II (*n*=1,903)	Algebra II (*n*=13,758)	Trigono-metry (*n*=3,918)	Pre-calculus (*n*=6,217)	Calculus (*n*=1,958)	AP calculus (*n*=1,364)	AP statistics (*n*=566)
ACT mathematics score	17.31	22.38	24.29	24.52	26.37	28.22	25.81
ACT composite score	18.02	22.77	24.34	24.46	25.91	27.51	25.77
Gender							
Female	53.97%	53.75%	51.38%	50.67%	45.35%	43.55%	49.12%
Male	46.03%	46.25%	48.62%	49.33%	54.65%	56.45%	50.88%
Race/ethnicity							
Asian American	1.79%	1.88%	1.86%	2.90%	2.86%	4.47%	3.53%
African American	6.73%	1.58%	0.82%	1.30%	0.51%	0.73%	1.77%
Hispanic/Latino	9.46%	3.32%	2.37%	2.93%	3.37%	2.71%	2.83%
Multi-racial	3.31%	1.26%	1.30%	1.35%	1.28%	1.17%	1.59%
White	78.72%	91.96%	93.65%	91.52%	91.98%	90.91%	90.28%
Low socioeconomic status	36.00%	13.81%	9.14%	11.18%	10.52%	7.77%	7.60%
English language learner	1.47%	0.28%	0.18%	0.13%	0.36%	0.00%	0.35%
Student with disability	7.67%	0.60%	0.20%	0.31%	0.15%	0.07%	0.18%
Ninth grade mathematics test z-score	-0.3977	0.4601	0.7369	0.7574	1.0255	1.1691	0.8832
District size							
<300	1.58%	1.57%	1.91%	1.35%	1.53%	0.00%	0.00%
300-599	12.35%	12.65%	10.13%	10.76%	11.54%	6.20%	0.88%
600-999	12.93%	16.88%	17.05%	12.40%	19.05%	7.70%	1.41%
1,000-2,499	22.07%	27.38%	29.38%	24.40%	32.18%	25.95%	22.79%
2,500-7,499	10.56%	20.19%	22.15%	23.37%	13.38%	29.03%	26.50%
7,500+	40.52%	21.33%	19.37%	27.71%	22.32%	31.09%	48.41%
Attendance rate	94.02%	96.01%	96.38%	96.43%	96.93%	96.75%	96.19%
Mobility	5.26%	3.52%	2.86%	2.65%	2.50%	1.25%	2.47%

Table 2 continued. Description of Students by Advanced Mathematics Course Enrollment

	Did not enroll in algebra II (*n*=1,903)	Algebra II (*n*=13,758)	Trigono-metry (*n*=3,918)	Pre-calculus (*n*=6,217)	Calculus (*n*=1,958)	AP calculus (*n*=1,364)	AP statistics (*n*=566)
Algebra II	0.00%	-	100.00%	100.00%	100.00%	100.00%	100.00%
Trigonometry	0.00%	28.48%	-	24.11%	45.71%	31.23%	29.33%
Pre-calculus	0.00%	45.19%	38.26%	-	66.04%	77.71%	58.67%
Calculus	0.00%	14.23%	22.84%	20.80%	-	13.27%	11.31%
AP calculus	0.00%	9.91%	10.87%	17.05%	9.24%	-	24.03%
AP statistics	0.00%	4.11%	4.24%	5.34%	3.27%	9.97%	-

Students who enrolled in AP calculus had the highest ACT mathematics score, with an average score of 28.22.They are followed by students who enrolled in calculus (26.37), then AP statistics (25.81), pre- calculus (24.52), trigonometry (24.29), and algebra II (22.38). Students who did not enroll in algebra II had the lowest average ACT mathematics score (17.31). Students who enrolled in AP calculus also earned the highest ACT composite score of all the groups, with an average score of 27.51. They are followed by students who enrolled in calculus (25.91), then AP statistics (25.77), pre-calculus (24.46), trigonometry (24.34), and algebra II (22.77). Students who did not enroll in algebra II had the lowest average ACT composite score (18.02).

The majority of students who did not enroll in algebra II, and of those who enrolled in algebra II, trigonometry, and pre-calculus were female (53.97 percent, 53.75 percent, 51.38 percent, and 50.67 percent, respectively), while the majority of students who enrolled in calculus, AP calculus, and AP statistics were male (54.65 percent, 56.45 percent, and 50.88 percent, respectively). Students who did not enroll in algebra II had the most racial/ethnic diversity, with 1.79 percent Asian American, 6.73 percent African American, 9.46 percent Hispanic/Latino, 3.31 percent multi-racial, and 78.72 percent white. Among students who enrolled in algebra II, 1.88 percent were Asian American, 1.58 percent were African American, 3.32 percent were Hispanic/Latino, 1.26 percent were multi-racial, and 91.96 percent were white. Students who enrolled in trigonometry had the least racial/ethnic diversity, with 1.86 percent Asian American, 0.82 percent African American, 2.37 percent Hispanic/Latino, 1.30 percent multi-racial, and 93.65 percent white. Among students who enrolled in pre-calculus, 2.90 percent were Asian American, 1.30 percent were African American, 2.93 percent were Hispanic/Latino, 1.35

percent were multi-racial, and 91.52 percent were white. Among students who enrolled in calculus, 2.86 percent were Asian American, 0.51 percent were African American, 3.37 percent were Hispanic/Latino, 1.28 percent were multi-racial, and 91.98 percent were white. Among students who enrolled in AP calculus, 4.47 percent were Asian American, 0.73 percent were African American, 2.71 percent were Hispanic/Latino, 1.17 percent were multi-racial, and 90.91 percent were white. Among students who enrolled in AP statistics, 3.53 percent were Asian American, 1.77 percent were African American, 2.83 percent were Hispanic/Latino, 1.59 percent were multi-racial, and 90.28 percent were white.

Students who did not enroll in algebra II had the highest percent of low socioeconomic status (36.00 percent). They are followed by students who enrolled in algebra II (13.81 percent), pre-calculus (11.18 percent), calculus (10.52 percent), trigonometry (9.14 percent), AP calculus (7.77 percent), and AP statistics (7.60 percent). Students who did not enroll in algebra II had the highest percentage of English language learners (1.47 percent). They are followed by students who enrolled in calculus (0.36 percent), AP statistics (0.35 percent), algebra II (0.28 percent), trigonometry (0.18 percent), and pre-calculus (0.13 percent). None of the students who enrolled in AP calculus were English language learners. Students who did not enroll in algebra II had the highest percent of disabilities (7.67 percent). They are followed by students who enrolled in algebra II (0.60 percent), pre-calculus (0.31 percent), trigonometry (0.20 percent), AP statistics (0.18 percent), calculus (0.15 percent), and AP calculus (0.07 percent).

Ninth grade mathematics ITED score was measured as a z-score with a mean of zero and standard deviation of one. Students who enrolled in AP calculus earned the highest ninth grade mathematics test score of all the groups, with an average z-score of 1.1691. They are followed by students who enrolled in calculus (1.0255), then AP statistics (0.8832), pre-calculus (0.7574), trigonometry (0.7369), and algebra II (0.4601). Students who did not enroll in algebra II had the lowest average ninth grade mathematics test z-score (-0.3977).

