College and Career Readiness: Access to Advanced Mathematics and Science Courses in Virginia Public High Schools

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Dissertation submitted to the faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of

Doctor of Education

In

Educational Leadership and Policy Studies

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October 30, 2015
Blacksburg, Virginia

Key words: College and career readiness, access, opportunity to learn, advanced mathematics and science course offerings, rigorous curriculum, equity

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Abstract

A renewed focus to produce college and career ready graduates capable of thriving in science, technology, engineering, and mathematics (STEM) and other career and technical education professions has made access to advanced mathematics and science courses for all students a priority in K-12 education. Previous research on achievement has indicated that Black and Latino students are underrepresented in advanced mathematics and science courses and are lagging behind their peers in academic performance. Some researchers have suggested that these disparities in participation and achievement result from unequal access to educational opportunities.

This purpose of this study was to examine student access to advanced mathematics and sciences courses in Virginia public high schools as an indicator of college and career readiness. This study employed secondary data analysis of school level data from the Virginia Department of Education. Regression analyses, simple and multiple, were used to examine access to advanced mathematics (Algebra II and higher) and advanced science (Chemistry and higher) course offerings by school characteristics, including school size, economically disadvantaged percentage, the percentage of minority students, and urbanicity locale. The results of this study indicated that student access to advanced mathematics and science course offerings, excluding and including AP mathematics and science courses, as in indicator of college and career readiness, differed based upon school size, economically disadvantaged percentage, and urbanicity locale. These findings, consistent with national statistics and other research, suggested that students who attend public high schools in the Commonwealth of Virginia do not have equal access to advanced mathematics and science course offerings, including AP mathematics and science courses, when school size, economically disadvantaged, and urbanicity locales are considered. Other findings related to access based on the percentage of minority students were inconsistent with prior research, as there was no significant difference in the number of advanced mathematics and science course offerings, excluding and including AP mathematics and science courses, based on the percentage of Black and Latino students enrolled in Virginia public high schools.

Dedication

This dissertation is dedicated to all educational leaders who work tirelessly to ensure all students are afforded equal and equitable educational opportunities. It is my hope that the findings from this study will be meaningful for educational practitioners and other stakeholders passionate about graduating college and career ready students in K -12 education. As a secondary school educational leader, it has been and will forever be an honor to work collaboratively with all educational leaders, parents, teachers, and students on closing gaps associated with opportunity to learn.

In addition, this dissertation is dedicated to my late mother, Ms. Marie Bosier Ballard, who instilled in my brothers and me the value of a quality education, hard work, and perseverance.

Acknowledgements

First, I would like to give honor to God who has been my rock and a pillar of strength to me throughout this entire educational experience. I am truly grateful to Him for bestowing upon me this incredible educational and professional opportunity at Virginia Tech University. There is no doubt that God's grace helped me reach this milestone.

In addition, I am extremely grateful to my wife (Roshonda), son (Christian), late mother (Marie Bosier Ballard), brothers (Allen and Terence), mother-in-law (Shirley), father-in-law (Robert), sister-in-laws (Athenia and Sharonda), niece (Alexis), nephews (Lamarkus and Xavier), step-dad (Albert), best friend (John), mathematics mother (Doris), cousin (Horace), Godmother (Rosetta) and a host of other family members, fraternity brothers, and friends, who have faithfully prayed, encouraged, and inspired me to complete this dissertation. I am forever grateful to you for your love and sacrifices, those seen and not seen, that have afforded me the opportunity to pursue my dream. You all are amazingly wonderful.

Next, I would also like to sincerely express the utmost gratitude to my dissertation committee, Dr. Carol Cash, Dr. William Glenn, Dr. Ted Price, and Dr. Valija Rose. I am forever indebted to each of you for your support, encouragement, advisement, constructive yet candid feedback, expertise, and time. I have grown so much as an educational leader under your leadership and advisement. Thank you for the wisdom that you have imparted to me that has contributed to my educational and professional growth.

Lastly, I would like to thank members of the 2012 Richmond doctoral cohort. Like iron sharpening iron, I've really enjoyed learning from a group of dynamic and passionate educational leaders. I would especially like to thank Zenia, Kecia, Tinkhani, Darnell, and

Johnette. Over the past 3 plus years, I have added to my extended family and am blessed to have had the opportunity to share in this experience with each of you.

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Chapter One: Introduction

Equal access to educational opportunities for all students has been a focus in America since the *Brown v. Board of Education* (1954) decision. With the ruling, the Supreme Court declared that "separate but equal" was not equal and suggested that all students, especially Black students, were entitled to equal educational opportunities to learn. However, more than 60 years after this historic decision, disparities in access to educational opportunities to learn remain pervasive (Carter & Welner, 2013; Office of Civil Rights [OCR], 2012; Schott Foundation, 2009). Black and Latino students continue to lag behind their White counterparts in a series of achievement indicators, including college and career readiness (College Board, 2013, 2014; Kena et al., 2014; OCR, 2012). Closing the gap in opportunities to learn remains a priority among educational leaders and researchers because of the impact that access has on college and career readiness for students.

In 2009, President Obama and his administration initiated the Race to the Top, an educational reform initiative designed to promote novelty and excellence in America's schools in order to prepare every child for the challenges of the 21st century. One of the primary focuses of Race to the Top was to encourage states to be innovative about raising standards and preparing students for college and careers (U.S. Department of Education [USDOE], 2010*)*. Student success in mathematics is integral to that goal and serves as a gateway for college and career opportunities as well as enhanced prospects for future income (National Mathematics Advisory Panel [NMAP], 2008). Specifically, student success in high school mathematics at the Algebra II level or higher is positively correlated with access to college enrollment, college graduation, and employment income earnings in the top quartile (NMAP, 2008). Equally as important, student access to advanced mathematics courses is important to the rapid job growth in science, technology, engineering, and mathematics (STEM) careers that require advanced mathematics and science skills (Langdon, McKittrick, Beede, Khan, & Doms, 2011). Langdon et al. (2011) reported that job growth in intensive STEM careers was outpacing non-STEM jobs in America by an estimated 2 to 1 ratio. Between 2010 and 2020, STEM occupations are projected to be among the three fastest growing occupational clusters, with a 26% rate of growth (Carnevale, Smith, & Strohl, 2013).

International and national statistics illustrated that American students are not excelling in the areas of mathematics and science at levels expected of an international leader (Organisation for Economic Co-operation and Development [OECD], 2014). In fact, Programme for International Student Assessment data from 2012 highlighted that American student achievement in mathematics is mediocre in comparison to peers worldwide (OECD, 2014). In 2012, students in the United States were outperformed by more than 30 other OECD countries in mathematics with a mean score of 481, which was 13 points less than the OECD average and 92 points less than students from Singapore. Shanghai, China had the highest mean score in mathematics of 613, which was 119 points or the equivalent to 3 years of schooling above the OECD mathematics average (OECD, 2014). The nation's report card from the National Assessment of Educational Progress (NAEP) highlighted a similar level of mathematics achievement. The most recent NAEP results indicated that 32% of students in Grade 8 scored at or above the proficient level, while only 23% in Grade 12 scored at this level (National Center for Education Statistics [NCES], 2014).

The disparities in advanced mathematics and science achievement related to race, gender, and income are also documented (Lleras, 2008; Riegle-Crumb, 2006). In its *10th Annual AP Report to the Nation* publication, College Board (2014) highlighted an increase in the number of students accessing and participating in advanced placement (AP) courses across all ethnic groups. However, the organization also reported that among the class of 2013, Black students were the most under-represented group in AP course enrollment and successful AP exam takers. The College Board (2014) reported that:

> Hundreds of thousands of prepared students in this country either did not take a course in an available AP subject for which they had the potential to succeed or attended a school that did not offer a course in the subject. (p. 28)

Other researchers have found similar results, and have reported limited student access to advanced mathematics and science courses in high school (Achieve, 2008; Adelman, 2007; Handwerk, Tanegatta, Coley, & Gitomer, 2008). Handwerk and colleagues (2008), in an examination of access to AP programs, reported Black students less likely to attend public high school classified as "high AP" schools and more likely to attend "low AP" schools. Not only are Black and Latino students less likely to attend schools that offer advanced courses (Handwerk et al., 2008; Schott Foundation, 2009), they are more likely to require remedial classes in college (U.S. Department of Education Office of Planning, Evaluation and Policy Development, 2010).

Participation in a rigorous high school curriculum enhances longer-term life opportunities and outcomes (Achieve, 2008; Tai, Liu, Almarode, & Fan, 2010). Advanced mathematics and science courses are rigorous courses that enrich students' problem solving, critical thinking, and logical thinking skills, all vital for college and career opportunities in a competitive global labor market. Students, particularly Black and Latino students, who successfully complete advanced mathematics and science courses in high school, have greater economic opportunities and future earnings (Achieve, 2012). These courses have also been found to decrease income gaps between students from low-income and middle-class income backgrounds (Rose & Betts, 2004).

This purposed study examined student access to advanced mathematics and sciences courses in Virginia public high schools as an indicator of college and career readiness by school size (fall 2012 membership enrollment), economically disadvantaged percentage, minority student percentage (percentage of Black or Latino students), and urbanicity locale. Student access to these advanced courses is important to the production of college and career-ready graduates. Furthermore, student completion of these courses has been found to impact college participation and success (Adelman, 2006; College Board, 2013, 2014), economic earnings (Rose & Betts, 2004), and the labor market, nationally and globally (Carnevale et al., 2013; Hanushek, Woessmann, Jamison, & Jamison, 2008). Despite these findings, from a national perspective, students who attend majority minority schools seemingly have less access to these educational opportunities than those who attend low minority high schools (OCR, 2012).

Statement of the Problem

The cumulative disparities in participation and performance reflect the need to ensure access to college and career readiness coursework in K-12 education (College Board, 2013, 2014; Kena et al., 2014; NCES, 2013; National Council of Teachers of Mathematics, 2013; OCR, 2012). The gap in student access to college and career opportunities has become increasingly an important concern for economists, educators, researchers, and politicians (Achieve, 2008; Carnevale et al., 2013; Hanushek et al., 2008; Rose & Betts, 2004). Race to the Top clearly identified the production of college and career-ready graduates as a priority and encouraged states to be innovative about raising standards in order to achieve those goals (Kena et al., 2014; USDOE, 2010). However, more than 5 years later, gaps in access to and achievement in college and career-ready coursework persist (College Board, 2013; Klopfenstein & Thomas, 2009).

In a national study, the OCR (2012) reported disparities in student access to advanced mathematics and science course offerings in high schools with majority Black and Latino enrollment in comparison to those with low Black and Latino enrollment. Using a more comprehensive opportunity to learn index, the Schott Foundation (2009) measured access to high-quality schools in each state and in the District of Columbia. The index measured the extent to which minority and disadvantaged students had access to high schools with high graduation rates relative to White, non-Latino students. Combining the index with student performance on the eighth grade Reading NAEP assessment to rank states, the organization found that schools with a majority of Black and Latino students had less opportunity to learn than White, non-Latino students. A recommendation that emerged from the report was that all students should have access to "college preparatory curricula that will prepare all youth for college, work, and community" (Schott Foundation, 2009, p. 2). Advanced mathematics and science courses, at the Algebra II and higher and Chemistry and higher levels, are college and career preparatory courses that can help achieve that goal (Achieve, 2008).

Although a number of researchers have examined the impact that the completion of advanced mathematics and science courses may have on college and career readiness and student educational outcomes from a national perspective (Bozick, Lauff, & Wirt, 2007; Chen, 2009; Riegle-Crumb, 2005), the Commonwealth of Virginia has a college and career readiness initiative (VCCRI) focused on ensuring that college and career standards are taught in Virginia high schools (Virginia Department of Education [VDOE], 2010). In addition, one of VCCRI's goals is to increase students' preparedness for postsecondary opportunities prior to graduation (VDOE, 2010). The present study seeks to examine the availability of these courses as a college and career readiness indicator, thereby increasing the likelihood of graduating college and career-ready students in Virginia.

Conceptual Framework

Many researchers have contended that a series of factors contribute to the achievement outcomes of students, especially Black and other minority students (Achieve, 2008; Carter & Welner, 2013; Ferguson, 2007; Ford, Grantham, & Whiting, 2008; Lewis, James, Hancock, & Hill-Jackson, 2008; Lewis & Moore, 2008a, 2008b; Moore & Lewis, 2012; Riegle-Crumb, 2005). Carter and Welner (2013) have argued that the achievement gap is predicated upon a gap in access to educational opportunities to learn. The researchers posited that in-school and out-of-school factors negatively impact Black and Latino students' opportunity to learn in K-12 education. Among these in-school factors are teacher expectations of students, teacher experiences (number of years in the profession), and student access to rigorous curricula and courses. Other variables such as health and nutrition, housing, safety, school location, parent education, and SES were also identified and have been found to be contributing factors to student achievement outcomes. Although this study did not focus on out-of-school factors, Carter and Welner (2013) have asserted that such factors impact Black and Latino students' educational outcomes.

The OCR (2012) framework focused on school-related factors exclusively. The OCR (2012) has maintained that resource equity, which includes teacher quality (i.e., pay, experience, and expectations), college and career readiness, and discipline rates are among key factors that explain the opportunity gap in K-12 education. The OCR (2012), in an investigation to determine if schools were providing opportunities to learn for all students, examined each factor within schools. The results of the study found that disparities in schools associated with these variables explained the extent that students had equal opportunity to learn.

A review of the literature indicated that in school and out of school factors led to either opportunity or lack of opportunity to learn (Carter & Welner, 2013; Welner, 2005). One indicator of opportunity is access to advanced mathematics and science courses (OCR, 2012). This access subsequently impacts college and career readiness and longer-term educational, career, and life outcomes for students. Figure 1 illustrates the combination of the Carter and Welner (2013) and OCR's (2012) frameworks, which form the basis for the conceptual framework for this study.