Among the students who did not enroll in algebra II, 1.58 percent attended districts with an enrollment of fewer than 300 students, 12.35 percent attended districts with enrollments between 300 to 599 students, 12.93 percent attended districts with enrollments of 600 to 999 students, 22.07 percent attended districts with enrollments of 1,000 to 2,499 students, 10.56 percent attended districts with enrollments of 2,500 to 7,499 students, and 40.52 percent attended districts with enrollments of 7,500 or more students. Among the students who enrolled in algebra II, 1.57 percent attended districts with an enrollment of fewer than 300 students, 12.65 percent attended districts with enrollments between 300 to 599 students, 16.88 percent attended districts with enrollments of 600 to 999 students, 27.38 percent attended districts with enrollments of 1,000 to 2,499 students, 20.19 percent attended districts with enrollments of 2,500 to 7,499 students, and 21.33 percent attended districts with enrollments of 7,500 or more students. Of the students who enrolled in trigonometry, 1.91 percent attended districts with an enrollment of fewer than 300 students, 10.13 percent attended districts with enrollments between 300 and 599 students, 17.05 percent attended districts with enrollments of 600 to 999 students, 29.38 percent attended districts with enrollments of

1,000 to 2,499 students, 22.15 percent attended districts with enrollments of 2,500 to 7,499 students, and 19.37 percent attended districts with enrollments of 7,500 or more students. Of the student who enrolled in pre-calculus, 1.35 percent attended districts with an enrollment of fewer than 300 students, 10.76 percent attended districts with enrollments between 300 to 599 students, 12.40 percent attended districts with enrollments of 600 to 999 students, 24.40 percent attended districts with enrollments of 1,000 to 2,499 students, 23.37 percent attended districts with enrollments of 2,500 to 7,499 students, and 27.71 percent attended districts with enrollments of 7,500 or more students.

Of the students who enrolled in calculus, 1.53 percent attended districts with an enrollment of fewer than 300 students, 11.54 percent attended districts with enrollments between 300 and 599 students, 19.05 percent attended districts with enrollments of 600 to 999 students, 32.18 percent attended districts with enrollments of 1,000 to 2,499 students, 13.38 percent attended districts with enrollments of 2,500 to 7,499 students, and 22.32 percent attended districts with enrollments of 7,500 or more students. Of the students who enrolled in AP calculus, none attended districts with an enrollment of fewer than 300 students, 6.20 percent attended districts with enrollments between 300 and 599 students, 7.70 percent attended districts with enrollments of 600 to 999 students, 25.95 percent attended districts with enrollments of 1,000 to 2,499 students, 29.03 percent attended districts with enrollments of 2,500 to 7,499 students, and 31.09 percent attended districts with enrollments of 7,500 or more students. Of the students who enrolled in AP statistics, none attended districts with an enrollment of fewer than 300 students, 0.88 percent attended districts with enrollments between 300 and 599 students, 1.41 percent attended districts with enrollments of 600 to 999 students, 22.79 percent attended districts with enrollments of 1,000 to 2,499 students, 26.50 percent attended districts with enrollments of 2,500 to 7,499 students, and 48.41 percent attended districts with enrollments of 7,500 or more students.

Students who enrolled in calculus had the highest attendance rate, at 96.93 percent. They are followed by students who enrolled in AP calculus (96.75 percent), pre-calculus (96.43 percent), trigonometry (96.38 percent), AP statistics (96.19 percent), and algebra II (96.01 percent). Students who did not enroll in algebra II had the lowest attendance rate, at 94.02 percent. In addition to the lowest attendance rate, students who did not enroll in algebra II also had the highest percent of mobile students (5.26 percent). They are followed by students who enrolled in algebra II (3.52 percent), trigonometry (2.86 percent), pre-calculus (2.65 percent), calculus (2.50 percent), and AP statistics (2.47 percent). Students who enrolled in AP calculus had the lowest percent of mobile students (1.25 percent).

All students who enrolled in trigonometry, pre-calculus, calculus, AP calculus, or AP statistics also enrolled in algebra II. Of the students who enrolled in algebra II, 28.48 percent also enrolled in trigonometry, 45.19 percent enrolled in pre-calculus, 14.23 percent enrolled in calculus, 9.91 percent enrolled in AP calculus, and 4.11 percent enrolled in AP statistics. Among the students who enrolled in trigonometry, 38.26 percent also enrolled in pre-calculus, 22.84 percent enrolled in calculus, 10.87 percent enrolled in AP calculus, and 4.24 percent enrolled in AP statistics. Among the students who enrolled in pre-calculus, 24.11 percent enrolled in trigonometry, 20.80 percent enrolled in calculus, 17.05 percent enrolled in AP calculus, and 5.34 percent enrolled in

AP statistics. Among the students who enrolled in calculus, 45.71 percent also enrolled in trigonometry, 66.04 percent enrolled in pre-calculus, 9.24 percent enrolled in AP calculus, and 3.27 percent enrolled in AP statistics. Among the students who enrolled in AP calculus, 31.23 percent enrolled in trigonometry, 77.71 percent enrolled in pre-calculus, 13.27 percent enrolled in calculus, and 9.97 percent enrolled in AP statistics. Among the students who enrolled in AP statistics, 29.33 percent also enrolled in trigonometry, 58.67 percent enrolled in pre-calculus, 11.31 percent enrolled in calculus, and 24.03 percent enrolled in AP calculus.

General Linear Model Analysis

Data were analyzed using a general linear model (GLM). The GLM used in this study predicted a continuous dependent variable (ACT mathematics score and ACT composite score, with a range of 1 to 36) with 15 continuous and categorical independent variables. A coefficient for a given independent variable is the predicted difference in the dependent variable for a one-unit increase on the given independent variable, holding all other independent variables constant. If the dependent and independent variables have a positive relationship, the ACT score of a student increases as the value of the independent variable increases (StatSoft, Inc., 2013; Tabachnick & Fidell, 2013).

Before the GLM models were estimated, a correlation matrix was estimated using all variables in the study. No variables had a bivariate correlation greater than 0.90 (see Appendix A). Therefore, no variables were eliminated from the analysis to reduce multicollinearity. Interaction between variables was also checked for in both models. If the interaction coefficient for two variables was statistically significant, the interaction was included in the model.

ACT Mathematics Score Prediction Model

Table 3 displays the coefficients for all independent variables in the ACT mathematics score prediction model. On average, being female was associated with a 0.2225 lower ACT mathematics score compared to males. Asian American was related with a 1.0732 point higher ACT mathematic score on average compared to white students. The estimated relationships between all other race/ethnicities and ACT mathematics score compared to white were not statistically significant. Low socioeconomic status was associated with a 0.1141 point lower ACT mathematics score on average (compared to students who were not of low socioeconomic status). The relationships between English language learner and ACT mathematics score and between students with disability and ACT mathematics score were not statistically significant. Ninth grade mathematics test z-score was positively related with ACT mathematics score. For each increase of one standard deviation in ninth grade mathematics score, the ACT mathematics score increased 2.8459 points on average. Attending a small school district (compared to a district with 7,500 or more students) was associated with 0.5596 and 0.1768 point lower ACT mathematics score on average for students attending districts with an enrollment of fewer than 300, and 300 to 599 students, respectively. A one percent increase in attendance rate was associated with a mean increase of 0.0303 in ACT mathematics score. One day of school is 0.556 percent of attendance (1 ÷ 180). Therefore, for the average high school in Iowa that has 180 days in a school year, this

Table 3. GLM Partial Regression Coefficients for Independent Variables Estimating ACT Mathematics Score

	Coefficient	Standard error
Intercept	20.1823*	(0.6879)
Gender (male is baseline)		
Female	-0.2225*	(0.0440)
Race/ethnicity (white is baseline)		
Asian American	1.0732*	(0.3085)
African American	-0.3732	(0.5137)
Hispanic/Latino	-0.4215	(0.2752)
Multi-racial	-0.6651	(0.3611)
Low socioeconomic status	-0.1141*	(0.0459)
English language learner	-0.0517	(0.1725)
Student with disability	-0.0653	(0.0933)
Ninth grade mathematics test z-score	2.8459*	(0.0322)
District size (7,500+ is baseline)		
<300	-0.5596*	(0.1851)
300-599	-0.1768*	(0.0802)
600-999	-0.0159	(0.0756)
1,000-2,499	0.0841	(0.0680)
2,500-7,499	0.2462*	(0.0767)
Attendance rate	0.0303*	(0.0066)
Mobility	0.0410	(0.0577)
Algebra II	0.1532	(0.0799)
Trigonometry	0.6754*	(0.0269)
Pre-Calculus	0.7920*	(0.0259)
Calculus	0.5917*	(0.1214)
AP calculus	1.6568*	(0.1318)
AP statistics	0.6836*	(0.0593)
Low socioeconomic status × district size (7,500+ is baseline)		
Low SES × <300	0.2868	(0.1849)
Low SES × 300-599	0.0454	(0.0799)
Low SES × 600-999	-0.0179	(0.0754)
Low SES × 1,000-2,499	0.1079	(0.0678)
Low SES × 2,500-7,499	-0.0953	(0.0764)
Algebra II × race/ethnicity (white is baseline)		
Algebra II × Asian American	-0.5266*	(0.2119)
Algebra II × African American	-0.2034	(0.1418)
Algebra II × Hispanic	-0.0059	(0.1223)
Algebra II × multi-racial	0.4879*	(0.1763)