Carter and Welner (2013) stated:

> The 'opportunity gap' frame, in contrast [to the achievement gap frame], shifts our attention from outcomes to inputs to the deficiencies in the foundational components of societies, schools, and communities that produce significant differences in educational and ultimately socioeconomic outcomes. Thinking in terms of 'achievement gaps' emphasizes the symptoms; thinking about unequal opportunity highlights the causes. Learning and life chances depend on key out-of-school factors such as health, housing, nutrition, safety, and enriching experiences, in addition to opportunities provided through formal elementary and secondary school preparation. (p. 3)

Many researchers have agreed that access to advanced mathematics and science courses is essential to college and career readiness opportunities (Adelman, 2006, 2007; Dougherty, Mellor, & Shuling, 2006; Klopfenstein, 2004; Klopfenstein & Thomas, 2009). However, some researchers have discovered that high schools with high minority student populations are less

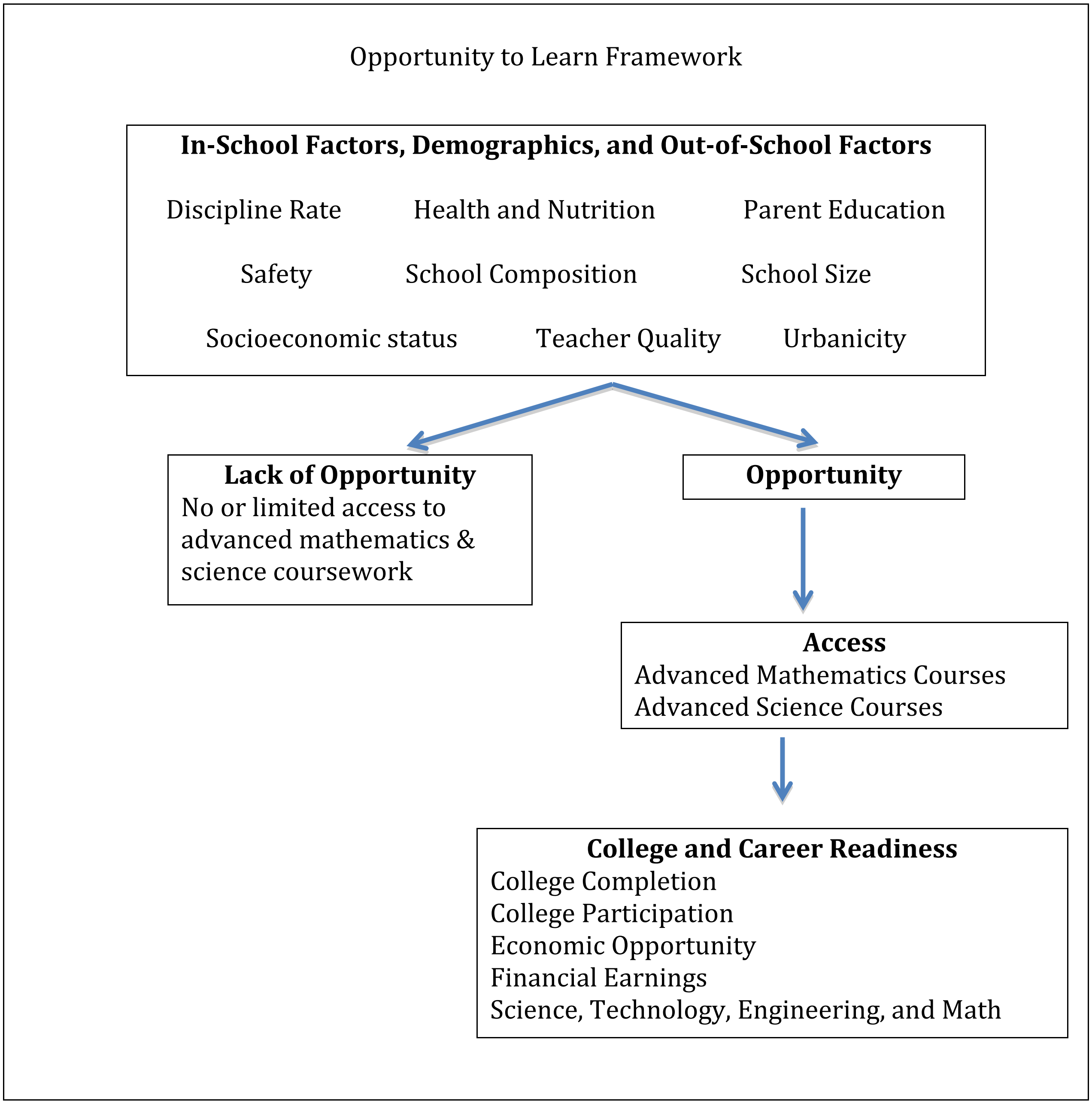

Figure 1. Opportunity gap framework. Adapted from combined schematic illustration of the "Opportunity Gap Conceptual Framework" P. L. Carter and K. G. Welner, 2013, *Closing the Opportunity Gap: What America Must do to Give Every Child an Even Chance*, Oxford University Press; and "The Transformed: Civil Rights Data Collection" by Office of Civil Rights, 2012, Washington, DC.

likely to offer advanced mathematics and science courses than high schools with low minority student populations (OCR, 2012; Riegle-Crumb, 2010). These disparities highlight an opportunity gap. Closing the opportunity gap in advanced mathematic and science course offerings could lead to greater achievement outcomes for students, particularly Black and Latino students.

This conceptual framework was used to explore the extent that students have access to college and career readiness opportunities in Virginia public high schools, as defined by access to advanced mathematics and science courses. Student access to these opportunities has been found to have a positive impact on postsecondary successes to include college participation, degree attainment, and financial earnings.

Purpose of the Study

This study investigated student access to advanced mathematics and sciences courses in Virginia public high schools as an indicator of college and career readiness by school size (fall 2012 membership enrollment), economically disadvantaged percentage, minority student percentage (percentage of Black or Latino students), and urbanicity locale. This study examined the extent of disparities in access to opportunity to learn based upon several identified factors. A national focus to produce more college and career-ready graduates inherently requires access to advanced mathematics and science courses. Closing the gap in access to educational opportunity is needed in order for America to remain competitive in the world in the STEM field.

Research Questions

Using descriptive statistics and regression analysis, this quantitative study addressed the following research questions:

1. To what extent does access to advanced mathematics and science courses among students in Virginia public high schools vary by school size, as defined by fall 2012 membership enrollment?
2. To what extent does access to advanced mathematics and science courses among students in Virginia public high schools vary by economically disadvantaged percentage, as defined by the percentage of students classified as economic disadvantaged?
3. To what extent does access to advanced mathematics and science courses among students in Virginia public high schools vary by minority student percentage, as defined as the percentage of Black or Latino students?
4. To what extent does access to advanced mathematics and science courses among students in Virginia public high schools vary by urbanicity locale (city, suburban, town, and rural)?
5. Controlling for teacher quality and discipline rate, to what extent do school size, economically disadvantaged percentage, minority student percentage, and urbanicity factors predict access to the number of advanced mathematics and science course offerings in Virginia public high schools?

Significance of Study

This study is important because it investigated student access to advanced mathematics and science course offerings in Virginia public high schools. Examining college and career-readiness opportunities, where all students have access to advanced mathematics and science courses at the secondary school level, is timely. Carnevale and colleagues (2013) reported that by 2020, an estimated 65% of all jobs in the Unites States, a 37 percentage point increase since

1973, will require postsecondary education and training beyond high school. Many of these jobs will be in STEM-related fields, which are among the fastest growing occupations in the nation (Carnevale et al., 2013; Zuckerman, 2011). Despite these statistics, today, “four of every 10 new college students, including half of those at 2-year institutions, take remedial courses, and many employers comment on the inadequate preparation of high school graduates” (U.S. Department of Education Office of Planning, Evaluation and Policy Development, 2010, p. 7). In addition, nationally, OCR (2012) reported disparities in access to college and career-ready courses between schools with high minority populations and those with low minority populations. It is important that graduates at the secondary and postsecondary levels have college and career readiness skills (Achieve, 2008).

There have been limited studies that have examined access to advanced mathematics and science courses at the state level. The VDOE (2010), as part of the Virginia College and Career Readiness Initiative (VCCRI), indicated that student participation in college preparatory curricula, including Algebra II, Chemistry, advanced placement, international baccalaureate, and dual enrollment courses, is among a series of college and career-readiness indicators that are “independently associated with a high probability of enrollment and persistence in four-year postsecondary institutions” (VDOE, 2010, p. 1). This study adds to the literature regarding the nature of and extent of access to opportunity to learn and the production of college and career-ready graduates. Understanding the extent and/or context that students in Virginia have access to advanced mathematics and science course offerings across all public high schools is important for Virginia educators, economists, policymakers, educational leaders, and other researchers. The findings from this study may provide insight to various stakeholders on the condition of education relative to college and career-readiness for Virginia students.

In addition, the results from this study may be used to highlight college and career readiness efforts across the state and to develop programs in K-12 education. From an economic perspective, economists, policymakers, and educators may use the results of this study to highlight the production of high school graduates with the necessary skills needed to fulfill 21st century STEM and Career and Technical Education (CTE) careers. This in turn may enhance the production of college and career ready students and may help to close disparities in achievement, earnings, and college success for students.

Definition of Terms

The following operational definitions were used in this study:

Access. Access refers to school course offerings of advanced mathematics and science courses (OCR, 2012)

Advanced mathematics courses refer to mathematics courses at the Algebra II level and higher. This includes advanced placement mathematics courses. International baccalaureate and dual enrollment advanced mathematics courses will be categorized or paralleled with similar courses based upon course description. Table 1 provides the course title and Virginia course code for advanced mathematics courses at or above the level of Algebra II (VDOE, 2013).

Advanced science courses refer to advanced science courses at the Chemistry level and higher. This includes advanced placement science courses. International baccalaureate and dual enrollment advanced mathematics courses will be categorized or paralleled with similar courses based upon course description. Table 2 provides the course title and Virginia course code for advanced science courses at or above the level of Chemistry (VDOE, 2013).

College and career readiness. The term college and career readiness refers to standards designed to “strengthen students’ preparation for college and the work force before leaving high school" (VDOE, 2009, p. 1). OCR (2012) defined as access to advanced mathematics and science courses offerings, at the level of Algebra II or higher and Chemistry or higher,

Table 1

Virginia Advanced Mathematics Courses at or Above the Level of Algebra II

Course title	Virginia course codes
Advanced Mathematics	3160
Algebra II	3135
Algebra II and Trigonometry	3137
Analytic Geometry	3176
Discrete Mathematics	3154
Elementary Mathematics Functions	3163
Mathematical Analysis/Pre-Calculus	3162
Mathematics Capstone	3136
Multivariate Calculus	3178
Probability and Statistics	3190
Trigonometry (one semester)	3150
Advanced Placement Calculus AB	3177
Advanced Placement Calculus BC	No Virginia Code
Advanced Placement Computer Science A	3185
Advanced Placement Computer Science AB	No Virginia Code
Advanced Placement Statistics	3192

Note. Adapted from "Board of Education Courses Approved for Advanced and Standard Diplomas," by the Virginia Department of Education, 2013.

Table 2

Virginia Advanced Science Courses at or Above the Level of Chemistry

Course title	Virginia course codes	Changes in course
Chemistry	4410	
Chemistry II	4420	
Physics I	4510	
Physics II	4520	
Principles of Technology II[a]	9812	
Advanced Placement Biology	4370	
Advanced Placement Chemistry	4470	
Advanced Placement Environmental Science	4270	
Advanced Placement Physics 1	4573	
Advanced Placement Physics 2	4574	
Advanced Placement Physics B[b]	4570	
Advanced Placement Physics C	4571	

[a]The Principles of Technology I (9811) and II (9812) sequence will satisfy one standard unit of credit unit in laboratory science for physics and one elective credit. Students who enroll in Principles of Technology sequence must have completed Algebra I and two other laboratory science courses as specified by the Standard of Accreditation prior to enrolling in Principles of Technology.

[b]Advanced Placement Physics 1 and 2 will begin to be offered in the 2014-2015 academic school year. Advanced Placement Physics B will be discontinued following the 2013-2014 school year.

Note. Adapted from "Board of Education Courses Approved for Advanced and Standard Diplomas," by the Virginia Department of Education, 2013.

respectively. For this study, college and career readiness is defined based upon percentage of advanced mathematics and science course offerings. (OCR, 2012; VDOE, 2009a)

Economically disadvantaged percentage refers to percentage of students who met any of the following: (a) eligible for free or reduced meals, (b) received TANF, (c) eligible for Medicaid, or (d) identified as experience or migrant homelessness. This term was used to examine the percentage of economically disadvantaged students (VDOE, 2009a).

Minority students. For purposes of this study, minority student referred to Black or Latino students.

Minority student percentage was defined as ratio of number of Black or Latino students enrolled in school and total school enrollment based upon fall 2012 membership count (VDOE, 2009a).

Opportunity gap. Opportunity gap was defined by disparities/differences in advanced mathematics and science course offerings among Virginia public high schools.

Race/ethnicity. The VDOE uses the following racial/ethnicity codes to describe students' ethnicity.

a. American Indian or Alaska Native. A person having origins in any of the original peoples North and South America (including Central America), and who maintain tribal affiliation or community attachment (VDOE, 2009b).

b. Asian. A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam (VDOE, 2009b).

c. Black or African American. A person having origins in any of the Black racial groups of Africa (VDOE, 2009b).

d. Hispanic/Latino. A person of Cuban, Mexican, Puerto Rican, South or Central American, or other Spanish culture or origin, regardless of race (VDOE, 2009b).

e. Native Hawaiian or Other Pacific Islander. A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands. (VDOE, 2009b).

f. White. A person having origins in any of the original peoples of Europe, the Middle East, or North Africa (VDOE, 2009b).

School size was defined based on fall membership numbers on September 30th of the 2012-2013 school year. Fall membership count refers to the number of students that were actively enrolled in each Virginia public high school on September 30, 2012 (VDOE, 2009a).

Teacher quality was defined based on the percentage of core academic classes taught by teachers meeting the federal definition of highly qualified within their area of endorsement. (VDOE, 2015).

Urbanicity or urban-centric locale codes refer to school location based upon the geographic location of the school building. School locale codes are based upon each school's geographic location and proximity to densely populated urban areas (Keaton, 2015). NCES uses urbanicity or urban-centric locale codes that are divided into four main locale types (see Appendix A). Each locale type has three subtypes (large, midsize, and small for city and suburb locale types and fringe, distant, and remote for town and rural locale types) (Keaton, 2015). For purposes of this study, urbanicity is defined using the four main locale types and code. See Appendix A.

a. City (small, midsize, large) refers to territory inside an urbanized area and inside a principal city with population ranging between fewer than 100,000 to 250,000 or more (Keaton, 2015).

b. Suburb (small, midsize, large) refers to territory outside a principal city and inside an urbanized area with population ranging from 50,000 to 250,000 or more (Keaton, 2015).

c. Town (remote, distant, fringe) refers to territory inside an urban cluster that ranges from 10 or fewer miles to more than 35 miles of an urbanized area. (Keaton, 2015).

d. Rural (remote, distant, fringe) refers to rural territory that is 5 or fewer miles from an urbanized area to more than 25 miles from an urbanized area and is also 2.5 or fewer miles from an urban cluster to more than 10 miles from an urban cluster (Keaton, 2015).

Limitations and Delimitations

Limitations refer to restrictions in a study that are beyond the control of the researcher (Rudestam & Newton, 2014). There are several limitations that should be considered relative to this study. This study was limited to advanced mathematics and science course offerings, as defined by VDOE, at the Algebra II, Chemistry, and higher levels in Virginia public high schools. This study also entailed the analysis of secondary data, which unlike primary data, are subject to inaccuracies, misreporting, or skewedness, given that the data were not collected by the researcher (Burstein, 1978; Creswell, 2014; Kassner, 2012).

Rudestam and Newton (2014) explained that delimitations explicitly describe limitations on the research design that the researcher intentionally imposed to restrict the generalization of the results to other populations. An important delimitation to note is the synthesis of Carter and Welner's (2013) and OCR's (2012) conceptual frameworks for examining college and career readiness. The purpose of this study was to examine student access to advanced mathematics and science course offerings in Virginia public high schools during the 2012-2013 school year. This study did not examine advanced mathematics and science course offerings in private or charter high schools in Virginia. Additionally, it only examined data from the 2012-2013 school year. This study did not examine advanced mathematics and science course offerings in other states. Finally, this study was not intended to focus on student enrollment or achievement in advanced mathematics and science courses as an indicator of college and career readiness.

This study explored advanced offerings in mathematics and science courses only and did not examine advanced course offerings in any other content areas. Student access to advanced mathematics and science course offerings was examined school size, economically disadvantaged percentage, the percentage of minority students, and urbanicity locale in Virginia public high schools. This study did not focus on any other variables. Lastly, although the results from this study can only be generalized to public high schools in the Commonwealth of Virginia during 2012-2013 school year, they may highlight disparities in access and indicate the magnitude of access to college and career readiness opportunities in Virginia.

Organization of the Study

This dissertation is organized and presented in five chapters. Chapter One provides an introduction of the topic of interest for this study, which presented an overview, statement of the problem, conceptual framework, purpose of the study, research questions, significance of the study, operational definitions, and potential limitations and delimitations. Chapter Two reviews research literature regarding factors associated with opportunities to learn that influence college and career preparedness outcomes for students at the secondary school level. Chapter Three outlines the methodology and provides a description of the research design and data analysis that will be used. Chapter Four shares data analysis results and Chapter Five will present findings, a brief summary, conclusions, and implications for future research, policy, and practice.