*$p<.05$

Table 3 continued. GLM Partial Regression Coefficients for Independent Variables Estimating ACT Mathematics Score

	Coefficient	Standard error
Calculus × race/ethnicity (white is baseline)		
Calculus × Asian American	-0.0105	(0.1991)
Calculus × African American	-0.4533	(0.3606)
Calculus × Hispanic	0.0186	(0.1854)
Calculus × multi-racial	-0.0427	(0.2684)
AP calculus × race/ethnicity (white is baseline)		
AP calculus × Asian American	0.6702*	(0.2019)
AP calculus × African American	0.0532	(0.3643)
AP calculus × Hispanic	-0.1914	(0.2237)
AP calculus × multi-racial	-0.5264	(0.3191)
Algebra II × gender (male is baseline)		
Algebra II × female	-0.0980*	(0.0337)
Calculus × gender (male is baseline)		
Calculus × female	-0.1271*	(0.0332)
Pre-calculus × attendance rate	-0.0132*	(0.0065)

*p<.05

equates to a 0.0168 point increase in ACT mathematics score per day in attendance (0.0303 × 0.556). Moving from one district to another between ninth and twelfth grades did not have a statistically significant relationship with ACT mathematics score.

Enrolling in algebra II did not have a statistically significant relationship with ACT mathematics score. However, all advanced mathematics courses did have a significant relationship with ACT mathematics score. Enrolling in trigonometry was associated with a 0.6754 increase on average in ACT mathematics score. Enrolling in pre-calculus was associated with a 0.7920 increase on average in ACT mathematics score. Enrolling in calculus was associated with a 0.5917 increase on average in ACT mathematics score. Enrolling in AP calculus was associated with the largest increase in ACT mathematics score for all advanced mathematics courses, with an increase of 1.6568 points on average. Enrolling in AP statistics was associated with a 0.6836 increase on average in ACT mathematics score.

The interaction between low socioeconomic status and district size was statistically significant. However, none of the groups were statistically significantly different from the group of low socioeconomic status and attendance in a district with 7,500 or more students. The interaction between calculus and race/ethnicity was also statistically significant. However, none of the groups were statistically significantly different from the group of white students who were enrolled in calculus.

Among students who enrolled in algebra II, Asian American was associated with a 0.5266 point lower mean increase in ACT mathematics score compared to white students, and multi-racial was associated with an additional 0.4879 point mean increase in ACT mathematics score. Females who enrolled in algebra II saw a 0.0980 point smaller increase in ACT mathematics score compared to males who enrolled in algebra II. Among students who enrolled in AP calculus, Asian American was associated with an additional 0.6702 point mean increase in ACT mathematics score. Females who enrolled in calculus saw a 0.1271 point lower mean increase in ACT mathematics score compared to males who enrolled in Algebra II. Enrolling in pre-calculus was associated with a 0.0132 point lower mean increase in ACT mathematics score per one percent increase in attendance rate compared to not enrolling in pre-calculus.

GLM summary results (Table 4) indicated that the overall model did significantly predict ACT mathematics score outcomes. The adjusted R^2 value for the model was 0.6782.

Table 4. GLM Model Summary: ACT Mathematics Score Prediction Model

R^2	R^2 adjusted	F ratio	Significance of F ratio
0.6790	0.6782	786.7015	$p<.0001$

Hypotheses One Through Five

The GLM model predicting ACT mathematics score was used to test hypotheses one through five. All hypotheses were tested at the 0.05 level of significance.

Hypothesis One

Enrolling in trigonometry was associated with a 0.6754 point mean increase in ACT mathematics scores (p <.0001). Therefore, hypothesis 1, H_O**:** There is no relationship between enrollment in trigonometry in high school and ACT mathematics score is rejected.

Hypothesis Two

Enrolling in pre-calculus was associated with a 0.7920 point mean increase in ACT mathematics scores (p <.0001). Therefore, hypothesis 2, H_O: There is no relationship between enrollment in pre-calculus in high school and ACT mathematics score, is rejected.

Hypothesis Three

Enrolling in calculus was associated with a 0.5917 point mean increase in ACT mathematics score (p <.0001). Therefore, hypothesis 3, H_O: There is no relationship between enrollment in calculus in high school and ACT mathematics score, is rejected.

Hypothesis Four

Enrolling in AP calculus was associated with a 1.6568 point mean increase in ACT mathematics score (p <.0001). Therefore, hypothesis 4, H_O: There is no relationship between enrollment in AP calculus in high school and ACT mathematics score, is rejected.

Hypothesis Five

Enrolling in AP statistics was associated with a 0.6836 point mean increase in ACT mathematics score (p <.0001). Therefore, hypothesis 5, H_O: There is no relationship between enrollment in AP statistics in high school and ACT mathematics score, is rejected.

ACT Composite Score Prediction Model

A second GLM model was estimated using ACT composite score as the predicted outcome. Table 5 displays the coefficients for all independent variables in the ACT composite score prediction model.

On average, being female was associated with a 0.1566 higher ACT composite score compared to males. The estimated relationships among all race/ethnicities and ACT composite score compared to white were not statistically significant. Low socioeconomic status was associated with a 0.2099 point lower ACT composite score on average (compared to students who were not of low socioeconomic status). Being an English language learner was associated with a 0.8410 point decrease on average in ACT composite score. Being a student with disability was associated with a 0.7643 point decrease on average in ACT composite score.

Ninth grade mathematics test z-score was positively related with ACT composite score. For each increase of one standard deviation in ninth grade mathematics score, the ACT composite score increased 2.9425 points on average.

Attending a small school district (compared to a district with 7,500 or more students) was associated with a 0.2281 and 0.1641 point lower ACT composite score on

Table 5. GLM Partial Regression Coefficients for Independent Variables Estimating ACT Composite Score

	Coefficient	Standard error
Intercept	19.3944*	(0.6312)
Gender (male is baseline)		
Female	0.1566*	(0.0345)
Race/ethnicity (white is baseline)		
Asian American	0.1495	(0.2041)
African American	-0.6665	(0.3720)
Hispanic/Latino	-0.3155	(0.1883)
Multi-racial	0.2323	(0.2617)
Low socioeconomic status	-0.2099*	(0.0478)
English language learner	-0.8410*	(0.1788)
Student with disability	-0.7643*	(0.0969)
Ninth grade mathematics test z-score	2.9425*	(0.0335)
District Size (7,500+ is baseline)		
<300	-0.2139	(0.1929)
300-599	-0.2281*	(0.0835)
600-999	-0.1641*	(0.0788)
1,000-2,499	0.0650	(0.0708)
2,500-7,499	0.2672*	(0.0799)
Attendance rate	0.0143*	(0.0061)
Mobility	-0.0346	(0.0601)
Algebra II	0.3786*	(0.0394)
Trigonometry	0.4414*	(0.0280)
Pre-calculus	0.4600*	(0.0269)
Calculus	0.1770	(0.1232)
AP calculus	1.1821*	(0.0430)
AP statistics	0.5486*	(0.0618)
Low socioeconomic status × district size (7,500+ is baseline)		
Low SES ×<300	0.2757	(0.1927)
Low SES × 300-599	0.0904	(0.0832)
Low SES × 600-999	0.0525	(0.0785)
Low SES × 1,000-2,499	0.1559*	(0.0707)
Low SES × 2,500-7,499	-0.1777*	(0.0796)
Calculus × race/ethnicity (white is baseline)		
Calculus × Asian American	-0.0375	(0.2032)
Calculus × African American	-0.4962	(0.3714)
Calculus × Hispanic	0.0821	(0.1874)
Calculus × multi-racial	-0.1054	(0.2616)
Calculus × gender (male is baseline)		
Calculus × female	-0.0707*	(0.0343)

*p<.05

average for students attending districts with an enrollment of 300 to 599 and 600 to 999 students, respectively. Attending a medium-size school district (compared to a district with 7,500 or more students) was associated with a 0.2672 higher ACT composite score on average for students attending districts with an enrollment of 2,500 to 7,499 students. A one percent increase in attendance rate was associated with a mean increase of 0.0143 in ACT composite score. One day of school is 0.556 percent of attendance (1 ÷ 180). For the average high school in Iowa that has 180 days in a school year, this equates to a 0.0079 point increase in ACT composite score per day in attendance (0.0143 × 0.556). Moving from one district to another between ninth and twelfth grades did not have a statistically significant relationship with ACT composite score.

Enrolling in algebra II was associated with a 0.3786 increase in ACT composite score on average. All advanced mathematics courses had a significant relationship with ACT composite score, except for calculus. Enrolling in trigonometry was associated with a 0.4414 increase on average in ACT composite score. Enrolling in AP calculus was associated with the largest increase in ACT composite score for all advanced mathematics courses, with an increase of 1.1821 points on average. Enrolling in AP statistics was associated with a 0.5486 increase on average in ACT composite score.

The interaction between low socioeconomic status and district size was statistically significant. Being of low socioeconomic status and attending a district with 1,000 to 2,499 students was associated with a 0.1559 point higher mean increase in ACT composite score compared to not being of low socioeconomic status and attending a district with 7,500 or more students. Being of low socioeconomic status and attending a district with 2,500 to 7,499 students was associated with a 0.1777 point lower mean increase in ACT composite score compared to not being of low socioeconomic status and attending a district with 7,500 or more students.

The interaction between calculus and race/ethnicity was also statistically significant. However, none of the groups were statistically significantly different from not being enrolled in calculus and white. The interaction between enrolling in calculus and gender was also statistically significant. Being female and enrolling in calculus was associated with a 0.0707 lower increase in ACT composite score compared to males enrolled in calculus.

GLM summary results (Table 6) indicated that the overall model did significantly predict ACT composite score outcomes. The adjusted R^2 value for the model was 0.6103.

Table 6. GLM Model Summary: ACT Composite Score Prediction Model

R^2	R^2adjusted	F ratio	Significance of F ratio
0.6111	0.6103	767.4608	$p < .0001$

Hypotheses Six Through Ten

The GLM model predicting ACT composite score was used to test hypotheses six through ten. All hypotheses were tested at the 0.05 level of significance.

Hypothesis Six

Enrolling in trigonometry was associated with a 0.4414 point mean increase in ACT composite scores ($p < .0001$). Therefore, hypothesis 6, H_O**:** There is no relationship between enrollment in trigonometry in high school and ACT composite score, is rejected.

Hypothesis Seven

Enrolling in pre-calculus was associated with a 0.4600 point mean increase in ACT composite scores ($p<.0001$). Therefore, hypothesis 7, H_O: There is no relationship between enrollment in pre-calculus in high school and ACT composite score, is rejected.

Hypothesis Eight

Enrolling in calculus was not significantly associated with ACT composite score at the 0.05 level of significance. Therefore, hypothesis 8, H_O: There is no relationship between enrollment in calculus in high school and ACT composite score, is not rejected.

Hypothesis Nine

Enrolling in AP calculus was associated with a 1.1821 point mean increase in ACT composite score ($p < .0001$). Therefore, hypothesis 9, H_O: There is no relationship between enrollment in AP calculus in high school and ACT composite score, is rejected.

Hypothesis Ten

Enrolling in AP statistics was associated with a 0.5486 point mean increase in ACT composite score ($p < .0001$). Therefore, hypothesis 10, H_O: There is no relationship between enrollment in AP statistics in high school and ACT composite score, is rejected.

Summary

ACT Mathematics Score

All advanced mathematics courses included in the analysis had a positive relationship with ACT mathematics score. AP calculus had the largest impact on ACT mathematics score of all advanced mathematics courses, with enrollment in the course associated with a 1.6568 point increase in ACT mathematics score. Enrollment in trigonometry, pre-calculus, calculus, and AP statistics were each associated with an increase in ACT mathematics score of less than one point. Ninth grade mathematics test score was the most significant predictor of ACT mathematics score. Being a female (male is baseline), low socioeconomic status, attending a district with fewer than 600 students enrolled (7,500 and more is baseline) were negatively associated with ACT mathematics score. Being Asian American (white is baseline), attending a district with 2,500 to 7,499 students enrolled (7,500 and more is baseline), and attendance rate were positively associated with ACT mathematics score. All race groups except Asian American did not have a statistically significant relationship with ACT mathematics score (white is baseline). Enrolling in algebra II, English language learner, student with disability, attending a district with 600 to 2,499 students enrolled (7,500 and more is baseline), and student mobility also did not have statistically significant relationship with ACT mathematics score.

Several variables interacted in the model. Asian American students had less of a positive impact from algebra II enrollment than white students (baseline), and multi-racial students had more of a positive impact from algebra II enrollment than white students. However, Asian American students had more of a positive impact from AP calculus enrollment than white students. Female students had less of a positive impact from enrollment in both algebra II and calculus than male students.

ACT Composite Score

Trigonometry, pre-calculus, AP calculus, and AP statistics each had a positive relationship with ACT composite scores. Calculus did not hold a statistically significant relationship with ACT composite score. AP calculus had the largest impact on ACT composite score of all advanced mathematics courses, with enrollment in the course associated with a 1.1821 point increase in ACT composite score. Enrollment in trigonometry, pre-calculus, and AP statistics were each associated with an increase in ACT composite score of less than one point. Ninth grade mathematics test score was also the most significant predictor of ACT composite score. Enrollment in algebra II, being a female (male is baseline), attending a district with 2,500 to 7,499 students enrolled (7,500 and more is baseline), and attendance rate were positively associated with ACT composite score. Low socioeconomic status, English language learner, students with disabilities, and attending a district with 300 to 999 students enrolled (7,500 and more is baseline) were negatively associated with ACT composite score. Low socioeconomic status had less of a negative relationship with ACT composite score for students attending districts with 1,000 to 2,499 students than for students attending districts with 7,500 and more students. Low socioeconomic status also had more of a negative relationship with ACT composite score for students attending districts with 2,500 to 7,499 students than for students attending districts with 7,500 and more students.

CHAPTER 5

SUMMARY, CONCLUSIONS, AND DIRECTIONS FOR FUTURE RESEARCH

This study explores the relationship between students' enrollment in specific advanced mathematics courses and college readiness as measured by the ACT. Specifically, the impact of enrollment in trigonometry, pre-calculus, calculus, AP calculus, and AP statistics courses on ACT mathematics and ACT composite scores was measured. To maximize student learning by exposing students to the content most likely to increase student knowledge, it is important to isolate the contributions of high school curriculum (administered through mathematics courses) on student college readiness. Determining the effect of enrollment in advanced mathematics courses on ACT scores, while controlling for previous achievement and determining the effect of enrollment in specific individual courses (trigonometry, pre-calculus, calculus, AP calculus, and AP statistics) on ACT scores informs the placement of high school students in advanced course-taking patterns.

Major Findings

All advanced mathematics courses included in the analysis (trigonometry, pre-calculus, calculus, AP calculus, and AP statistics) had a positive relationship with ACT mathematics score. Trigonometry, pre-calculus, AP calculus, and AP statistics had a positive relationship with ACT composite scores. Calculus did not hold a statistically significant relationship with ACT composite score. AP calculus had the largest impact of all advanced mathematics courses on both ACT mathematics and composite scores with enrollment in the course associated with a 1.6568 point increase in ACT mathematics score and a 1.1821 point increase in ACT composite score on average. Enrollment in trigonometry, pre-calculus, calculus, and AP statistics were each associated with an average increase in ACT mathematics score of less than one point. In addition, enrollment in trigonometry, pre-calculus, and AP statistics were each associated with an average increase in ACT composite score of less than one point.