Chapter Two: Review of the Research Literature

Background

In 2009, President Barack Obama and the Obama administration enacted Race to the Top, an educational reform initiative designed to promote innovation and excellence in America's schools to prepare every child for the challenges of the 21st century. One of the primary focuses of Race to the Top was to encourage states to be innovative about raising standards and preparing students for college and careers (USDOE, 2010). Researchers have indicated that student success in advanced mathematics and science courses is a gateway to college and career opportunities and increases prospects for future income (Achieve, 2008; Adelman, 2007; Lleras, 2008; NMAP, 2008). Student success in advanced mathematics and science coursework is strongly correlated with a series of postsecondary outcomes, such as college participation, college graduation, employment in STEM careers, and higher earnings in the top quartile (College Board, 2014; Klopfenstein & Thomas, 2009; NMAP, 2008; Tai et al., 2010). NMAP (2008) asserted that such correlation is projected to be greater in the future. In fact, Carnevale et al. (2013) reported that job growth in intensive mathematics, science, engineering, and other STEM occupations is outpacing job growth in other areas such as social science, community service, and art. Between 2010-2020, job vacancies in STEM careers are projected to exceed 2.6 million (Carnevale et al., 2013). College and career-ready graduates, capable of filling these positions are important to the vitality of the economy (Zuckerman, 2011).

International and national statistics indicated that American students are not excelling in the areas of mathematics and science at levels expected of an international leader of the western world (OCED, 2014). For example, recent achievement data from the Programme for International Student Assessment (2012) indicated that the achievement of American students in mathematics and science is mediocre in comparison to the achievement of peers worldwide. In addition, from a national perspective, the latest national report card by NAEP, (2014) suggested that only 32% of students in Grade 8 scored at or above the "proficient" level and only 23% are proficient at Grade 12 in mathematics.

Both the achievement gap in mathematics and science courses and the opportunity gap in access to advanced mathematics and science course offerings are troubling (College Board, 2014; Lleras 2008; Riegle-Crumb & Grodsky, 2010). While the College Board (2013, 2014) has reported an increase in the number of students enrolled in advanced placement courses across all racial/ethnicity subgroups over the last decade, Black students remain among the most under-represented groups of students to take AP courses and lag behind White counterparts' performance (Riegle-Crumb & Grodsky, 2010). The College Board (2014) indicated that among students who had high potential for success in AP science courses, only 3 out of 10 Black students took such courses in comparison to 4 out of 10 White students and 6 out of 10 Asian/Asian American/Pacific Islander students. Students' potential to do well was measured by their performance on the Preliminary Scholastic Achievement Test (PSAT) and National Merit Scholarship Qualifying Test (NMSQT) results, which the College Board suggests is "currently the strongest predictor of success" (College Board, 2014, p. 28) in AP courses. Both tests assessed students' knowledge in the areas of critical reading, writing, and mathematics. This report did not disaggregate the data by gender and it did not provide an explanation for why students did not capitalize on the opportunity to enroll in such AP courses (College Board, 2014).

A review of empirical research on the state of education indicated that minority students do not have equal access to college and career readiness opportunities and resources in high school (Aud et al., 2012; Carter & Welner, 2013; OCR 2012). The term college and career-ready coursework refers to advanced mathematics and science courses including AP courses. The disparities in access to these and other educational opportunities are of great influence.

Specifically, enhancing student access to and completion of high-level mathematics and science coursework, including AP courses, is of great importance and remains a priority among politicians, economists, educational leaders, policymakers, and other stakeholders (Adelman, 2006; College Board, 2013; Darling-Hammond, 2004; Lleras, 2008; Riegle-Crumb, 2005). Many of these courses influence the educational outcomes and postsecondary aspirations of students such as postsecondary degree attainment, college participation, earnings, access to STEM and CTE careers, and the labor market (Adelman, 2007; Riegle-Crumb, 2005). Therefore, this review will outline and provide an understanding of factors that contribute to the disparities in access to college and career college-readiness opportunities in K-12 education and direction for further research.

Purpose of the Literature Review

The purpose of this literature review is to examine empirical studies of factors associated with student access to college and career-ready courses in high school and the impact that high-level mathematics and science courses have on college and career-readiness and other postsecondary outcomes. This review of literature is organized and outlined in the following three themes: the importance of college and career readiness opportunities, linking high-level mathematics and science course participation to college entrance and career readiness, and access to college and career-readiness opportunities. Collectively, this literature review provides insight on the importance of college and career-ready opportunities and disparities in access at the secondary school level.

Search Process

The search process employed to conduct a comprehensive review of the literature on this educational topic entailed a variety of methods. Research specifically related to opportunities to learn and factors that impact student access to college and career preparatory courses helped provide a general context for the current literature review. Readings related to closing the opportunity gap and student access to educational opportunities led to: (a) identifying key researchers and authors in the field and their findings, (b) identifying factors associated with student access to educational opportunities, (c) importance of high-level mathematics and science courses on college and career readiness opportunities for all students, and (d) identification of methods used to study this topic.

Peer-reviewed journal articles, resources published by national organizations such as College Board, Educational Testing Services, U.S. Department of Education, National Council for Teachers of Mathematics, and books provided information regarding factors of influence, important terms, and background knowledge. Specifically, Carter and Welner's (2013) book entitled, *Closing the Opportunity Gap: What America Must Do to Give Every Child an Even Chance,* was a primary source that described how the achievement gap exists as a consequence of gaps in opportunities to learn for students, especially those from disadvantaged or impoverished communities. In addition, the USDOE's Office of Civil Rights provided a framework for defining and/or identifying the opportunity gap.

Online search engines such as Google Scholar, EBSCHOHost, Springer, ERIC, and Summons were used to find scholarly peer-reviewed literature published within the last 10 years. Key words and search terms used included (a) closing the opportunity gap, (b) access (c) rigorous curriculum, (d) teacher quality, (e) college and career readiness, (f) advanced mathematics and science course offerings, and (g) opportunity to learn. Seminal studies conducted prior to 2005 were also included to provide a historical perspective regarding disparities in opportunities to learn for Black students.

Overview of Broad Ramifications of College and Career Readiness

Barton and Coley (2009) defined college and career readiness as access to a rigorous or high-quality curriculum such as gifted education and AP courses, while others refer to college and career readiness as student access to and completion of advanced mathematics and science courses (College Board, 2014; OCR, 2012; Riegle-Crumb, 2005). ACT, Inc. (2013) defined college and career readiness as

> the acquisition of the knowledge and skills a student needs to enroll and succeed in credit-bearing first-year courses at a postsecondary institution (such as a 2 or 4 year college, trade school, or technical school) without the need for remediation. (ACT, Inc., 2013). (p. iii)

Unfortunately, the need for remediation can persistently be an obstacle for Black and Latino students in high school and in college, where they are disproportionately represented in comparison to their peers (Attewell, Domina, Lavin, & Levey, 2006; Ignash, 1997; Schott Foundation, 2009). Opportunities in K-12 education that ensure students have access to and participate in college and career-ready coursework are essential to a series of postsecondary outcomes, including higher SAT and ACT performance, success in college participation (College Board, 2013, 2014; Schott Foundation, 2009), college degree attainment (Achieve, 2008; Rose, 2013), and economic stability (Moller & Stern, 2012)

Since 1959, ACT, Inc. has examined the extent that students are academically ready for college (ACT, Inc. 2013a). In a recent publication, *The Condition of College and Career*

Readiness (ACT, Inc., 2013a) provided a snapshot of the extent that high school students from the class of 2013 are college and career ready. ACT, Inc. (2013a) used the ACT College Readiness Benchmarks, and indicated the minimum scores that students needed on ACT subject area tests to earn a 50% chance of obtaining a B or higher, or a 75% chance of obtaining a C or higher in corresponding credit-bearing first-year college courses. ACT, Inc. (2013a) found that only 44% of all ACT-tested high school graduates met the Mathematics ACT College Readiness Benchmarks, while 36% met the ACT College Readiness Benchmark in science. Both statistics reflect a steady increase over the past 4 years. Further, a review of ACT test takers' performance by race/ethnicity among the class of 2013 nationally revealed that Asian graduates met all ACT College Readiness Benchmarks at a higher rate than graduates of all other racial/ethic groups. Forty-three percent of Asian graduates met all four benchmarks in comparison to 33% of White graduates, and 14% of Latino graduates. Black graduates were least likely to meet all four benchmark standards, at only 5% (ACT Inc., 2013a).

In Virginia, 26% of Virginia high school graduates (22,165 students) from the class of 2013 took the ACT test, reflecting a 23.8% increase from 2009 to 2013. Fifty-eight percent of 2013 ACT-tested high school graduates in Virginia who completed or exceeded the recommended core curriculum met the ACT College Readiness Benchmark in mathematics in comparison to only 7% of those who completed less than the core curriculum coursework. Similarly, 49% of 2013 ACT-tested high school graduates in Virginia who completed or exceeded the recommended core curriculum met the ACT College Readiness Benchmark in science in comparison to only 16% of those who completed less than the core curriculum coursework (ACT, Inc., 2013b).

The U.S. Department of Labor, Bureau of Labor Statistics (2010) indicated that careers in education, computer information specialties, community services, management, and marketing/sales are among the five fastest growing careers in America for the years 2010-2020. ACT, Inc. (2013) indicated that an estimated 55% of jobs during this time frame would require at least a 2-year postsecondary degree. In an examination of interest in these five careers among 2013 ACT tested high school graduates and the annual projected number of job openings. ACT, Inc. (2013) found that the number of projected job openings exceeded the percentage of 2013 ACT-tested high school graduates who were interested in these careers. For example, this report cited the projected demand in 2020 in the fields of computer/information specialties, marketing/sales, and education to be more than twice the potential interest among ACT-tested high school graduates (ACT, Inc. 2013). Furthermore, among those 2013 ACT-tested high school graduates interested in these careers, less than 50% of ACT-tested high school graduates met the ACT College Readiness benchmark in science. In the same analysis, ACT, Inc. (2013) found that more than 50% of 2013 ACT-tested high school graduates met the mathematics benchmark standards for computer information specialties careers, but failed to do so for the remaining four fastest growing careers in education, community service, management, and marketing sales. This pattern remained consistent in Virginia where the percentage of job openings requiring 2-year degrees or more exceeded career interest in the state's five fastest growing fields among Virginia 2013 ACT-tested high school graduates (ACT, Inc., 2013b). These findings illustrate a concern relative to the preparation of 2013 ACT-tested high school graduates to fulfill many of these careers.

A glimpse of the nation's report card on academic achievement (ACT, Inc., 2013; Aud et al., 2012; College Board, 2014; Kena et al., 2014; Schott Foundation, 2009), population growth, and economic growth of STEM and CTE-related careers revealed that producing college and career-ready graduates must remain a priority in America. Failure to do so could adversely impact America's economic stability and the potential of the nation's economy to remain competitive in global market (Kirsch, Braun, Yamamoto, & Sum, 2007). The research of Kirsch et al. (2007) warrants close attention.

Kirsch and colleagues (2007) asserted that America is heading into "the midst of a perfect storm—the result of three confluence forces, divergent skill distributions, changing economy, and demographic trends" (p. 3). These three factors, discussed below, are associated with educational and economic outcomes. First, Kirsch et al. (2007) argued that the spread of skills associated with college and career readiness continues to diverge. The graduation rate for students from disadvantaged backgrounds was poor in comparison to students from nondisadvantaged backgrounds (Kirsch et al., 2007). The researchers also reported large and stable achievement gaps in reading and mathematics between 13-and-17 year old Black-White students and Latino-White students. Although student performance in reading and mathematics continues to rise, the gaps by subgroup in achievement persist (Kena et al., 2014). Further, Kirsch et al. indicated a rise in inequities, and an increase in adults aged 16 and older, with insufficient literacy and numeracy skills for the workforce. The authors concluded that these factors appear to contribute to an increased of divergence skill distribution in America.

Secondly, Kirsch et al. (2007) posited that advancements in technology, innovation, and globalization are leading to a changing economy both nationally and internationally. Manufacturing jobs in America have consistently declined since the mid-1900s: during the 1950s (33.1%), in 1989 (18.2%), and in 2003-2010 (7%), due to technological innovations and cost saving, while labor market jobs that require college degree graduates have steadily increased

(Kirsch et al., 2007). In addition, financial earnings have accrued to levels of educational degree attainment (e.g., high school diploma/GED, bachelor's degree).

Lastly, Kirsch et al. (2007) argued rapid demographic changes in America as the third force. The researchers referenced a more diverse population where international migrants account for more than half of the nation's population growth in America between 2000 to 2015 and a relatively large immigrant Latino population without high school diplomas.

Kirsch et al. (2007) forecasted that

> over the next 25 years or so, as better-educated individuals leave the workforce, they will be replaced by those who, on average, have lower levels of education and skill. Over this same period, nearly half projected job growth will be concentrated in occupations associated with higher education and skill levels. (p. 4)

However, findings from the 2005 Adult Literacy and Life Skills Survey (ALLS) illustrated that less than 50% of the U.S. population between the ages of 16 to 65 performed at a Level 3, which was considered the baseline standard for labor market success, or higher, on each literacy scale (Kirsch et al., 2007). The authors reported that literacy proficiency levels were measured along three distinct scales, prose literary, document literature, and numeracy. Levels ranged from 1 (lowest) to 5 (highest). A review of prose proficiency level by race or ethnicity demonstrated that "the percentage of Hispanic adults who demonstrate skills in the lowest of the five literacy levels is four times that of White adults (49 percent compared with 12 percent)" (Kirsch et al., 2007, p. 13). Further, the percentage of Black adults in comparison to White adults in the lowest literacy level was 33% in comparison to 12%, respectively.

This seems troubling as it suggests that millions of American students and adults will not qualify for higher paying jobs in a future national or international economy. Ensuring students have access to and participation in college and career-ready coursework in high school is vital to calming the storm and counteracting all three forces. Researchers have asserted that access to college and career readiness opportunities impacts closing the achievement gap in secondary schools (Achieve, 2008), participation in AP courses (College Board, 2014; Flowers, 2008), and postsecondary college enrollment and degree attainment (Barton & Coley 2009; Flowers, 2008; Ford & Moore, 2013; Reigle-Crumb, 1998). In addition, students, especially minority students, who take college and career-ready course work have greater success in employment outcomes in the labor market (Moller & Sterns, 2012).

Education Policy: The Virginia College and Career-Readiness Initiative

In 2007, directed by the Virginia Board of Education, the VDOE, as part of the VCCRI, began studying academic indicators associated with preparing high school students for college and careers (VDOE, 2011). Examining factors that impact college and career preparedness, the VDOE requested that Achieve, the American Diploma Project, the College Board, and ACT, Inc. conduct studies to compare postsecondary readiness standards to Virginia's Standards of Learning in English, reading, and mathematics (VDOE, 2010). Within 3 years of the start of this initiative, the Virginia Board of Education adopted revised standards in English and mathematics that reflected recommendations from a series of experts that included College Board, ACT, Inc., the American Diploma Project, and business leaders (VDOE, 2010). According to this report, the VCCRI was designed to "ensure that college and career ready learning standards in reading, writing, and mathematics are taught in every Virginia high school classroom; and strengthen students' preparation for college and the work force before leaving high school" (VDOE, 2010, p. 1). These organizations identified several college and career-ready indicators including student participation in a college preparatory curriculum that includes Algebra II and chemistry, earning advanced proficient scores on mathematics, reading, and writing Standards of Learning assessments, earning an advanced studies diploma, participation in AP, international baccalaureate, dual-enrollment courses, the Virginia Early College Scholars program, and earning college-ready scores on college entrance examinations such as the SAT and ACT (VDOE, 2010).

An important focus on the VCCRI and building on the aforementioned work, Virginia is focused on improving "the number of high school graduates who meet or exceed college and career ready benchmark" (VDOE, 2010, p. 2). VDOE continues to lead efforts in collaboration with the Virginia Community College System and the State Council of Higher Education for Virginia to identify and enhance the percentage of Virginia high school graduates with the necessary academic and career skills needed to be successful in postsecondary education program (VDOE, 2010). More than 7 years after the start of the VCCRI, the study is timely because investigated student access to college and career ready course offerings in Virginia public high schools.