Enrollment in calculus was associated with less of an increase in ACT mathematics score than trigonometry and pre-calculus. This is surprising as calculus covers more advance mathematics concepts than both trigonometry and pre-calculus. This may be the result of a lack of instructional support for calculus teachers. Few students enroll in calculus (12 percent of students included in this study), which equates to a small number of calculus teachers. Many calculus teachers are the lone teachers of this advanced course in their school. They lack the peer instructional support of other teachers and school administrators rarely have deep knowledge of calculus content. Calculus teachers often choose what and how to teach in isolation, void of the benefit of peer review and input. If a calculus teacher struggles with content or instructional strategies, it can be difficult for them to find support. Therefore, instruction in the calculus classroom suffers and less of an increase in ACT scores occurs. In contrast, the increase in ACT scores associated with ACT calculus is high. Like calculus, few students enroll in ACT calculus (nine percent of students included in this study). However, AP calculus teachers receive a high level of support from the College Board. This support includes summer trainings, clearly articulated course content and expectations, and print and web-based teacher resources. AP calculus teachers are highly supported in their instruction and student enrollment in AP calculus is associated with a large increase in ACT scores. AP statistics teachers also receive a high level of support from the College Board. However, the content covered in AP statistics is covered on the ACT test, limiting the ability of AP statistics to increase ACT scores.

The relationship between enrollment in advanced mathematics courses and ACT scores was influenced by race/ethnicity for algebra II, calculus, and AP calculus, and gender for algebra II and calculus. Asian Americans saw more of an increase in ACT mathematics score from taking AP calculus and less of an increase in ACT mathematics score from taking algebra II. Multi-racial students saw more of an increase in ACT mathematics score from taking algebra II. Female students saw less of an increase in ACT mathematics score when taking algebra II than males and less of an increase in ACT mathematics and composite score when taking calculus than male students. African American students saw less of an increase in ACT mathematics score than white students from taking algebra II and calculus. However, the difference between African American and white students is not statistically significant because of a small number of African American students taking these courses and subsequent large standard error of the coefficient. This suggests a lack of cultural sensitively of instructional strategies and materials in mathematics classrooms. Previous studies have found mathematics course content and curriculum to have little connection and relevance to minority students' cultures and experiences (Gutstein, Lipman, Hernandez, & De Los Reyes, 1997; Ladson-Billings, 1997; Tate, 1994).

Discussion

Theoretical Significance

Student Background Characteristics

Being female was associated with a slightly lower ACT mathematics score than being male. This is consistent with the study of NAEP data conducted by McGraw, Lubienski, and Strutchens (2006) that found males to have consistently higher mathematics test scores than females. There was no statistically significant relationship between race/ethnicity and ACT mathematics and composite scores (with the exception of Asians associated with a 1.0732 higher ACT mathematics score than whites). This is contradictory to the achievement gaps between African American and white students and Hispanic and white students found in multiple academic achievement data sets (ACT, Inc., 2012b; Bali & Alvarez, 2004; Wolk, 2011). This study controlled for prior achievement, while other references studies did not control for prior achievement. The difference in findings suggests that a racial/ethnic achievement gap may develop early in students' educational careers and remain relatively unchanged over time.

Low socioeconomic status was associated with a lower ACT mathematics and composite score. This is consistent with the negative relationship found between low socioeconomic status and student achievement in previous studies (Parke & Kanyongo, 2012; Siegler et al., 2012). However, English language learner status and disability status were associated with lower ACT composite scores. This is consistent with the findings of Garcia, Lawton, and DeFigueiredo (2012) and Guglielmi (2012). English language learner and student with disability status were not significantly associated with ACT mathematics scores. Since prior mathematics achievement was included in the analysis, the achievement gap between English language learners and non-English language learners and students with disabilities and students without disabilities may have been controlled for.

Previous Mathematics Achievement

Ninth grade mathematics score had the largest effect on both ACT mathematics and composite scores. This confirms previous research indicating that the strongest predictor of academic achievement on standardized tests is previous achievement (Aubrey, Dahl, & Godfrey, 2006; Kyttälä, & Björn, 2010). Without intervention, students will continue to achieve on the same trajectory. Previous academic achievement also appears to impact course enrollment. According to the descriptive statistics, students who enrolled in advanced mathematics courses had higher ninth grade mathematics scores than all students who enrolled in algebra II and students who did not enroll in algebra II. Students who enrolled in AP calculus had the highest ninth grade mathematics test scores with an average z-score of 1.1691.

District Characteristics

Attending a mid-sized district (2,500 to 7,499 students enrolled) was associated with increased ACT mathematics and composite scores. Attending a small district (fewer than 1,000 students enrolled) was associated with a decrease in ACT mathematics and composite scores. Weiss, Carolan, and Baker-Smith (2010) found that students attending high schools with class sizes of more than 400 students had lower student achievement than students in smaller high schools. Students attending districts with fewer than 1,000 students total would have fewer than 80 students in a class (grade level). This is much smaller than what Weiss, Carolan, and Baker-Smith (2010) considered small. These districts are located in rural Iowa and may have difficulty attracting talented teachers, causing student achievement to suffer. Districts with total enrollments of 2,500 to 7,499 students would have between 150 and 600 students in a class (grade level). Most districts located in medium-sized towns and suburban areas of Iowa fit into this category. Districts of this size may have the resources to attract quality teachers and benefit from small learning communities at the same time. In addition, district size may impact students with low socioeconomic status differently than their more advantaged peers. Low socioeconomic status students were associated with less of an increase in ACT composite score when attending mid-sized districts (2,500 to 7,499) and more of an increase in ACT when attending districts with 1,000 to 2,499 students. This may suggest that low socioeconomic students benefit more from small learning environments than their advantaged peers. More research is needed to explore this potential finding.

Consistency

Attendance rate was positively associated with ACT mathematics and composite scores. Previous studies have found both attendance and mobility to be significantly related with student achievement (Lamdin, 1996; Parke & Kanyongo, 2012; Parke & Keener, 2011; Roby, 2004). However, mobility was not significantly associated with ACT mathematics or composite score. This lack of relationship may be due to the way mobility was measured. In this analysis, students were indicated as mobile if they were attending a different district at the end of their twelfth grade year from in their ninth grade year. This method may not have captured all student moves. If a student started ninth grade in district A, moved to district B, then moved back to district A before the end of the twelfth grade year, the student would not be flagged as mobile. Additionally students who moved high schools within one district were also not captured as being mobile.

Advanced Mathematics Courses

Enrollment in advanced mathematics courses had a positive relationship with ACT mathematics and composite scores (with the exception of a statistically insignificant relationship between enrollment in calculus and ACT composite score). Less of an increase in ACT scores was found by this study than by Noble et al. (1999). For example, Noble et al. (1999) found that calculus was associated with a 3.48 increase in ACT mathematics score, while this study found calculus to be associated with an average increase of 0.79 points in ACT mathematics score. This difference in findings can be attributed to the fact that the Noble et al. (1999) study did not control for prior achievement. Enrolling in trigonometry was associated with an average increase of 0.6754 points in ACT mathematics score and an average increase of 0.4414 points in ACT composite score. Noble and Schnelker (2007) found that taking trigonometry or one additional advanced mathematics course beyond algebra II was associated with an average increase in ACT mathematics score of 1.0 to 1.5 points. This difference in the scale of benefit of taking trigonometry may be due to Noble and Schnelker's (2007) inclusion of "other" advanced mathematics courses, which introduces variability into the model.

Enrolling in calculus was associated with an average increase of 0.5917 points in ACT mathematics score, but was not statistically significantly related to ACT composite score. Noble and Schnelker (2007) found that taking trigonometry and calculus or trigonometry and one other advanced mathematics course was associated with an increased ACT mathematics score of over 2.0 points. Adding together the associated increases in ACT mathematics score with enrolling in trigonometry and enrolling in calculus, enrolling in trigonometry and calculus is associated with an average increase of 1.2671 points in ACT mathematics score. This difference in the scale of benefit of taking trigonometry and calculus may be due to Noble and Schnelker's (2007) inclusion of "other" advanced mathematics courses in place of calculus.

AP calculus had the largest impact on ACT scores. Enrolling in AP calculus was associated with an average increase of 1.6836 points in ACT mathematics score and an average increase of 1.1821 points in ACT composite score. Mo, Yang, Hu, Calaway, and Nickey (2011) also found a positive association between enrollment in AP mathematics courses (calculus or statistics) and ACT mathematics score. That study found students who took AP calculus or AP statistics to be six times more likely to pass the ACT's college readiness benchmark in mathematics (a score of at least 19). However, this study found AP statistics to have less of an impact on ACT mathematics score than AP calculus. This difference in impact of courses on ACT score is likely affected by the alignment between specific course content and content covered on the ACT test. AP statistics covers data, sampling, patterns, and statistical inference (Bradby, Pedroso, & Rogers, 2007). The ACT mathematics test does not cover statistics. The ACT test focuses on pre-algebra, elementary algebra, intermediate algebra, coordinate geometry, plane geometry, and trigonometry (ACT, Inc., 2012a). Based on alignment, the higher impact of pre-calculus than calculus on ACT mathematics score is expected, as pre-calculus covers algebra and trigonometry content (Bradby, Pedroso, & Rogers, 2007).

Pre-calculus was associated with an average increase of 0.7920 points, while calculus was associated with an average increase of 0.5917 points on the ACT mathematics test.

The relationship between enrollment in advanced mathematics courses and ACT scores was influenced by race/ethnicity for algebra II, calculus, and AP calculus. Asian Americans saw more of an increase in ACT mathematics score from taking AP calculus and less of an increase in ACT mathematics score from taking algebra II. Multi-racial students saw more of an increase in ACT mathematics score from taking algebra II. African American students saw less of an increase in ACT mathematics score than white students from taking algebra II and calculus. However, this difference is not statistically significant because of a small number of African American students taking these courses and subsequent large standard error of the coefficient.

The relationship between enrollment in advanced mathematics courses and ACT scores was also influenced by gender for algebra II and calculus. Female students saw less of an increase in ACT mathematics score when taking algebra II than males and less of an increase in ACT mathematics and composite score when taking calculus than male students.

Practical Significance

AP calculus had the largest impact of all advanced mathematics courses on both ACT mathematics and composite scores, with enrollment in the course associated with an average increase of 1.6568 points in ACT mathematics score and an average increase of 1.1821 points in ACT composite score. When considering advanced mathematics course options, students should be encouraged to enroll in AP calculus, as it may provide more benefit in preparing students for college-level mathematics in comparison to other advanced mathematics courses.

Enrollment in trigonometry, pre-calculus, calculus, and AP statistics had limited impact on ACT score individually, as each was associated with an increase in ACT mathematics score of less than one point. When viewing the effects of enrollment in advanced mathematics courses in terms of course sequence, the effect of enrolling in advanced mathematics courses becomes more significant (see table 7). For example, the effect of taking trigonometry, pre-calculus, and AP calculus is an increase in ACT mathematics score of 3.1242 points on average and an increase in ACT composite score of 2.0835 points on average, compared to ending the mathematics course sequence with algebra II. Viewed cumulatively, the effect of an advanced mathematics course sequence in high school is substantial.

Table 7. Advanced Mathematics Course Sequences and Increase in Estimated ACT Score (compared to Algebra II)

Course sequence	ACT mathematics score	ACT composite score
Trigonometry and pre-calculus	1.4674	0.9013
Trigonometry, pre-calculus, and calculus	2.0591	1.0783
Trigonometry, pre-calculus, and AP calculus	3.1242	2.0835
Pre-calculus, calculus, and AP calculus	3.0405	1.8191
Pre-calculus, calculus, and AP statistics	2.0673	1.1855
Pre-calculus, AP calculus, and AP statistics	3.1324	2.1907

The relationship between enrollment in advanced mathematics courses and ACT scores was influenced by race/ethnicity for algebra II, calculus, and AP calculus and by gender for algebra II and calculus. Female students saw less of an increase in ACT mathematics score when taking algebra II than males and less of an increase in ACT mathematics and composite score when taking algebra II and calculus than male students. African American students saw less of an increase in ACT mathematics score than white students from taking algebra II and calculus. However, this difference is not statistically significant because of a small number of African American students taking these courses and subsequent large standard error of the coefficient.

Advanced mathematics courses are disproportionately lacking African American and Hispanic students. For example, African American students comprised 2.2 percent of the dataset, but only 0.5 percent of student enrolled in calculus and 0.73 percent of students enrolled in AP calculus. This lack of a peer group may influence the ability of minority students to benefit from advanced mathematics courses. Minority students may feel uncomfortable and unsupported in an advanced academic classroom that is predominantly white students (Yonezawa, Wells, & Serna, 2002).

This suggests a lack of cultural sensitively of instructional strategies and materials in mathematics classrooms. Previous studies have found mathematics course content and curriculum to have little connection and relevance to minority students' cultures and experiences (Gutstein, Lipman, Hernandez, & De Los Reyes, 1997; Ladson-Billings, 1997; Tate, 1994). According to the latest figures from the U.S. Department of Education (n.d.), 83 percent of our nation's teachers are white (2007-2008 school year). This lack of racial diversity among teachers may negatively affect minority students' ability to connect with classroom teachers and the content they present.

Studies have found females to view themselves as lower achieving in mathematics (Frenzel, Pekrun, & Goetz, 2007; Pajares & Kranzler, 1995). Previous research has found that females are more susceptible to mathematics anxiety due to their aversion to high stakes testing and social comparison (Beilock, 2008; Haynes, Mullins, & Stein, 2004; Miller & Bichsel, 2004).

In many classrooms, mathematics instruction is based on a skills based model. Too often, this means memorization and rote recitation rather than active concept-based learning (Cates & Rhymer, 2003). Mathematics is often taught as if all the students are identical in terms of ability, learning style, and pace. Therefore, under-achievement of females and minorities in mathematics may be linked to the method of instruction rather than to ability (Boaler, 2002). Through the Algebra Project, Robert Moses advocates for an experiential learning approach to mathematics (Moses & Cobb, 2001). Mathematics concepts are often presented in a way that is very disconnected from the lives and experiences of students, especially minority students and those from low socioeconomic backgrounds. The Algebra Project presents mathematical concepts in a way that connects with students' everyday experiences (or culture), bridging the "transition from real life to mathematical language and operations" (Moses & Cobb, 2001, p. 120). Strategies must use experiences from students' lives to connect what students know to what is being taught in the classroom (Delpit, 2012).

Through the process of inquiry, students integrate previous knowledge with newly discovered knowledge. Teachers utilize inquiry strategies to act more as guides or coaches than teachers and encourage self-reliance in finding answers to problems (Moses & Cobb, 2001). In the traditional mathematics classroom, students are presented with mathematical symbols without connection to the real world. However, mathematics instruction must start where the student is. Through the instructional methods utilized in the Algebra Project, students find the mathematics in everyday experiences, and then use mathematics to symbolize those experiences. For all students to be successful, mathematics must not be “a game of signs they are unable to play” (Moses & Cobb, 2001, p. 122). Mathematics language must be taught as a way to communicate mathematical ideas, not as a way to solve textbook problems (Delpit, 2012).

Every student learns differently. They also respond differently to different instructional approaches (Leedy, LaLonde, & Runk, 2003). To provide sensitive instruction to students, teachers must know their students. Muller found a strong teacher-student relationship to increase mathematics achievement for at-risk students (2001). Teacher-student relationships are a cornerstone of culturally and gender-sensitive instruction. “A lack of knowledge and understanding of students’ out-of-school experiences severely limit a teacher’s ability to see his or her students’ intelligence and problem-solving skills” (Delpit, 2012, p. 139). Teachers need to understand how students relate (or fail to relate) to instruction occurring in the classroom.