Impact of Advanced Mathematics and Science Courses on College Enrollment and Completion

Some researchers contended that Algebra I is the "gateway" to students taking more advanced level mathematics courses in high school and essential to greater levels of achievement (Adelman, 2002, 2006; Dougherty, 2010; Loveless, 2008; Riegle-Crumb & Humphries, 2012; Tierney et al., 2009). Algebra I is widely known as a prerequisite for advanced mathematics courses-taking such as Algebra II and above. Students who complete honors courses such as Algebra I in middle school have greater access to advanced mathematics courses in high school than those enrolled in lower level mathematics classes (Nomi, 2012 & Walker, 2007). Completion of advanced mathematics courses in high school also leads to greater college and career opportunities (Adelman, 2006; OCR, 2012). Therefore, greater attention to middle school mathematics instruction, particularly for traditionally low performing (minority) students, is crucial so that these students are ready to access opportunities for Algebra I in middle school. Such success in Algebra I in middle school would go far in improving these students' readiness for more rigorous advanced mathematics courses in high school (Achieve, 2008; National Council for Mathematics, 2008; Nunez, Bugarin, & Warburton, 2001).

Adelman (2006) examined taking advanced mathematics courses in high school and postsecondary educational outcomes. The researcher found that student completion of advanced mathematics courses in high school was a strong predictor of college graduation among students, irrespective of family background. Students who completed advanced mathematics courses were twice as likely to attain a bachelor's degree than those who did not.

Klepfur and Hull (2012) examined the impact of advanced mathematics course-taking on student college success. Using Education Longitudinal Study (ELS) 2002-2006 data, the researchers analyzed longitudinal data from high school students who were sophomores in 2002 through their second year of 2-and-4 year colleges in 2006. The researchers found that students who took advanced mathematics courses beyond Algebra II in high school were more likely to successfully reach sophomore status in college. Further, they found completing the highest level of mathematics in high school to be among one of the greatest predictors of college success (Klepfur & Hull, 2012).

These researchers also found that a student with above average SES and achievement had a 10% better chance of persistence in a 4-year college/university if that student completed pre-calculus, calculus, or an advanced mathematics course above Algebra II. SES was based upon five weighted variables including family income, mother and father's occupation, and mother and father's education divided into quintiles. A student with a low SES and achievement who completed advanced mathematics courses in high school was 22% more likely to persist in college (Klepfur & Hull, 2012). The persistence rate for students who completed advanced mathematics courses beyond Algebra II in high school and attended 2-year institutions was greater; 18% for students from above average SES and achievement and 27% for students from lower SES and achievement, respectively (Klepfur & Hull, 2012).

In addition, Klepfur and Hull (2012) found that advanced placement and international baccalaureate courses had a substantial positive impact on students' chances of reaching their sophomore year of college even if they were unsuccessful on the end of the course exam. Low achieving and low SES students who took AP/IB courses were 30% more likely to persist in 2-year institutions and 17% more likely to persist in 4-year colleges. Similar to Klepfur and Hull (2012), Sadler and Tai (2007) reported that students who completed advanced mathematics courses at the Algebra II level or higher, generally felt adequately ready for college mathematics courses and were more successful in higher-level science courses such as advanced biology, chemistry, and physics. ACT, Inc. (2006) also indicated that the mathematics competencies needed for Career and Technical Education occupations were also comparable to those needed for college success. In a more recent analysis, ACT Inc. (2013b) found that students who completed a core curriculum, which they defined as 4 years of English, 3 years of mathematics, science, and social studies, respectively, increased their readiness for college and careers more than those who took fewer core courses.

However, contrary to these findings, there is also mixed evidence about the relationship between AP course-taking and postsecondary outcomes for students. Thompson and Rust (2007) studied the relationship between AP course completion and college GPA. Their research yielded results showing no significant difference in college GPA among students who did not enroll in AP courses in high school than those who did. In contrast, Taliaferro and DeCuir-Gunby (2008) posited that student participation in AP courses would "help students not only be competitive for college admission, but also give them college credits and familiarity with advanced course content" (p. 175). In addition, the College Board (2014) has argued that AP courses are one of several college and career-ready indicators. These opportunities beyond college in terms of careers have been found to positively improve earning, especially among those from disadvantaged or low-SES backgrounds (Achieve, 2008).

Impact of advanced science course-taking. A number of researchers have explored the relationship between advanced science course-taking and college success and interest in STEM careers (Robinson, 2003; Robinson, Fadali, Ochs, & Willis, 2002; Tai, Sadler, & Mintzes, 2006; Tyson, Lee, Borman, & Hanson, 2007). Many researchers agree that the skills and content knowledge gained in advanced mathematics courses are foundational and relevant for success in advanced science courses (Stern, 1987).

Tyson et al. (2007) examined postsecondary degree attainment data of 16,587 students who earned a college degree within 6 years of high school graduation. Using longitudinal data to analyze high school course completion during the 1996-1997 school year, Tyson and colleagues discovered that students who completed calculus or physics in high school were more likely to earn a postsecondary STEM degree. In fact, the researchers discovered that race and gender were predictors of STEM degree attainment. For example, Tyson et al. (2007) found that Latino and Asian students obtained STEM degrees at rates higher than their non-Latino and non-Asian peers. In addition, male students obtained STEM degrees at a higher rate than females. Black and Latino students were more likely to not take the highest level of mathematics and science courses in high school; however, those who did reportedly were just as likely to pursue STEM degrees as their White peers. A suggestion that emerged from this study was that

> schools find ways to offer opportunities for all students to enroll in the highest level courses in mathematics and science, for if they do, students taking these courses are more likely to persist in the STEM pathway regardless of race or ethnicity. (Tyson et al., 2007, p. 269)

Using data from the National Education Longitudinal Study of 1988 (NELS:88), Maltese and Tai (2011) found that high school students who took chemistry and biology in Grades 11 and 12, respectively, were more likely to pursue majors associated with STEM careers entering college. The researchers controlled for earlier interest in a STEM career and student's knowledge of and attitude toward mathematics and science. In addition, controlling for prior interest in science, Maltese and Tai (2011) found that the total number of high school science courses including physics and chemistry was positively associated with students earning a college degree in science, technology, engineering, or mathematics. Student completion of pre-calculus and calculus coursework in high school was also reported as a positive predictor of students earning a college degree in science, technology, engineering, and/or mathematics after controlling for student background.

Using data from 8 of 10 high schools in a western diverse school district with more than an estimated 15,000 high school students in Grades 9 through 12, Robinson (2003) examined the relationship of AP course completion and student interest and pursuit of college degrees in STEM-related fields among minority and nonminority students. The researcher analyzed AP data from the 2002-2003 school year for 315 students (5 Native American/Alaskan Native students, 14 Latino students, 32 Asian/Pacific Islander students, 4 African Americans, 14 others, and 246 Caucasian students) enrolled in 512 AP courses. Robinson found that students enrolled in AP science courses (i.e., AP chemistry, biology, and physics) were more likely to pursue college degrees in STEM-related fields than non-STEM fields, including humanities, business, and fine arts. In fact, the researcher discovered that minority male students enrolled in AP science courses and AP calculus pursued STEM careers in college at more than twice the rate of non-STEM career choices. In addition, Robinson (2003) reported differences in enrollment of AP courses by SES and school size. Schools with high SES offered more AP courses and had greater student enrollment. Small and rural schools were also identified as not offering as many AP courses as nonsmall and rural schools.

Impact of Advanced Mathematics and Science Completion on Careers and Earnings

Beyond college success, student completion of advanced mathematics courses can impact income and earnings. In a seminal study, Levine and Zimmerman (1995) examined the effect that mathematics and science courses have on wages 6 years after high school graduation. Using data from the National Education Longitudinal Survey of Youth and High School and Beyond's (HSB) 1980 senior cohort, with separate estimation models by gender, the researchers used the number of mathematics and science credits independently as the curriculum measure in the HSB data. Levine and Zimmerman (1995) found that the number of science classes had little to no effect on wages for both males and females. However, in the same analysis, the researchers found that the number of mathematics classes completed had a positive effect on wages for both males and females.

For example, the authors reported students who took an additional semester of mathematics earned an average wage increase ranging between 2% to 3%. However, Levine and Zimmerman (1995) reported that the mathematics effect were limited to males with only high school diplomas at 3.1%, while the mathematics effect for female college graduates who took an additional semester of mathematics during high school was a 5.4% increase in wages. The researchers indicated that mathematics and courses in the HSB data were standardized so that each course was equivalent to a year-long course. Course codes numbered 0 through 7 represented half-year courses in a subject area. A value of 6 represented three year-long courses and 8 represented four or more year-long courses. For the National Longitudinal Survey of Youth data, the researchers assumed all courses were the same length (i.e., semester and year-long) and computed the percentage of mathematics and sciences courses for a student in order to compare across students (Levine & Zimmerman, 1995).

In a more recent study, similar to that of Levine and Zimmerman (1995), Rose and Betts (2004) also examined the effects of high school mathematics curriculum courses on earnings. The researchers used the sophomore cohort of the HSB data set from 1980 to investigate the impact of six specific types of high school mathematics courses (vocational math, pre-algebra, algebra/geometry, intermediate algebra, advanced algebra, and calculus) on students' financial earnings nearly a decade after graduating from high school. Their longitudinal study surveyed over 30,000 high school sophomores in 1980 and followed up with an estimated 15,000 of them in 1982, 1984, 1986, and 1992 and documented the effects that each type of mathematics had on earnings. In their analysis, Rose and Betts (2004) found that an additional year of calculus had the greatest impact on increasing wages. For example, the researchers discovered that an additional year of calculus was projected to increase earnings by an estimated 19.5%, 11 percentage points more than taking an additional year of algebra/geometry. However, vocational math courses appeared to have no effect on earnings.

Current research studies have explored the relationship between student completion of advanced mathematics and science courses and college and career-readiness opportunities for all students, especially minority students from low SES and urban school settings (Lleras 2008; Robinson, 2003). Some researchers have found that students' completion and enrollment in AP courses have a significant association with high school completion, increased college enrollment, and reduction in postsecondary education cost or expenditures (Lewin, 2009; Taliaferro & DeCuir-Gunby, 2008). Hence, an important additional benefit of participating in AP courses is associated with reductions in college expenses when college credit is granted. Lewin (2009) reported that AP exam takers, especially minority students from disadvantaged or lower SES backgrounds, were seemingly more likely to benefit from reductions in costs associated college expenses, thereby making college more affordable, hence enabling school persistence rather than adding an obstacle to college entrance and likelihood of completion.

Flowers (2008) explored the association of AP courses with employment and labor market outcomes. Informed by the human capital theory (Becker, 1993; Schultz, 1971), he used data from the National Education Longitudinal Study of 1988 (NELS: 88/2000) and found that Black and Latino students who participated in AP programs had better educational outcomes and success with college entrance examination scores, undergraduate GPAs, postsecondary degree attainment, and income than those who did not participate in AP courses in high school. An emerging recommendation from this study was that all students should have the opportunity to participate in AP programs due to the long-term benefits associated with college and career opportunities. Yet, students must be prepared well enough in the early grades to be successful in AP courses.

On the other hand, Challenge Success (2013) asserted that the disparity in successful postsecondary degree attainment and beyond "may not be attributed to the AP program alone" (p. 4). There is a paucity of research that has investigated factors that influence student participation in honors classes as early as elementary school and subsequently advanced courses in middle and high school.

Opportunity Access

The literature review will now address access to college and career readiness opportunities and the variables of this research. Those variables include urbanicity, race/ethnicity and SES, school composition, and other factors.

Access by urbanicity. Several researchers have examined the extent that student access to college and career-readiness opportunities varies by urbanicity (i.e., urban, suburban, and rural) (Klopfenstein, 2004; Tate, 2008). Investigating access based upon the geographical location of schools and school size, a number of researchers reported disparities in student access to advanced, high-level, or rigorous mathematics and science course offerings in high school based upon urbanicity (Anderson & Chang, 2011; Greenberg & Teixeira, 1998; Lleras, 2008; Monk & Haller, 1993; Planty, Provasnik, & Daniel, 2007; Tate 2008). In a seminal study, Greenberg and Teixeira (1998) documented substantial differences in student access to advanced mathematics and science course offerings based upon urbanicity. In their analysis, the researchers found high school students who attended urban high schools had greater access to advanced mathematics courses such as calculus than those who attended rural schools. The researchers reported an estimated 64% of rural 12^{th} grade students attended high schools that offered calculus in comparison to an estimated 93% of urban 12^{th} grade students whose high schools offered calculus.

In a more recent study, Anderson and Chang (2011) examined college and career-readiness opportunities of rural high school students. The researchers investigated student access to advanced mathematics courses, mathematics course-taking patterns, and the number of mathematics credits earned by students who attended rural high schools in comparison to nonrural high schools. Using data from the 2005 NAEP High School Transcript Study that consisted of completed transcripts of over 26,000 high school seniors sampled from an estimated 2.7 million students who graduated from high school by October 2005, Anderson and Chang (2011) found that high school graduates from rural high schools had less opportunity than nonrural graduates to take advanced mathematics courses, specifically AP calculus and AP statistics, in high school. The authors discovered that AP calculus AB was offered in high schools of only 58% of rural students in comparison to 84% of students who attended nonrural schools. In addition, AP calculus BC and AP statistics were also offered less often for students who attended rural high schools in comparison to nonrural schools. Although the researchers did not indicate why such a disparity existed (i.e., lack of qualified teachers, low enrollment, etc.), an emerging recommendation from the study was that educators and school leaders should seek other means such as distance learning to ensure all rural students have access to college and career opportunities (Anderson & Chang, 2011).

In a similar analysis, Planty et al. (2007) found that high schools in rural areas were less likely to offer AP mathematics and science courses. However, the researchers reported student access to college and career-readiness courses at a greater rate through dual credit options, where students earn high school and college credits for the same course. According to Planty et al. (2007):

> Public schools located in rural areas were less likely to report offering AP courses (50 percent) than public schools in cities (77 percent). Dual-credit courses in contrast, were less likely to be offered in public schools located in cities than in public schools located in towns or urban fringe areas (65 vs. 79 and 74 percent, respectively). Seventy percent of rural schools offered courses for dual credit. (p. 6)

Other researchers have found that SES impacts the educational opportunities to include secondary and postsecondary outcomes of students in K-12 education (Kena et al., 2014; Rose, 2013; Schott Foundation, 2009; Yoon & Gentry, 2009) relating to urbanicity. Kena et al. (2014) and Aud et al. (2012) have reported that students from low-income backgrounds are not as likely to reside in suburban school communities. In fact many of these students have been found to reside in rural or urban school communities and are less likely to be represented in advanced mathematics and science courses to include AP courses (Achieve, 2008; College Board, 2014; Wyner, Bridgeland, & Diiulio, 2007).

Howley and Howley (2004) examined urbanicity (or school location) on student achievement. Howley and Howley (2004) explored achievement between students from poor backgrounds and affluent backgrounds in large (suburban or large towns) and small schools (rural or small towns). Controlling for school location, they found differences by SES between small and large high schools. The researchers reported that students from poor backgrounds enrolled in small or rural schools performed significantly better in mathematics and other subject areas (reading, science, and history) by almost 50%. Howley and Howley did not report degrees of freedom.

Overall, the literature suggests that students who attend schools in rural areas have less access to high-level mathematics and science course offerings. Considering the impact that high-level mathematics and science courses have on postsecondary outcomes, it is important to ensure that all students have access to college and career readiness opportunities irrespective of school location (OCR, 2012; Schott Foundation, 2009).

Access by race/ethnicity and socioeconomic status. Over the last decade, student enrollment and completion of advanced mathematics and science courses to include AP courses have increased (College Board, 2007, 2013, 2014). The College Board (2014), in its *10th Annual AP Report to the Nation* publication, highlighted an increase in the number of students accessing and participating in AP courses that include high-level mathematics and science courses across all ethnicities. Despite the increase in completion of advanced mathematics and science courses, recent data illustrate that gaps still persist in access to and completion of college and career opportunities for minority students, especially among Latino and Black students in comparison to White and Asian students (College Board, 2013, 2014).

For example, using College Board data on trends in the percentage of AP examinees compared to the graduating senior population in U.S. public schools in 2006, Handwerk et al. (2008) documented Black, American Indian or Alaska Native, and Latino students were under-represented in AP programs. To wit, these researchers reported that although Black students comprised an estimated 14% of public high school seniors, only 7% were among the AP examinee population. In the same analysis, Handwerk et al. (2008) reported Latino students were evenly represented at 14%; however, Asian or Pacific Islanders were over-represented in the AP program by more than five percentage points.

In a similar recent study, College Board (2014) investigated trends in access to AP courses, which is a college and career-ready indicator (Achieve, 2008; Adelman, 2007;VDOE, 2010), among the class of 2013. College Board (2014) reported that that Black students were and remained the most under-represented group in AP course enrollment and successful exam takers. College Board (2014) reported that,

> hundreds of thousands of prepared students in this country either did not take a course in an available AP subject for which they had the potential to succeed or attended a school that did not offer a course in the subject. (p. 28)

In a similar study of high school mathematics and science course-taking to include advanced course-taking among high school seniors between 1972-2004, Ingels and Dalton (2008) found differences among student enrollment in advanced mathematics classes by race/ethnicity and SES. Asian students enrolled in advanced mathematics classes an estimated three times more than Black or Latino students. In addition, despite an increase in advanced mathematics and science course-taking across all racial groups, White students enrolled or participated at a rate twice that of Black or Latino students (Ingel & Dalton, 2008).

Schott Foundation (2009), using an opportunity to learn index that measured access to high-quality schools throughout the United States and the District of Columbia, found that Black students had less than 50% opportunity to learn in comparison to White and non-Latino students. The opportunity to learn index was calculated by sorting New York City middle schools by student results on the New York State Grade 8 English Language Arts assessment. Then schools were divided into four groups, each containing equal number of students, by student performance in descending order. The percentage of students in the highest group in each community school district indicated the opportunity that a student in that group had of studying (or learning) in one of that district's schools that rank among the city's top quartile of schools (Schott Foundation, 2009). Schott Foundation (2009) found that many of the middle school inequities transitioned to high school as well where students from low-income household, irrespective of race or ethnicity, were more likely to attend one of New York City's poorest performing high schools. A recommendation that emerged from the report was that all students should have access to, "college preparatory curricula that will prepare all youth for college, work, and community" (Schott Foundation, 2009, p. 2).

Other researchers have examined student access to college and career opportunities based upon the interaction of students' race and school characteristics, including school demographic composition (Lucas & Garmoran, 2002; Michelson, 2001). In fact, some researchers found composite race to be a main effect and predictor of educational track in high school for Black students; controlling for students' race and ethnicity, student achievement, and social background (Lucas & Garmoran, 2002; Mickelson, 2001), Blacks were placed in the lowest tracks. In a startling opposition to the preponderance of the findings, Lucas and Garmoran (2002), using a nationally representative sample, found that an increase in the proportion of Black student enrollment in high school enhanced the likelihood of students being placed on higher educational track, irrespective of race and whether data were self-reported or from the transcript.

Kelly (2004) found that Black students who attended majority White schools were less likely to be enrolled in higher math course sequences when compared to similar White students in identical types of school. Contrary to Kelly (2004), Mickelson (2001) argued that a series of mechanisms influence racial segregation and impacted learning opportunities for Black students who attended racially isolated schools. Using internal data from the Charlotte-Mecklenburg School District in North Carolina, the researcher explored the effects of school desegregation and tracking on the educational outcomes of Black students. The researcher surveyed high school students (1,833 participants) from 11 high schools in Grade 12 English classes. Mickelson

(2001) found that inexperienced teachers, teachers with less educational credentials, and a greater number of lower track course offerings and enrollment in schools with predominantly Black student enrollment are all factors that contribute to fewer opportunities for Black students. An important finding from the study was the influence that racial composition had on a future educational track for students as early as elementary school. Mickelson (2001) reported that Black students who attended racially isolated elementary schools were more likely to be enrolled in lower track courses and demonstrated lower school achievement. Consistent with literature on the importance of closing the achievement gap and tracking, students who lag behind their peers early seemingly lag further behind in later grades (Jacobson, Olsen, Rice, Sweetland, & Ralph, 2001; Lleras, 2008; Welner & Burris, 2005). These findings highlight the impact that segregated tracking and low achievement prior to high school have on future educational opportunities to include college and career-readiness opportunities at the secondary school level.

Several empirical studies suggest that the Black-White achievement gap starts as early as elementary school, where Black students start elementary school lagging behind White students in knowledge, skills, and academic achievement (i.e., standardized test scores and course grades) and continue in subsequent grade levels (Jacobson et al., 2001). In later years, researchers have found that the achievement gap during middle school and within the first years of high school between Black and White students widens in mathematics (Phillips, Crouse, & Ralph, 1998). Hence, a series of variables such as skills, knowledge, effort, and access to educational opportunities to learn (Carbonaro, 2005; Carter & Welner, 2013; Ferguson, 2007) constitute racial gaps that influence subsequent college and career opportunities for Black students.

Access issues by school composition. Student access to college and career opportunities can vary by school composition. The OCR (2012) found disparities in access to advanced mathematics and science course offerings within schools in diverse districts. For example, while 66% of schools in diverse districts serving fewer Latino and Black students offered physics, only 40% of the schools serving predominantly Black and Latino students offered the same course (OCR, 2012). The OCR (2012) documented similar disparities in course offerings of advanced mathematics courses such as Algebra II and Calculus. OCR (2012) found that Algebra II was offered in 82% of high schools with low-minority enrollment in comparison to 65% of high schools with high minority enrollment schools. In the same analysis, the researcher reported that 55% of high schools with low-minority enrollment offered Calculus in comparison only 29% of high schools with high minority enrollment respectively (OCR, 2012). Although the researcher did not indicate the reason for the disparity, there was a stark disproportionality in access to advanced mathematics and science course offerings for students who attend high schools with high Black and Latino populations.

In addition, Barnard-Brak, McGaha-Garnett, and Burley (2011) examined the relationship between school characteristics and number of students enrolled in AP courses at the high school level. Controlling for school size, Barnard-Brak et al. (2011) investigated school-level factors (e.g., percentage of students with an ethnic minority background and percentage receiving free and reduced lunch) to reflect school-level characteristics that might influence the number of AP course offerings. Using data from the National Education Longitudinal Study (NELS: 88/2000), the authors found that high minority and low SES school characteristics were not associated with student enrollment in AP courses; however, they were associated with the availability of AP courses. Barnard-Brak and colleagues (2011) reported that "schools with lower minority percentage and lower percentage of students receiving free lunch were likely to have a higher number of AP courses available to students, even while controlling for school size"

(p. 171). The authors also asserted "the intersection of minority status and SES compounds access to AP course programming" (Barnard et al., 2011, p. 171).

Lyons (2004) has explored the association between school characteristics such as high school poverty levels and school size on student achievement on mathematics and reading accountability assessments in Kentucky public high schools. The researcher sampled Kentucky public high schools that contained Grades 9-12 only, resulting in a sample of 220 high schools. School poverty was operationalized based upon the percentage of students who received free and reduced lunch and achievement was defined based upon student performance on Kentucky's Comprehensive Test of Basic Skills (5^{th} version) and the Kentucky Core Content Test, a criterion-referenced test. School poverty, based upon the percentage of students who received free and reduced lunch, and school size were divided into five categories. Using a Chi-square analysis to examine differences between the distribution of students on the assessments and school classification (equitable or inequitable), Lyons (2004) found disparities in student achievement and equitable opportunities for economically disadvantaged students who attended large public high schools in comparison to those who attended smaller public high schools. Economically disadvantaged students who attended large high schools performed more poorly in comparison to those who attended small high schools. The author did not indicate degree of freedom. In addition, Lyons (2004) did not examine performance of advanced students only because the Kentucky Core Content assessment categorized distinguished (advanced) performance in the same category as proficient. Nevertheless, the researcher's findings highlight a disparity in achievement by school size. The researcher argued that "large schools benefit advantaged students at the expense of disadvantaged students" (Lyons, 2004, p. 10).

Lleras (2010) investigated the extent that racial gaps in learning processes differ based upon racial composition and urbanicity (i.e., school location–urban, suburban, or rural) of schools. Using data from a nationally representative sample from National Education Longitudinal Study (NELS 1988-1990), Lleras estimated the over time effects of student achievement, opportunities to learn (course-taken), and student engagement on one another. The sample for this study was restricted to those who participated in surveys given in Grades 8 and 10, and those who attended public middle and comprehensive high schools. The final sample for this study included 6,063 White and 650 Black students in 660 public middle schools and 667 comprehensive public high schools.

Lleras (2008) found that students in "high minority" middle schools left eighth grade with lower math achievement, lower student engagement, and having taken fewer demanding math classes in comparison to students who attended "low minority" middle schools. In the same analysis, the author reported that by Grade 10, initial disadvantages in learning outcomes increased, particularly for students who attended majority Black urban high schools. The researcher also discovered that the Black-White achievement gap was more prevalent in high minority urban schools and less prevalent in high minority suburban schools. The researcher concluded that "increased access to more advanced and rigorous coursework could have a significant impact on African American math achievement directly and indirectly via improved student engagement and behavior, particularly in predominantly Black urban schools" (Lleras, 2008, p. 909). Further, Lleras (2008) contended that many Black students attend high minority schools where predominantly nonadvanced courses are offered. Subsequently, opportunities and the benefits of advanced coursework are limited for these students, thus perpetuating the opportunity gap structurally (Lleras, 2008). Lleras (2008) argued, "reforms that increase the academic rigor of mathematics courses within high minority schools as well as efforts aimed at desegregations are likely to reduce racial gaps in student achievement" (p. 909).

Other Factors Affecting Access and College and Career Readiness

Some researchers have argued that a lack of preparation for honors and advanced placement coursework starts as early as pre-elementary school. Many researchers have examined the relationship between factors such as parental support, educational level, teacher support, financial earnings, resources, and disproportionate discipline rates and student participation in honors and advanced courses in K-12 education (Crozier 2001; Daniel-White 2002). A review of the latest NAEP data in mathematics and reading for students in Grade 3 show that minority students, especially Black and Latino students are underperforming in comparison to their White and Asian counterparts (Kena et al., 2014).

Some researchers have examined teachers' expectations on the student achievement gap to include student participation in honors and AP coursework, and found teacher expectations to be higher for White students than Black students (Baron, Tom, & Cooper, 1995; DeMeis & Turner, 1978). Differing teacher expectations, lower for Black students, has been found to start as early as elementary school (DeMeis & Turner, 1978). DeMeis and Turner (1978) examined teacher expectation on three variables, one of which included current academic ability of fifth grade elementary school students. Sixty-eight White female elementary school teachers, with an average of 7 years of experience in Kentucky, were participants in the study. The researchers found student race to be a significant predictor for student academic ability at a .01 alpha level. These expectations can serve as impediments and obstacles for students by the time they reach secondary school.

Others have indicated that minority students, particularly Black students, do not participate in honors and AP courses due to peer pressure of "acting White" from their peers (Ferguson, 2007). Ferguson (2007) reported, "hearing some Black students accuse their peers of acting White when their personal styles seem to resemble those of the smart White kids" (p. 137). Ferguson asserted that it appears that, "being smart is valued, but acting smart or aspiring to move up in the achievement hierarchy, with the associated peers and teacher relationship pattern is frowned on" (p. 137). This type of peer pressure has been reported to influence student participation in honors courses including AP courses. However, contrary to this perspective, Philip and Ludwig (1997) in an examination of peer pressure among adolescents and "acting White" found that neither was responsible for disparities in academic performance between Black and White students. Rather, Philip and Ludwig found that group differences in peer attitude did not significantly impact the achievement gap between Black and White students. The authors concluded that Black students are not alienated more than White students for succeeding academically, nor do they incur social penalties in high school greater than their White counterparts. However, Philip and Ludwig (1997) stated, "family backgrounds of blacks and whites do account for racial group differences in student inputs into the educational process" (p. 275). An emerging suggestion from this study was that educational leaders and policymakers should improve efforts to minimize the burden of poverty and provide additional support for students from disadvantaged backgrounds (Philips & Ludwig, 1997). Data from the National Education Longitudinal Study (NELS 88(90) was used to conduct this study.

Other factors some researchers have investigated suggest that inequities in resources such as highly qualified teachers, competitive teacher pay, and teacher experience, impact student participation in honors advance courses, especially within urban communities, where these issues are exacerbated in schools that have high poverty rates, low student academic achievement, and low teacher retention rates (Aud et al., 2012; Darling-Hammond, 2010, 2013; Ferguson, 2007; Ford & Moore, 2013; OCR, 2012; Schott Foundation, 2009; Uhlenberg & Brown, 2002). Several empirical studies have documented the impact that these resource inequities have had on the educational outcomes for Black and Latino students in K-12 education (Darling-Hammond, 2000, 2010; OCR, 2012; Uhlenburg & Brown, 2002). For example, in a seminal study, Ferguson (1991) examined the impact that expenditure levels had on student performance and found that increased spending on instructional resources including highly qualified teachers appeared to correlate with improved student performance. In fact, in a later study, Ferguson (2007) reported that teacher quality and expertise, which were measured by teacher state certification score, experience, and post bachelor's degree attainment, were strongly associated with student achievement. Using data from Texas school districts, Ferguson (2007) found that the disparities in achievement between Black and White students were accounted for by differences in teacher qualification, after controlling for SES. The researcher concluded that skilled teachers are vital when considering all schooling inputs.

Oftentimes, the association between teacher pay and securing quality teachers seemingly is unfavorable and disproportionate for students who attend majority minority schools (Darling-Hammond, 2010; OCR 2012). In a recent study, the OCR (2012) reported that teachers in elementary schools serving majority Latino and Black students were paid an average $2,251 less per year than their colleagues in other schools within the same district that served the fewest Latino and Black students. Teachers working in schools attended by students from majority disadvantaged or high poverty backgrounds were compensated an estimated 33% less in salary than teachers working in more affluent high income schools (NCES, 1997). These disparities in teacher pay, along with factors such as working conditions, stress, and limited resources, seemingly impact the recruitment of highly qualified teachers needed to teach honors and advanced courses in high poverty schools, urban schools, or schools that serve students from disadvantaged backgrounds (Darling-Hammond 2000, 2010).

Asserting the importance of teachers with strong content knowledge, Haycock and Crawford (2008) reported that disadvantaged students in need of qualified teachers in various content areas were more likely taught by teachers with the least content knowledge. For students of color, addressing this disparity in schools can have a major impact on increasing student performance (Boyd, Lankford, Loeb, Rockoff, & Wyckoff, 2008; Ferguson, 1998, 2007; Noguera, 2009; OCR, 2012). These factors are more prevalent in schools that serve predominantly Black and Latino students, making it more difficult to close the gap in academic achievement and participation (Darling-Hammond, 2000; Ford & Moore, 2013; Klopfenstein, 2004; Mickelson, 2001; OCR, 2012)

In another study, Clotfelter, Ladd, and Vigdor (2007), using a micro-level data set of high school students in North Carolina, examined the impact of teacher qualification on student achievement. The researchers found that student achievement was higher among those who were taught by more qualified teachers (e.g., nationally board certified, certified in the content area of their teaching assignment, had higher scores on the state teacher license exam, graduated from a competitive college, or had 2 or more years of teaching experience) than students who were not. Clotfelter et al. (2007) reported that the combined influence of many of these teacher qualification variables on student achievement was greater than the effects of race and parent education combined. The authors asserted that the differences in the effects of highly qualified teachers and nonhighly qualified teachers on student achievement were larger than the average difference in achievement between a White student with college-educated parents and a Black student with high school educated parents.

In contrast, Aaronson, Barrow, and Sander (2007) investigated teacher quality and student achievement in public schools in Chicago, IL. Controlling for teacher and student fixed effects, the researchers found strong effects of teachers on student performance, but teacher characteristics such as experience, credential status, and education had minimal effect on student academic achievement results. The researchers employed a gains score approach method to conduct the analysis. In a more recent study, Boyd et al. (2008), like Clotfelter et al. (2007), found that teacher qualifications such as SAT mathematics scores, teaching experience, graduation from a competitive college, certification or endorsement status, and pathway into the teaching profession, were predictors of teacher effectiveness in elementary and middle school mathematics classes.