On-going professional development to assist teachers in understanding the importance of these relationships and strategies to help them build relationships with students enables teachers to better meet the needs of students. These relationships must be based on frequent contact—“a relationship that can move young people, penetrate their cultural barriers, and become a relationship that can help them grow” (Moses & Cobb, 2001, p. 132). To relate instruction to the experiences of students, teachers must know all students as individuals on a personal level. Teachers must make the time to have a conversation with each student in their classroom every day—even if it is only a short check-in. Trust is a cornerstone to these types of deep relationships; students must know that an adult will be there for them when they need to reach out (Moses & Cobb, 2001).

Policy Implications

To increase college readiness in mathematics, students need exposure to advanced mathematics courses. Students need not only to take advanced mathematics courses in high school, but to be prepared for such courses in their elementary and middle school grades. Experience in high school is highly influenced by student experience in elementary and middle school. To provide opportunities for students to take multiple advanced mathematics courses in high school, students need exposure to algebra concepts in their middle school years. To prepare students for algebra in middle school, expectations in the mathematics classroom must increase in all grade levels.

It is naïve to expect all high school students to enroll in advanced mathematics courses. However, all students need to be provided equal opportunity and access to these courses. Pathways to these courses need to be reviewed to increase access for students from a variety of backgrounds. Schools must have high expectations for all students and encourage all students to enroll in advanced mathematics courses. Providing the pre-requisite knowledge for these courses early in the student's career is one step in providing access. Pre-algebra concepts need to be broken down into knowledge that all students can connect with, such as the strategies implemented in the Algebra Project (Moses & Cobb, 2001). Engaging students with experiential learning strategies middle school classrooms provides not only minority students access to mathematical concepts, but increase access for all young learners. States and districts must re-examine middle school mathematics curriculum through the lens of the experiences of students. Deconstructing the language of mathematics and presenting it in a relevant way for middle school students will increase pre-requisite knowledge so that students will be prepared to enroll in advanced mathematics courses in high school.

Another possible barrier to advanced mathematics courses is school offerings. To increase access to advanced mathematics courses, states should mandate that all school offer pre-calculus, calculus, AP calculus, and AP statistics. Larger schools have the ability to offer these courses on their own; however, many small schools do not have the resources to offer advanced mathematics courses for students. Therefore, the state needs to support small schools by offering advanced mathematics (including AP) courses through the area education agency (AEA) system. AEAs would assist schools in developing consortiums through which advanced mathematics courses are offered. These consortiums would benefit from the utilization of technology to ensure that students have the opportunities to access advance coursework either remotely via webcast or online learning. The technological advances in online learning have broken geographical barriers once faced by rural schools, providing the opportunity to increase access for all students.

Schools need to not only offer advanced mathematics courses, but to support the teachers of these courses. For example, the increase in ACT scores associated with enrollment in calculus is surprisingly small. Enrollment in calculus may be limited in its ability to increase ACT scores because of a lack of instructional support for teachers. Many calculus teachers are the lone teachers of this advanced course in their school. Calculus teachers often choose what and how to teach in isolation, lacking the benefit of peer review and input. The state and AEA should assist advanced mathematics course teachers in connecting with a peer group for support. This could be facilitated through online forums, discussions, and resource libraries where teachers could reach out to each other to share content and instructional strategies. In addition, AEA should host annual or semi-annual regional meetings where teachers could share best practices and collaborate face-to-face. Increasing the instructional support of teachers is likely to strengthen the skills of advanced mathematics teachers and, in turn, increase the ability of advanced mathematics courses to influence student achievement.

Current and pre-service teachers also need training on how to connect with a diverse student population, including students from other cultures. All schools and teacher preparation programs must emphasize the importance of teacher-student relationships. Teachers will be incentivized to engage in student caring once it becomes the normative behavior in our school systems. A cultural of caring and building relationships must be built into all facets of schools and teacher training, including pre-service training, in-service training, leadership training, and teacher and leader evaluation. For caring to become ingrained in the culture of our school systems, it must be expected of all teachers and administrators. Therefore, states and districts must include the ability to foster positive teacher-student relationships in teacher and administrator evaluations.

Limitations

A number of variables that may influence ACT scores are not accounted for in this analysis, including: student motivation, student self-efficacy, student engagement, parental educational attainment, teacher quality, local course content, and school climate. Due to the limitations of the dataset, these variables could not be controlled for in this study. The effect of advanced mathematics courses on ACT score varied by race/ethnicity and gender. This difference by student demographic group suggests that student self-efficacy or engagement may influence the model if these demographic groups are systematically different in their self-efficacy or engagement.

This study was limited in measuring the effect of advanced courses by way of enrollment in courses. Intuitively, the benefit of a course depends upon the successful completion of the course. Some of the students in this study who enrolled in advanced mathematics courses may have failed or dropped the course mid-year. It is expected that these students experienced little or no benefit from the course, but were indicated as enrolled in an advanced mathematics course just the same as students who successfully completed the course with an A or B grade.

In addition, local course curricula may vary between districts. This variety in curricula makes it more difficult to generalize the effect of courses. The effect of calculus in district A may be much more positive than the effect of calculus in district B. The same variation applies to teacher quality. Student benefit from specific courses is dependent on the quality of instruction they receive in that course. Teachers are the largest influence on student achievement. The dataset analyzed in this study did not contain any teacher data.

Only students who graduated from high school were included in the dataset. Therefore, high school dropouts were not included in the analysis. Dropouts may be different in their mathematics achievement and course enrollment patterns than their graduating peers. This study provides no insight into how advanced mathematics course enrollment (or lack of advanced mathematics enrollment) affects the academic achievement of high school dropouts.

Directions for Future Research

The main weakness of this study is the inability to explain the differences in effect of advanced mathematic courses on ACT scores due to gender and race/ethnicity. The cultural sensitivity of advanced mathematic course content and curriculum needs to be explored within the context of the benefit (increased mathematics achievement score) of mathematics courses. Why are females and possibly African Americans benefitting less from advanced mathematics courses? Is the content of advanced mathematics courses presented in a way that is relevant for minorities and females? Are the instructional strategies used in the typical advanced mathematics course engaging for all students? Previous research indicates traditional mathematics instructional practices are limited in their ability to engage females and students from low socioeconomic backgrounds (Boaler, 2002; Cates & Rhymer, 2003). These questions need to be examined to ensure that advanced mathematics courses are equally beneficial to all students.

This study needs to be replicated with different units of analysis to allow comparisons among schools, classrooms, and teachers. These units of analysis would enable researchers to isolate pockets of excellence within our school systems. Once the excelling schools, classrooms, and teachers are located, they could be studied in depth to determine promising practices and replicate those practices in other schools and classrooms. The ability to quantify the difference in student benefit of advanced mathematics courses will help identify successful teachers and strategies which could be replicated across classrooms.

This study was severely limited in its ability to measure consistency. Consistency needs to be explored more broadly, not only in terms of student mobility and attendance, but also in terms of the stability of schools. Leadership tenure and teacher mobility also play a role in consistency and need to be included in future research. It is expected that schools with high mobility among leadership and teachers offer lower consistency to students, making it difficult to implement new strategies with the constant turnover of trained staff.

Conclusion

This study explored the relationship between students' enrollment in specific advanced mathematics courses and college readiness as measured by the ACT. Specifically, the impact of enrollment in trigonometry, pre-calculus, calculus, AP calculus, and AP statistics courses on ACT mathematics and ACT composite scores was measured. To maximize student learning by exposing students to the content most likely to increase student knowledge, it is important to isolate the contributions of high school curricula (administered through mathematics courses) on student college readiness.

All advanced mathematics courses included in the analysis (trigonometry, pre-calculus, calculus, AP calculus, and AP statistics) had a positive relationship with ACT mathematics score. Trigonometry, pre-calculus, AP calculus, and AP statistics had a positive relationship with ACT composite scores. AP calculus had the largest impact of all advanced mathematics courses on both ACT mathematics and composite scores with enrollment in the course associated with an average increase of 1.6568 points in ACT mathematics score and an average increase of 1.1821 points in ACT composite score. When viewing the effects of enrollment in advanced mathematics courses in terms of course sequence, the effect of enrolling in advanced mathematics courses becomes substantial as increases in ACT scores from individual courses are added to each other.