Boyd and colleagues (2008) reported that student achievement was higher for those students taught by teachers with these qualifications; however, student achievement was lower for those students taught by inexperienced teachers. Boyd et al. (2008) reported that the achievement gap was closed by 25% between schools serving students from low SES backgrounds in comparison to those from high SES backgrounds based on teachers' experience. Nonhighly qualified and inexperienced teachers were oftentimes located in disadvantaged, low-income, urban, or high poverty schools with high minority student enrollments (Darling Hammond, 2010; Ferguson, 2007; Ford & Moore, 2013; Noguera, 2009).

In light of these factors' impact on access and readiness, given the influx of careers in STEM fields, student access to and participation in AP courses seemingly do more good for minorities, especially those in urban and high poverty communities in the long term (Buchanan, 2006; Wyner et al., 2007). Further, Achieve (2008) reported that access to college and career-readiness opportunities impact closing achievement gaps in secondary schools. Similarly, Darling-Hammond (2013) asserted that the lack of access to college and career opportunities, which includes high-quality curriculum and instruction, disproportionally influences the educational outcomes for Black and Latino students.

Summary

Educational leaders, researchers, and others stakeholders remain concerned regarding the unequal access to college and career readiness and other educational opportunities to learn (Carter & Welner, 2013; Darling-Hammond, 1998; OCR 2012). More than 55 years after *Brown v. Board of Education* (1954) and 10 years post the No Child Left Behind Act of 2001 many researchers have found disparities persist (Achieve, 2008; College Board 2013, 2014; Lleras, 2008; OCR, 2012; Tate, 2008). The College Board (2007) declared that, "all students deserve an opportunity to participate in rigorous and academically challenging courses and programs" (p. 1). More than 7 years later, student access to a rigorous curriculum and college and career-ready opportunities remains inconsistent and disproportionate across racial groups, school locations, school size, and percentage of the students receiving free and reduce lunch.

This chapter provided a review of the literature relative to the consequential importance of student access to college and career-readiness opportunities, and the factors that impact college enrollment, careers, and income. The review of the literature included (a) an overview of broad ramifications of college and career readiness, (b) educational policy: the VCCRI, (c) the impact of advanced mathematics and science courses on college enrollment and completion, (d) the impact of advanced mathematics and science completion on careers and earnings, (e) opportunity access, (f) other factors affecting access and college and career readiness, and (g) summary. Both quantitative and qualitative research studies were examined to understand the significance of college and career-readiness opportunities and factors that influence student access to these educational opportunities to learn. This review of the literature revealed the imperative of ensuring that all students have access to a rigorous curriculum and are prepared to take advantage of it and other college and career-readiness opportunities. Although some studies investigated this topic from a national level, few studies explored this matter at the state level. This study focused on student access to advanced mathematics and science courses in the Commonwealth of Virginia public high schools as an indicator of college and career readiness by school location, ethnic or racial composition, school size, and economically disadvantaged percentage. It is assumed that understanding the extent that these factors are associated with student access to college and career readiness opportunities is important for educators, business leaders, researchers, and other stakeholders. Chapter 3 will provide the procedures that will be used to conduct this quantitative study on the Commonwealth of Virginia public high schools.

Chapter Three: Methodology

This chapter provides an overview of the research methodology and design for this quantitative study. The chapter includes the purpose of the study and the research questions. Next, a brief description of secondary data from all public high schools in Virginia is provided. Both the independent and dependent variables are presented followed by procedures that were used for data collection, management, and analysis.

Purpose of Study

The purpose of this study was to examine student access to advanced mathematics and science courses in Virginia public high schools as an indicator of college and career readiness by school size (fall 2012 membership enrollment), economically disadvantaged percentage (percentage of students classified as economically disadvantaged), the percentage of minority students (percentage of Black or Latino students), and urbanicity locale. Carter and Welner's (2013) opportunity to learn framework and OCR's (2012) opportunity gap framework provided the conceptual framework to investigate access to college and career-ready opportunities in Virginia public high schools. With a national focus on producing more college and career-ready graduates, ensuring access is essential and timely. Student access to advanced mathematics and science courses plays an integral part in college and career-readiness opportunities. These opportunities seemingly impact students' ability to be and remain competitive in a 21st century global labor market (Carnevale et al., 2013; Hanushek et al., 2008; Rose & Betts, 2004).

Research Questions

Using descriptive statistics and regression analysis, this quantitative study addressed the following research questions:

1. To what extent does access to advanced mathematics and science courses among students in Virginia public high schools vary by school size, as defined by fall 2012 membership enrollment?
2. To what extent does access to advanced mathematics and science courses among students in Virginia public high schools vary by economically disadvantaged percentage?
3. To what extent does access to advanced mathematics and science courses among students in Virginia public high schools vary by the percentage of minority students, as defined by the percentage of Black or Latino students?
4. To what extent does access to advanced mathematics and science courses among students in Virginia public high schools vary by urbanicity locale (i.e., city, suburban, town, and rural)?
5. Controlling for teacher quality and discipline rates, to what extent do school size, economically disadvantaged percentage, the percentage of minority students, and urbanicity factors predict access to the number of advanced mathematics and science course offerings in Virginia public high schools?

Rationale for the Research Design

To investigate students' access to advanced mathematics and science courses, this study employed secondary data analysis of a data set to be obtained from the VDOE. A quantitative research strategy will be used to explore this topic. Examining the relationship of two or more variables warrants the research design of a correlational study. Correlation allows the researcher to examine relationships (Creswell, 2014). Multiple regression analysis allows the researcher to make predictions and to examine the relative impact of multiple variables simultaneously (Tabachnick & Fidell, 2007).

Data Source and Sample

Since 2011, as part of the federal requirements for the State Fiscal Stabilization Fund, the VDOE has conducted an annual master schedule course collection from all school divisions in Virginia (VDOE, 2011). Each school division is required to report school level master schedule data to the VDOE for all schools in the district. Course-level data, including advanced mathematics and science course level offerings, are a part of the state master schedule course collection data (VDOE, 2011).

The Commonwealth of Virginia has 132 school divisions divided into eight regions: Central Virginia (Region 1), Tidewater (Region 2), Northern Neck (Region 3), Northern Virginia (Region 4), Valley (Region 5), Western Virginia (Region 6), Southwest Virginia (Region 7), and Southside (Region 8) (VDOE, 2014). Each school division is classified based on its location. Based upon fall enrollment data on September 30, 2012, the Commonwealth of Virginia had 1,867 total schools, 32 middle schools, 1,169 elementary schools, 309 middle schools, 309 public high schools, and 48 combined schools. There were a total of 1,264,880 students in Virginia public schools. Table 3 provides an overview of data associated with student enrollment in Virginia public schools during the 2012-2013 school year, including data on enrollment, number of Black or Latino students, number of economically disadvantaged students, and the combined number of Black or Latino students identified as economic disadvantaged.

The VDOE data set that were used for this study contains school level data for all public high schools in Virginia. The data consist of advanced mathematics and science course offerings, including student course enrollment numbers, school division name, and school division number from all Virginia public high schools. In addition, the VDOE data set will include school level demographic or characteristic data, including school name, school size, and school location. Advanced mathematics and science course offerings for the 2012-2013 school year will be analyzed.

Table 3

Fall 2012 Virginia Public High Schools Data

Grade	Fall 2012 enrollment	No. of Black and Latino students combined	No. of economically disadvantaged	No. of Black and Latino students economically disadvantaged combined
Grade 9	101,738	36,998	36,930	21,840
Grade 10	94,801	32,826	30,736	18,051
Grade 11	90,123	29,810	26,251	15,069
Grade 12	88,840	29,202	23,718	13,699
Total (Grades 9-12)	375,502	128,836	117,635	68,659
Total (Grades PK-12)	1,264,880	454,372	482,113	283,243

Note. Adapted from Virginia Department of Education, 2012.

Coding Advanced Coursework

Advanced mathematics were defined for mathematics at or above Algebra II. Advanced science courses will be defined at or above Chemistry (OCR, 2012; VDOE, 2013). Using the VDOE (2013) listing of approved courses to satisfy graduation requirements for the Standard and Advanced Studies Diplomas, mathematics course codes were used to properly identify each advanced mathematics and science course. Table 1 provides a listing of advanced mathematics courses in Virginia. Beginning with the Grade 9 Class of 2010-2011, these are the approved courses for the Standard and Advanced Studies Diplomas. Similarly, Table 2 provides a listing of the approved advanced science courses for the Standard and Advanced Studies Diplomas in Virginia.

Variables

The dependent variables for this quantitative study were *access to college* and *career-readiness opportunities* as defined by advanced mathematics and science course offerings in Virginia public high schools. Advanced mathematics and science course offerings were indicated using continuous variables. There were four dependent variables.

1. Number of advanced mathematics courses at or above Algebra II, excluding AP mathematics course offerings.
2. Number of advanced mathematics courses at or above Algebra II, including AP mathematics course offerings.
3. Number of advanced science courses at or above chemistry, excluding AP science course offerings.
4. Number of advanced science courses at or above chemistry, including AP science course offerings.

Four sets of school-level independent variables were used for this study: school size (based on fall 2012 student membership enrollment), SES (based on percentage of students classified as economically disadvantaged), minority student percentage (based on percentage of Black and Latino students), and urbanicity (based on four main urban-centric locale type and code). Table 4 lists school locale types and the corresponding local code that were assigned to Virginia public schools based upon urban-centric locale during the 2012-2013 school year. Descriptive statistics were computed for all variables. See Appendix B for a listing of Virginia public high school enrollment and urbanicity information.

Table 4

Urbanicity or Urban-Centric Locale Types and Codes

School urban-centric locale type	Local code
City	1
Suburban	2
Town	3
Rural	4

Note. Adapted from "Documentation to the NCES Common Core of Data Public Elementary/Secondary School University Survey Preliminary Directory File: School Year 2013-2014 (NCES 2015-071), by Keaton, 2015

Data Analysis

This study employed a secondary data analysis of school-level data from the VDOE. Microsoft Excel® was used to organize the VDOE data and the Statistical Package for the Social Sciences® (SPSS) was used to calculate the statistical analysis of data. First, the researcher computed descriptive statistics for both the independent and dependent variables in an effort to describe the sample used for this study. Next, the researcher examined Questions 1-3 by conducting a simple regression analysis. An analysis of variance (ANOVA) was used to calculate group differences by urbanicity for Question 4. Lastly, a multiple regression analysis was executed for Question 5 to investigate the extent that school size (based upon fall 2012 student membership enrollment), economically disadvantaged percentage, the percent of minority students, and urbanicity locale factors influenced access to advanced mathematics and science course offerings in Virginia public high schools. Below is a brief description of how each research question was analyzed.

Student access to advanced mathematics and science courses in Virginia public high schools was analyzed based upon fall 2012 student enrollment data collected as part of the VDOE's master schedule collection process. Access was examined with four independent variables. The first two access variables examined access based upon the number of advanced mathematics and science course offerings at or above Algebra II and Chemistry, respectively, excluding AP mathematics and science courses. The total number of coded advanced mathematics courses available in Virginia, excluding AP mathematic courses, is 11. The total number of coded advanced science courses available in Virginia, excluding AP science courses, is 5. International baccalaureate and dual-enrollment mathematics and science courses were accounted for as offered based on their alignment with the coded advanced or AP courses.

The second two access variables examined college and career opportunities based upon the number of advanced mathematics and science course offerings, including AP courses, available to students. The total number of AP mathematics courses is 5, and the total number of AP science courses is 7. Advanced mathematics and science course offerings were categorized into two variables. One variable was based on advanced mathematics and science courses at or above Algebra II, including AP courses, with a possible number up to 16. The other variable was based on advanced science offerings at or above chemistry, including AP courses, with a possible number up to 12. International baccalaureate and dual-enrollment mathematics and sciences courses were accounted for, as offered and based on their alignment with the coded advanced or AP courses.

Research question 1. To what extent does access to advanced mathematics and science courses among students in Virginia public high schools vary by school size, as defined by fall 2012 membership enrollment? School size was examined using a continuous variable and based on fall 2012 membership enrollment reported to the VDOE on September 30, 2012. A simple regression analysis was conducted to understand variation by school size for each of the independent variables.

Research question 2. To extent does access to advanced mathematics and science courses among students in Virginia public high schools vary by economically disadvantaged percentage, percentage of students classified as economically disadvantaged? The economically disadvantaged percentage variable was examined using a continuous variable, percentage of students classified as economically disadvantaged. A simple regression analysis was conducted to understand variation based on the percentage of students classified as economically disadvantaged for each of the independent variables.

Research question 3. To what extent does access to advanced mathematics and science courses among students in Virginia public high schools vary by the percentage of minority students, as defined by the percent of Black or Latino students? The percentage of minority students variable was examined using a continuous variable. A simple regression analysis was conducted to understand variation based on the percentage of minority students for each of the independent variables.

Research question 4. To what extent does access to advanced mathematics and science courses among students in Virginia public high schools vary by urbanicity locale (i.e., city, suburban, town, and rural)? The urbanicity locale variable was a nominal variable where 1 = city, 2 = suburban, 3 = town, and 4 = rural. Analyses were performed on the dependent variables using ANOVA to determine group differences by urbanicity for each of the independent variables.

Research question 5. Controlling for teacher quality and discipline rate, to what extent does school size, economically disadvantaged percentage, minority student percentage, and urbanicity factors predict access to the number of advanced mathematics and science course offerings in Virginia public high schools? A multiple regression analysis was used to examine which independent variables influenced student access to college and career opportunities as defined by access to the number of advanced mathematics and science course offerings with and without AP mathematics and science courses in Virginia public high schools. To do this required four separate multiple regression analyses to address advanced mathematics access without AP mathematics course offerings, advanced mathematics access with AP mathematics course offerings, advanced science access without AP science course offerings, and advanced science access with AP science course offerings. The number of advanced courses was used to represent the four variables of access for advanced mathematics and science course offerings. Continuous variables for school size, economically disadvantaged percentage, and the percentage of minority students were used. The percentage of economically disadvantaged students was used to represent economically disadvantaged percentage, and Black and Latino students enrollment was used to represent the minority student percentage. School size was represented by the number of students enrolled in each Virginia public high school in the fall of 2012. The effect of each variable and magnitude of its influence on college and career opportunities for students in Virginia public high schools was explored. Statistical significance was reported. Suburban public high schools were the reference group for urbanicity.

Data Management

Creswell (2009) suggested that researchers identify a management system prior to collecting data for research. As such, all data requested and provided for this study were received via e-mail. Microsoft Excel® was used to organize information such as school name, division name, advanced mathematics and science course offerings, school number, division number, course enrollment numbers, and other school characteristic data for this study. For security purposes, the researcher maintained all data in an electronic folder. The electronic folder was housed on a locked computer that remained password protected and only accessible by the researcher.

Ethical Safeguards

This study employed secondary data analysis of a public use data set from the VDOE. As a public use data set, it contains school identifying information; however, it does not contain any student identifying information. Despite this, a request for approval to conduct this study was submitted to Virginia Tech's Institutional Review Board.

Permission to Conduct Research

An application was submitted to Virginia Polytechnic Institute and State University's (VT) Institutional Review Board (IRB) for approval to conduct this study. However, the researcher received notification that IRB approval was unnecessary. Refer to Appendix C for information regarding IRB approval.

Methodology Summary

The purpose of this chapter was to present the methodology that was used to conduct this study. This study was designed to examine student access to advanced mathematics and sciences courses in Virginia public high schools by school size, economically disadvantaged percentage, the percentage of minority students and urbanicity locale. The chapter began with a brief overview and a restatement of the purpose and research questions. Next, research design, data source and sample and variables, were presented. Lastly, the data analysis, management, and ethical safeguards associated with this study were presented.

The study investigated student access to advanced mathematics and science course offerings as an indicator of college and career readiness in Virginia public high schools. A combination of Carter and Welner's (2013) and the OCR's (2012) opportunity gap frameworks provided the conceptual framework to examine college and career readiness. This study could add to existing literature on closing the gap in opportunities to learn.

Chapter Four: Results and Data Analysis

Introduction

The purpose of this study was to examine student access to advanced mathematics and science courses in Virginia public high schools as an indicator of college and career readiness by school size (fall 2012 membership enrollment), economically disadvantaged percentage, the percentage of minority students (based on percentage of Black or Latino students), and urbanicity locale. This chapter provides a summary of the data collected, coded, and analyzed to investigate the five research questions for this study. The SPSS® 21.0 software was used to examine the following research questions:

1. To what extent does access to advanced mathematics and science courses among students in Virginia public high schools vary by school size, as defined by fall 2012 membership enrollment?
2. To what extent does access to advanced mathematics and science courses among students in Virginia public high schools vary by economically disadvantaged percentage?
3. To what extent does access to advanced mathematics and science courses among students in Virginia public high schools vary by the percentage of minority, as defined as the percentage of Black or Latino students?
4. To what extent does access to advanced mathematics and science courses among students in Virginia public high schools vary by urbanicity locale (i.e., city, suburban, town, and rural)?
5. Controlling for teacher quality and discipline rates, to what extent do school size, economically disadvantaged percentage, the percentage of minority students, and

urbanicity locale factors predict access to advanced mathematics and science course offerings in Virginia public high schools?

Description/Overview of Variables

Descriptive statistics for both the independent and dependent variables among 309 public high schools in Virginia are presented in this section. School size, economically disadvantaged percentage, the percentage of minority students, and urbanicity locale were the independent variables. Access was examined with four dependent variables. The first two access variables were examined based upon the number of advanced mathematics and science course offerings at or above Algebra II and Chemistry, respectively, excluding Advanced Placement (AP) mathematics and science courses. The second two access variables examined college and career opportunities based upon the number of advanced mathematics and science course offerings, including AP courses, available to students. International baccalaureate and dual-enrollment mathematics and science courses were accounted for as offered based on their alignment with the coded advanced or AP courses.

An analysis of both the independent and dependent variables in 309 Virginia public high schools revealed the following: an average school size, based on fall 2012 enrollment, of approximately 1195 students in Virginia public high schools, $M = 1194.95$, $SD = 697.83$; on average, 37.0% of the students enrolled in Virginia public high school were classified as economically disadvantaged, $M = 36.99$, $SD = 20.28$; the average minority student percentage, based on Black or Latino students, was 30.8% in Virginia public high schools, $M = 30.83$, $SD = 24.97$. In addition, the analysis revealed the discipline rate was 19.4% based on the ratio of the total number of disciplinary violations record by VDOE during 2012-13 academic school year, and the 2012 fall enrollment, $M = 19.42$, $SD = 18.79$. The teacher quality rating, based on the percentage of core academic classes taught by teachers meeting the federal definition of highly qualified within their area of endorsement, for public high schools across the Commonwealth of Virginia was 97.9%, $M = 97.86$, $SD = 3.02$.

An average of 4.4 advanced mathematics courses excluding AP mathematics courses were offered in Virginia public high schools, in comparison to 6.1 advanced mathematics courses including AP mathematics courses. An average of 2.3 advanced science courses excluding AP science courses were offered in Virginia public high schools, in comparison to 4.4 advanced science courses including AP science courses. School size and teacher quality were both statistically significant and positively associated with advanced mathematics excluding and including AP mathematics course offerings in Virginia public high schools. The percentage of economically disadvantaged students and discipline rate were both statistically significant and negatively associated with advanced mathematics excluding and including AP mathematics course offerings in Virginia public high school. The percentage of minority students was not correlated with advanced mathematics excluding and including AP mathematics course offerings in Virginia public high schools.

School size was the only variable positively correlated to advanced science excluding AP science course offerings in Virginia public high schools. The percentage of economically disadvantaged students was statistically significant and negatively correlated with advanced science excluding AP science course offerings in Virginia public high school. School size and teacher quality were both statistically significant and positively associated with advanced science including AP science course offerings in Virginia public high schools. The percentage of economically disadvantaged students and discipline rate were both statistically significant and negatively associated with advanced science including AP science course offerings in Virginia public high school. The percentage of minority students was not correlated with advanced science excluding and including AP science course offerings in Virginia public high schools.

The urbanicity locales, also referred to as school location, of public high schools across the Commonwealth of Virginia varied. Among the 309 public high schools for which urbanicity locale codes were identified, 16.8% were located in a city, 27.2% in a suburban area, 11.0% in a town, and 45.0% in a rural area. See Table 7 for descriptive statistics related to urbanicity.

Research Question Analysis

Access was examined with four independent variables. The first two variables examined access based on the number of advanced mathematics and science course offerings at or above Algebra II and Chemistry, respectively, excluding AP mathematics and science courses. The total number of coded advanced mathematics courses available in Virginia, excluding AP mathematics courses, was 11. The total number of coded advanced science courses available in Virginia, excluding AP science courses, was 5.

Table 5

Descriptive Statistics for Demographic, Advanced Mathematics and Science Variables (*N* = 309)

Variables	*Mean*	Standard Deviation	Range
School size	1194.95	697.83	68.00 - 4033.00
EDP[a,c]	36.99	20.28	2.00 -100.00
MSP[b,c]	30.83	24.97	0 - 99.00
Discipline rate[c]	19.42	18.79	0 -134.80
Teacher quality[c]	97.86	3.02	80 - 100
Advanced math excl AP	4.42	1.57	1 - 11
Advanced math incl AP	6.13	2.24	1 - 16
Advanced science excl AP	2.25	.880	1 - 5
Advanced science incl AP	4.42	1.85	1 - 12

Note. [a]EDP = economically disadvantaged percentage. [b]MSP = percentage of minority students. c = values reflect percentages. Math = mathematics. Excl = excluding. Incl = including.

Table 6

Correlations Between Demographic Variables and Advanced Mathematics and Science Variables

Variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**N**
1. School size	-									309
2. EDP[a]	-.412**	-								309
3. MSP[b]	.214**	.444**	-							309
4. Discipline rate	-.147**	.457**	.467**	-						309
5. Teacher quality	.168**	-.242**	-.076	-.048	-					309
6. Advanced mathematics excl AP mathematics	.377**	-.228**	-.001	-.166**	.122*	-				309
7. Advanced mathematics incl AP mathematics	.499**	-.340**	.002	-.192**	.203**	.899**	-			309
8. Advanced science excl AP science	.150**	-.022*	.059	-.043	.043	.385**	.337**	-		309
9. Advanced science incl AP science	.507**	-.306**	.049	-.139*	.216**	.563**	.720**	.536**	-	309

[a]EDP = Economically disadvantaged percentage; [b]MSP = Minority student percentage; [c]Urbanicity locale code: 1 = city, 2 = suburban, 3 = town, 4 = rural.
Note. *p < .05, **p < .001.

Table 7

Urbanicity Locale Variables: Descriptive Statistics (*N* = 309)

Urbanicity locale[a]	*N*	%
City	52	16.8
Suburban	84	27.2
Town	34	11.0
Rural	139	45.0

Note. [a]Urbanicity locale: 1 = city, 2 = suburban, 3 = town, 4 = rural.

Research question 1. To what extent does access to advanced mathematics and science courses among students in Virginia public high schools vary by school size, as defined by fall 2012 membership enrollment? This question was examined in four parts, investigating the extent that school size, as defined by fall 2012 enrollment, predicted: advanced mathematics, excluding AP mathematics course offerings, advanced mathematics, including AP mathematics course offerings, advanced science, excluding AP science course offerings, and advanced science, including AP science course offerings.

School size and advanced mathematics excluding and including AP mathematics course offerings. In order to investigate Research Question 1, a simple linear regression analysis was executed in SPSS® to determine the likelihood that school size, in isolation, as defined by fall 2012 membership enrollment, predicted student access to advanced mathematics courses excluding and including AP mathematics courses. The null hypothesis was that there is no relationship between school size and advanced mathematics course offerings, excluding and including AP mathematics courses. The data revealed the following: a statistically significant positive correlation between school size and advanced mathematics course offerings, excluding AP mathematics courses, $r = .377$, $p < .001$; a statistically significant positive correlation between school size and advanced mathematics course offerings, including AP mathematics courses, $r = .499$, $p < .001$. School size accounted for approximately 14.2% of the total variability in advanced mathematics course offerings, excluding AP mathematics courses, F (1, 307) = 50.873, $p < .001$, and 24.9% of total variability in advanced mathematics course, offerings including AP mathematics courses, in Virginia public high schools, F (1, 307) = 102.026, $p < .001$. The model equation for advanced mathematics, excluding AP mathematics courses, $\hat{y} = 3.409 + 0.001(x)$, where x represents school size based on fall 2012 membership enrollment, revealed that as school size increases by 1000 students, student access to advanced mathematics courses, excluding AP mathematics courses increases by one in Virginia public high schools. Similarly, the second model equation for advanced mathematics including AP mathematics courses, $\hat{y} = 4.210 + 0.002(x)$, where x represents school size based on fall 2012 membership enrollment, revealed that as school size increased by 1000 students, student access to advanced mathematics courses, including AP mathematics courses, increases by two in Virginia public high schools. See Table 8.

Further, a multiple regression analysis was also calculated to assess the ability that school size, economically disadvantaged percentage, the percentage of minority students, city, town, and rural predicted advanced mathematics course offerings, excluding and including AP mathematics courses, in Virginia public high schools, after controlling for discipline rate and teacher quality. The results revealed that school size explained 16.3% of variance in advanced mathematics excluding AP mathematics course offerings, F (8, 300) = 7.330, $p < .001$, and 28.7% of the total variance in advanced mathematics, including AP mathematics course offerings, F (8, 300) = 15.119, $p < .001$. The beta values for both analysis revealed that as school size increases by 1000 students, student access to advanced mathematics courses, excluding and including AP mathematics courses, increases by one.

Table 8

Summary of Simple Regression Analyses for School Size Predicting Advanced Mathematics Excluding and Including AP Mathematics Course Offerings (N =309)

	Advanced mathematics excluding AP mathematics course offerings			Advanced mathematics including AP mathematics course offerings		
Variable	*B*	*SE B*	*ß*	*B*	*SE B*	*ß*
School size	.001*	.000	.377*	.002*	.000	.499*
Constant	3.409	.165		4.210	.220	
R	.377*			.499*		
R^2	.142			.249		
F	50.873*			102.026*		

*p < .001

School size and advanced science excluding and including AP science course offerings. Continuing the analysis of Research Question 1, a simple linear regression analysis was executed in SPSS® to determine the likelihood that school size, in isolation, as defined by fall 2012 membership enrollment, predicted student access to advanced science courses, excluding and including AP science courses. The null hypothesis was that there is no relationship between school size and advanced science course offerings, excluding and including AP science courses. The data revealed the following: a statistically significant positive correlation between school size and advanced science course offerings, excluding AP science courses, $r = .150$, $p = .008$; a statistically significant positive correlation between school size and advanced mathematics course offerings, including AP mathematics courses, $r = .507$, $p < .001$. School size accounted for approximately 2.3% of the total variability in advanced science course offerings, excluding AP science courses, F (1, 307) = 7.097, $p = .008$, and 25.7% of total variability in advanced science course offerings, including AP science courses in Virginia public high schools, F (1, 307) = 106.255, $p < .001$. Although, the model equation for advanced science excluding AP science courses, $\hat{y} = 2.026 + 0.000(x)$, where x represents school size based on fall 2012 membership enrollment, was found to be statistically significant, the beta value suggest that student access to advanced science courses, excluding AP science courses remains the same irrespective of school size. Similarly, the second model equation for advanced science, including AP science course offerings, $\hat{y} = 2.818 + 0.001(x)$, where x represents school size based on fall 2012 membership enrollment, revealed that as school size increases by 1000 students, student access to advanced science courses, excluding AP science courses increases by one in Virginia public high schools. See Table 9.

Table 9

Summary of Simple Regression Analyses for School Size Predicting Advanced Science Excluding and Including AP Science Course Offerings (N = 309)

	Advanced science excluding AP science course offerings			Advanced science including AP science course offerings		
Variable	*B*	*SE B*	*ß*	*B*	*SE B*	*ß*
School size	.000**	.000	.150*	.001*	.000	.507*
Constant	2.026	.098		2.818	.180	
R	.150			.507		
R^2	.023			.257		
F	7.097**			106.255*		

* $p < .001$. ** $p < .01$.

Further, a multiple regression analysis was also calculated to assess the ability that school size, economically disadvantaged percentage, the percentage of minority students, city, town, and rural predicted advanced science course offerings, excluding and including AP science courses, in Virginia public high schools, after controlling for discipline rate and teacher quality. The model results revealed that none of the predictor variables were statistically significantly correlated with advanced science, excluding AP science courses, F (8, 300) = 1.249, $p = .270$. However, the multiple regression model for advanced science courses, including AP science courses, was found to be statistically significant, $R = .540$, $p < .001$. School size and teacher quality explained 29.2% of variance in advanced science, excluding AP science course offerings, F (8, 300) = 15.445, $p < .001$. The beta value for school size ($B = .001$, $p < .001$) revealed that as school size increased by 1000 students, student access to advanced science courses, including AP science courses increased by one, holding all variables constant. The beta value for teacher quality ($B = .063$, $p = .047$) indicates that a 16 unit or 16% change in teacher quality would increase student access to advanced science courses, including AP science courses, by one.

Research question 2. To what extent does access to advanced mathematics and science courses among students in Virginia public high schools vary by economically disadvantaged percentage, as defined by the percentage of students classified as economically disadvantaged? Similar to Research Question 1, this research question was examined in four parts, investigating the extent that economically disadvantaged percentage, as defined by school economically disadvantaged rate, predicted: advanced mathematics, excluding AP mathematics course offerings, advanced mathematics, including AP mathematics course offerings, advanced science, excluding AP science course offerings, and advanced science, including AP science course offerings.

Economically disadvantaged percentage and advanced mathematics, excluding and including AP mathematics course offerings. In order to investigate Research Question 2, a simple linear regression analysis was executed to determine the likelihood that economically disadvantaged percentage, in isolation, predicted student access to advanced mathematics courses, excluding and including AP mathematics courses. The null hypothesis was that there is no relationship between economically disadvantaged percentage and advanced mathematics course offerings, excluding and including AP mathematics courses. The data revealed the following: negative correlation between economically disadvantaged percentage and advanced mathematics course offerings, excluding AP mathematics courses, $r = -.228$, $p < .001$; negative correlation between advanced mathematics course offerings, including AP mathematics courses, $r = -.340$, $p < .001$. Economically disadvantaged percentage accounted for approximately 5.2% of the total variability in advanced mathematics course offerings, excluding AP mathematics courses, $F\ (1, 307) = 16.896$, $p < .001$, and 11.6% of total variability in advanced mathematics course offerings, including AP mathematics courses, in Virginia public high schools, $F\ (1, 307) = 40.133$, $p < .001$. The model equation for advanced mathematics courses, excluding AP mathematics courses, $\hat{y} = 5.079 - 0.018(x)$, where x represents economically disadvantaged percentage, illustrated that an approximately 55 unit or 55% increase in economically disadvantaged percentage would yield a decrease in advanced mathematics course offerings, excluding AP mathematics courses, by one. Similarly, the second model equation for advanced courses, including AP mathematics, $\hat{y} = 7.521 - 0.038(x)$, illustrated that an approximately 26 unit or 26% increase in economically disadvantaged percentage would yield a decrease in the number of advanced mathematics course offerings, including AP mathematics courses, by one in Virginia public high schools. See Table 10.