To increase college readiness in mathematics, students need exposure to advanced mathematics courses. Students should be highly encouraged to enroll in AP calculus, which had the largest effect among advanced mathematics courses on ACT score. To increase access to advanced mathematics courses, states should mandate that all schools offer pre-calculus, calculus, AP calculus, and AP statistics. The execution of those offerings would differ depending on the school's situation.

Students need not only take advanced mathematics courses in high school, but must be prepared for such courses in their elementary and middle school grades. All students need to be provided equal opportunity and access to these courses. Schools must have high expectations for all students and encourage all students to enroll in advanced mathematics courses. To create culturally sensitive classrooms in which all students reach their full potential, mathematical concepts must be taught in a way that relates to the experiences of students. Mathematics instruction must start where the student is. Mathematics classrooms must utilize Algebra Project (Moses & Cobb, 2001) instructional methods, in which students find the mathematics in everyday experiences and then use mathematics to symbolize those experiences. Strong teacher-student relationships are a cornerstone to culturally sensitive instruction and the Algebra Project model. Ongoing professional development to assist teachers in understanding the importance of these relationships and strategies to help them build those relationships with students will enable teachers to better meet the needs of students.

To increase college readiness, students must be provided the opportunity to enroll in advanced mathematics courses, including advanced placement (AP) courses. These opportunities for exposure to advanced mathematical concepts must exist for all students, including minority and female students. This requires increased exposure to pre-algebra concepts at the middle school grade levels and culturally sensitive instructional methods in which students relate their everyday experiences to mathematical concepts.

APPENDIX A

VARIABLE CORRELATION TABLE

Table 8. Variable Correlation Table

	ACT mathematics score	ACT composite score	Ninth grade mathematics test score	Algebra II	Trigonometry	Pre-calculus
ACT mathematics score	1.0000	0.8585	0.7418	-0.3478	-0.3058	-0.4688
ACT composite score	0.8585	1.0000	0.7292	-0.3443	-0.2751	-0.4086
Ninth grade mathematics test z-score	0.7418	0.7292	1.0000	-0.3304	-0.2596	-0.3835
Algebra II	-0.3478	-0.3443	-0.3304	1.0000	0.2149	0.3018
Trigonometry	-0.3058	-0.2751	-0.2596	0.2149	1.0000	-0.0170
Pre-calculus	-0.4688	-0.4086	-0.3835	0.3018	-0.0170	1.0000
Calculus	-0.3655	-0.3115	-0.2980	0.1406	0.1805	0.2031
AP calculus	-0.4184	-0.3644	-0.2961	0.1150	0.0450	0.2400
AP statistics	-0.1646	-0.1535	-0.1202	0.0721	0.0196	0.0750
Gender	0.1528	0.0594	0.1399	-0.0013	-0.0275	-0.0500
Race/ethnicity	0.1142	0.1386	0.1690	-0.1352	-0.0617	-0.0204
Low socioeconomic status	0.2118	0.2277	0.2102	-0.1951	-0.1147	-0.1163
English language learner	0.0651	0.0925	0.0847	-0.0601	-0.0216	-0.0366
Student with disability	0.1436	0.1855	0.1841	-0.1950	-0.0610	-0.0788
District size	0.0727	0.0569	-0.0492	0.0794	0.0094	-0.1219
Attendance rate	0.1849	0.1541	0.1433	-0.1695	-0.0912	-0.1389
Mobility	0.0505	0.0502	0.0385	-0.0307	-0.0266	-0.0461

Table 8 continued. Variable Correlation Table

	Calculus	AP calculus	AP statistics	Gender	Race/ethnicity	Low socioeconomic status
ACT mathematics score	-0.3655	-0.4184	-0.1646	0.1528	0.1142	0.2118
ACT composite score	-0.3115	-0.3644	-0.1535	0.0594	0.1386	0.2277
Ninth grade mathematics test z-score	-0.2980	-0.2961	-0.1202	0.1399	0.1690	0.2102
Algebra II	0.1406	0.1150	0.0721	-0.0013	-0.1352	-0.1951
Trigonometry	0.1805	0.0450	0.0196	-0.0275	-0.0617	-0.1147
Pre-calculus	0.2031	0.2400	0.0750	-0.0500	-0.0204	-0.1163
Calculus	1.0000	0.0067	-0.0062	-0.0641	-0.0170	-0.0610
AP calculus	0.0067	1.0000	0.1057	-0.0640	0.0043	-0.0720
AP statistics	-0.0062	0.1057	1.0000	-0.0187	0.0042	-0.0468
Gender	-0.0641	-0.0640	-0.0187	1.0000	-0.0057	0.0318
Race/ethnicity	-0.0170	0.0043	0.0042	-0.0057	1.0000	0.2711
Low socioeconomic status	-0.0610	-0.0720	-0.0468	0.0318	0.2711	1.0000
English language learner	-0.0037	-0.0201	-0.0020	0.0050	0.1912	0.1168
Student with disability	-0.0415	-0.0360	-0.0209	-0.0314	0.0677	0.1003
District size	0.0241	-0.1141	-0.1403	0.0172	-0.2245	-0.0513
Attendance rate	-0.1119	-0.0787	-0.0213	0.1109	0.0432	0.1809
Mobility	-0.0245	-0.0406	-0.0129	0.0166	0.0011	0.0509

Table 8 continued. Variable Correlation Table

	English language learner	Student with disability	District size	Attendance rate	Mobility
ACT mathematics score	0.0651	0.1436	0.0727	0.1849	0.0505
ACT composite score	0.0925	0.1855	0.0569	0.1541	0.0502
Ninth grade mathematics test z-score	0.0847	0.1841	-0.0492	0.1433	0.0385
Algebra II	-0.0601	-0.1950	0.0794	-0.1695	-0.0307
Trigonometry	-0.0216	-0.0610	0.0094	-0.0912	-0.0266
Pre-calculus	-0.0366	-0.0788	-0.1219	-0.1389	-0.0461
Calculus	-0.0037	-0.0415	0.0241	-0.1119	-0.0245
AP calculus	-0.0201	-0.0360	-0.1141	-0.0787	-0.0406
AP statistics	-0.0020	-0.0209	-0.1403	-0.0213	-0.0129
Gender	0.0050	-0.0314	0.0172	0.1109	0.0166
Race/ethnicity	0.1912	0.0677	-0.2245	0.0432	0.0011
Low socioeconomic status	0.1168	0.1003	-0.0513	0.1809	0.0509
English language learner	1.0000	0.0002	-0.0447	0.0248	-0.0024
Student with disability	0.0002	1.0000	-0.0243	0.0424	0.0094
District size	-0.0447	-0.0243	1.0000	-0.0185	0.0875
Attendance rate	0.0248	0.0424	-0.0185	1.0000	0.0893
Mobility	-0.0024	0.0094	0.0875	0.0893	1.0000

APPENDIX B

INSTUTUTIONAL REVIEW BOARD (IRB) APPROVAL

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Institutional Review Board
Office for Responsible Research
Vice President for Research
1138 Pearson Hall
Ames, Iowa 50011-2207
515 294-4566
FAX 515 294-4267

Date: 5/10/2013

To: Mary Grinstead
4331 Ingersoll Ave
Des Moines, IA 50312

CC: Dr. Jeffrey S Brooks
N229B Lagomarcino Hall
Holly Ryan
N24 Lagomarcino

From: Office for Responsible Research

Project Title: Which Advanced Mathematics Courses Influence ACT Score? A State Level Analysis of the Iowa Class of 2012

The Co-Chair of the ISU Institutional Review Board (IRB) has reviewed the project noted above and determined that the project:

☐ Does not meet the definition of research according to federal regulations.

☒ Is research that does not involve human subjects according to federal regulations.

Accordingly, this project does not need IRB approval and you may proceed at any time. We do, however, urge you to protect the rights of your participants in the same ways you would if IRB approval were required. For example, best practices include informing participants that involvement in the project is voluntary and maintaining confidentiality as appropriate.

If you modify the project, we recommend communicating with the IRB staff to ensure that the modifications do not change this determination such that IRB approval is required.

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