Table 10

Summary of Simple Regression Analyses for Economic Disadvantaged Percentage Predicting Advanced Mathematics Excluding and Including AP Mathematics Course Offerings (N = 309)

	Advanced mathematics without AP mathematics course offerings			Advanced mathematics with AP mathematics course offerings		
Variable	*B*	*SE B*	*ß*	*B*	*SE B*	*ß*
EDP	-0.018*	.004	-.228*	-0.038*	.006	-.340*
Constant	5.079	.182		7.521	.250	
R	-.228			-.340		
R^2	.052			.116		
F	16.896*			40.133*		

Note. EDP = Economically disadvantaged percentage.

**p* < .001.

Further, a multiple regression analysis was also executed to examine the ability that economically disadvantaged percentage with school size, the percentage of minority students, city, town, and rural predicted advanced mathematics course offerings, excluding and including AP mathematics courses, in Virginia public high school, after controlling for discipline rate and teacher quality. The results revealed that economically disadvantaged percentage was not a statistically significant predictor of advanced mathematics course offerings, excluding AP mathematics courses, $B = .001$, $p = .914$ and advanced mathematics course offerings, including AP mathematics courses, $B = -.011$, $p = .176$ in the multiple regression analyses.

Economically disadvantaged percentage and advanced science, excluding and including AP science course offerings. In order to investigate Research Question 2, a simple linear regression analysis was executed to determine the likelihood that economically disadvantaged percentage, in isolation, predicted student access to advanced science courses, excluding and including AP science courses. The null hypothesis was that there is no relationship between economically disadvantaged percentage and advanced science course offerings, excluding and including AP science courses. The data revealed the following: no statistically significant correlation between economically disadvantaged percentage and advanced science course offerings, excluding AP science courses, $r = -.022$, $p = .706$; statistically significant negative correlation between advanced science course offerings, including AP science courses, $r = -.306$, $p < .001$. Economically disadvantaged percentage accounted for approximately 9.4% of the total variability in advanced science course offerings, including AP science courses, $F(1, 307) = 31.780$, $p < .001$. The model equation for advanced science including AP science courses, □ $= 5.452 - 0.028(x)$, where x represents economically disadvantaged percentage, illustrated that an approximately 36 unit or 36% increase in economically disadvantaged percentage would yield a decrease in advanced science course offerings, including AP science courses, by one in Virginia public high schools. See Table 11.

Further, a multiple regression analysis was also executed to examine the ability that economically disadvantaged percentage with school size, the percentage of minority students, city, town, and rural predicted advanced science course offerings, excluding and including AP science courses, in Virginia public high school, after controlling for discipline rate and teacher quality. The results revealed that economically disadvantaged percentage was not a statistically significant predictor of advanced science course offerings, excluding AP mathematics courses, $B = .004$, $p = .311$ and advanced science course offerings, including AP science courses, $B = -.010$, $p = .131$ in the multiple regression analyses.

Research question 3. To what extent does access to advanced mathematics and science courses among students in Virginia public high schools vary by minority student percentage, as defined as the percentage of Black or Latino students? Research Question 3 was examined in four parts, investigating the extent that the percentage of minority students predicted: advanced mathematics, excluding AP mathematics course offerings, advanced mathematics, including AP mathematics course offerings, advanced science, excluding AP science course offerings, and advanced science, including AP science course offerings.

Minority student percentage and advanced mathematics excluding and including AP mathematics course offerings. A simple regression analysis was executed to determine the likelihood that the percentage of minority students, as defined by Black or Latino student enrollment, predicted student access to advanced mathematics courses, excluding and including AP mathematics courses. The null hypothesis was that there is no relationship between the

Table 11

Summary of Simple Regression Analyses for Economically Disadvantaged Percentage Predicting Advanced Science Excluding and Including AP Science Course Offerings

	Advanced science excluding AP science course offerings			Advanced science including AP science course offerings		
Variable	*B*	*SE B*	*ß*	*B*	*SE B*	*ß*
EDP	-.001	.002	-.022	-.028*	.005	-.306*
Constant	2.287	.104		5.452	.209	
R	-.022			-.306		
R^2	.000			.094		
F	0.143			31.780*		

Note. EDP = Economic disadvantaged percentage.
**p* < .001.

percentage of minority students and advanced mathematics course offerings, excluding and including AP mathematics courses. The data revealed the following: no statistically significant correlation between the percentage of minority students and advanced mathematics course offerings, excluding AP mathematics courses, in Virginia public high schools, $r = .001$, $p = .988$; no statistically significant correlation between the percentage of minority students and advanced mathematics course offerings, including AP mathematics courses, $r = .002$, $p = .971$. Subsequently, the researcher failed to reject the null hypothesis that coefficient for the percentage of minority students not a statistically significant predictor of advanced mathematics course offerings, excluding and including AP mathematics courses, in Virginia public high schools (refer to Table 12).

Minority student percentage and advanced science, excluding and including AP science course offerings. A simple regression analysis was also executed to determine the likelihood that the percentage of minority students, as defined by Black or Latino student enrollment, predicted student access to advanced science courses, excluding and including AP science courses. The null hypothesis was that there is no relationship between the percentage of minority students and advanced science course offerings, excluding and including AP science courses. The data analysis revealed the following: the percentage of minority students was not a statistically significant predictor of advanced science course offerings, excluding AP science courses in Virginia public high schools, $r = .059$, $p = .297$; the percentage of minority students was not a statistically significant predictor of advanced science course offerings, including AP science courses, in Virginia public high schools, $r = .049$, $p = .389$. Subsequently, the researcher failed to reject the null hypothesis that coefficient for the percentage of minority students is not different from 0.

Table 12

Summary of Simple Regression Analyses for Minority Student Percentage Predicting Advanced Mathematics Excluding and Including AP Mathematics Course Offerings (N = 309)

	Advanced mathematics excluding AP mathematics course offerings			Advanced mathematics including AP mathematics course offerings		
Variable	*B*	*SE B*	*ß*	*B*	*SE B*	*ß*
MSP	.000	.004	-.001	.000	.005	.002
Constant	4.426	.142		6.124	.203	
R	.001			.002		
R^2	.000			.000		
F	.000			.001		

Note. MSP = the percentage of minority students and therefore, not a statistically significant predictor of advanced science course offerings, excluding and including AP science courses, in Virginia public high schools (refer to Table 13).

Research question 4. To what extent does access to advanced mathematics and science courses among students in Virginia public high schools vary by urbanicity locale (i.e., city, suburban, town, and rural)? Research Question 4 was examined in four parts, investigating the extent that urbanicity locale (i.e., city, suburban, town, or rural) predicted: advanced mathematics, excluding AP mathematics course offerings, advanced mathematics, including AP mathematics course offerings, advanced science, excluding AP science course offerings, and advanced science, including AP science course offerings.

Urbanicity and advanced mathematics excluding AP mathematics course offerings. In order to investigate this question, a one-way ANOVA was executed to determine the likelihood that urbanicity locale predicted student access to advanced mathematics courses, excluding AP mathematics courses. The data analysis revealed statistically significant differences in the number of advanced mathematics course offerings, excluding AP mathematics course offerings, in Virginia public high schools based on urbanicity locale, F (3, 305) = 7.707, $p < .001$, $n_p^2 =$ .070. Urbanicity locale accounted for about 7% of variability in advanced mathematics course offerings, excluding AP mathematics course offerings in Virginia public high schools. Conducting a post hoc comparison using Tukey's HSD revealed statistically significant mean differences in advanced mathematics course offerings, excluding AP mathematics courses in Virginia public high schools.

Table 13

Summary of Simple Regression Analyses for Minority Student Percentage Predicting Advanced Science Excluding and Including AP Science Course Offerings (N = 309)

	Advanced science excluding AP science courses			Advanced science including AP science courses		
Variable	*B*	*SE B*	*ß*	*B*	*SE B*	*ß*
MSP	.002	.002	.059	.004	.004	.049
Constant	2.188	.080		4.309	.167	
R		.059			.049	
R^2		.004			.002	
F		1.090			.743	

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

For instance, using alpha level of .05, suburban public high schools offered significantly more advanced mathematics courses, excluding AP mathematics (*M* = 5.095) than city (*M* = 4.308), town (*M* = 4.029) and rural (*M* = 4.158), public high schools across the Commonwealth of Virginia, $p < .001$. Comparisons between city-town and city-rural were not found to be statistically significant. Refer to Tables 14-17.

Table 14

Analysis of Variance for the Effects of Urbanicity Locale on Advanced Mathematics, Excluding AP Mathematics Course Offerings

Variable and source	*SS*	*MS*	*F*(3, 305)	*p*	n_p^2
Advanced Mathematics Excluding AP					
Between	53.659	17.886	7.707	< .001	.070
Error	707.804	2.321			

Note. SS = sum of squares. MS = mean square. n_p^2 = partial eta squared.

Table 15

Urbanicity Locale—Between-Subjects Factors

		Value label	*N*
	1	City	52
	2	Suburban	84
Urbanicity locale	3	Town	34
	4	Rural	139

Table 16

Multiple Comparisons—Advanced Mathematics Excluding AP Mathematics Course Offerings

(I) Urbanicity locale	(J) Urbanicity locale	(I-J) Mean difference	Std. error	Sig.	95% confidence interval Lower bound	Upper bound
City	Suburban	-.7875*	.2688	.019	-1.482	-.093
	Town	.2783	.3360	.841	-.590	1.146
	Rural	.1494	.2476	.931	-.490	.789
Suburban	City	.7875*	.2688	.019	.093	1.482
	Town	1.0658*	.3096	.004	.266	1.866
	Rural	.9370*	.2105	.000	.393	1.481
Town	City	-.2783	.3360	.841	-1.146	.590
	Suburban	-1.0658*	.3096	.004	-1.866	-.266
	Rural	-.1289	.2915	.971	-.882	.624
Rural	City	-.1494	.2476	.931	-.789	.490
	Suburban	-.9370*	.2105	.000	-1.481	-.393
	Town	.1289	.2915	.971	-.624	.882

Note. The mean difference is significant at the 0.05 level.

Table 17

Tukey HSD[a,b] Advanced Mathematics Excluding AP Mathematics Course Offerings

Urbanicity locale	*N*	Subset for alpha = 0.05 1	2
Town	34	4.029	
Rural	139	4.158	
City	52	4.308	
Suburban	84		5.095
Sig.		.754	1.000

Note. Means for groups in homogeneous subsets are displayed.

[a]Uses harmonic mean sample size = 59.048.

[b]The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Data analysis for urbanicity and advanced mathematics, including AP mathematics course offerings. In order to investigate this question, a one-way ANOVA was executed to determine the likelihood that urbanicity predicted student access to advanced mathematics courses, including AP mathematics courses. The data analysis revealed a statistically significant difference among urbanicity locale and advanced mathematics, including AP mathematics course offerings, in Virginia public high schools, F (3, 305) = 13.065, $p < .001$, $n_p^2 = .114$. Urbanicity locale accounted for about 12.5% of variability in advanced mathematics course offerings, including AP mathematics totals in Virginia public high schools. Conducting a post hoc comparison using Tukey's HSD revealed statistically significant mean differences in advanced mathematics course offerings, including AP mathematics courses, in Virginia public high schools. For instance, using alpha level of .05, suburban public high schools offered significantly more advanced mathematics courses, including AP mathematics courses than city, (M = 6.212, p = .021), than town, (M = 5.382, $p < .001$), and than rural public high schools in the Commonwealth of Virginia, (M = 5.576, $p < .001$). Comparisons between city-town, town-rural, and city-rural were not found to be statistically significant (refer to Tables 18-20).

Table 18

Analysis of Variance for the Effects of Urbanicity Locale on Advanced Mathematics Including AP Mathematics Course Offerings

Variable and source	*SS*	*MS*	*F*(3, 305)	*p*	n_p^2
Advanced Mathematics Including AP					
Between	176.603	58.868	13.065	< .001	.114
Error	1374.219	4.506			

Note. SS = sum of squares. MS = mean square. n_p^2 = partial eta squared.

Table 19

Multiple Comparisons—Advanced Mathematics Including AP Mathematics Course Offerings

(I) Urbanicity locale	(J) Urbanicity locale	(I-J) Mean difference	Std. error	Sig.	95% confidence interval Lower bound	Upper bound
City	Suburban	-1.0861*	.3745	.021	-2.054	-.119
	Town	.8292	.4682	.289	-.380	2.039
	Rural	.6360	.3451	.255	-.255	1.527
Suburban	City	1.0861*	.3745	.021	.119	2.054
	Town	1.9153*	.4315	.000	.801	3.030
	Rural	1.7221*	.2933	.000	.964	2.480
Town	City	-.8292	.4682	.289	-2.039	.380
	Suburban	-1.9153*	.4315	000	-3.030	-.801
	Rural	-.1932	4061	.964	-1.242	.856
Rural	City	-.6360	.3451	.255	-1.527	.255
	Suburban	-1.7221*	.2933	.000	-2.480	-.964
	Town	.1932	.4061	.964	-.856	1.242

Note. The mean difference is significant at the 0.05 level.

Table 20

Tukey HSD[a,b] Advanced Mathematics Including AP Mathematics Course Offerings

Urbanicity locale	*N*	Subset for alpha = 0.05 1	2
Town	34	5.382	
Rural	139	5.576	
City	52	6.212	
Suburban	84		7.298
Sig.		.148	1.000

Note. Means for groups in homogeneous subsets are displayed.

[a]Uses harmonic mean sample size = 59.048.

[b]The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Data analysis for urbanicity and advanced science, excluding AP science course offerings. In order to investigate this question, a one-way ANOVA was executed in SPSS® to determine the likelihood that urbanicity predicted student access to advanced science courses, excluding AP science courses. The null hypothesis was that there was no difference among urbanicity locale on advanced science, excluding AP science course offerings, in Virginia public high schools. Failing to reject the null hypothesis, the data revealed no statistically significant difference among urbanicity locale and the number of advanced science course offerings, excluding AP science courses, in Virginia public high schools, F (3, 305) = 1.854, p = .137, n_p^2 = .018. See Table 21.

Table 21

Analysis of Variance for the Effects of Urbanicity Locale on Advanced Science Excluding AP Science Course Offerings

Variable and source	*SS*	*MS*	*F*(3, 305)	*p*	n_p^2
Advanced Science Excluding AP					
Between	4.269	1.423	1.854	.137	.018
Error	234.042	0.767			

Note. SS = sum of squares. MS = mean square. n^2 = partial eta squared.

Data analysis for urbanicity and advanced science including AP science course offerings. A one-way ANOVA was executed to determine the likelihood that urbanicity predicted student access to advanced science courses including AP science courses. The null hypothesis was that there was no difference among urbanicity locale on the number of advanced science including AP science course offerings in Virginia public high schools. Rejecting the null hypothesis, the data revealed a statistically significant difference among urbanicity locale and advanced science course offerings, including AP science totals in Virginia public high schools, F (3, 305) = 13.773, $p < .001$, $n_p^2 = .119$. Urbanicity locale accounted for about 11.9% of variability in advanced science course offerings, including AP science courses, in Virginia public high schools. Conducting a post hoc comparison using Tukey's HSD revealed statistically significant mean differences in advanced science course offerings, including AP science courses, in Virginia public high schools. For instance, using alpha level of .05, the number of advanced science, including AP science course offerings, in Virginia public high schools located in a city was significantly higher than those in rural public high schools in Virginia, $p = .005$. There was no statistically significant difference in advanced science, including AP science course offerings, in Virginia public high schools. Suburban public high schools offered significantly one more advanced science courses, including AP science offerings, than town, $p = .002$, and than rural public high schools in the Commonwealth of Virginia, $p < .001$. City public high schools offered an estimated statistically significant one more advanced science courses, including AP science offerings, than rural public high schools in the Commonwealth of Virginia, $p < .01$. Comparisons between suburban-city and rural-town, and city-town were not found to be statistically significant (see Tables 22-24).

Table 22

Analysis of Variance for the Effects of Urbanicity Locale on Advanced Science Including AP Science Courses

Variable and source	*SS*	*MS*	*F*(3, 305)	*p*	n_p^2
Advanced Science Including AP					
Between	125.193	41.731	13.773	< .001	.119
Error	924.114	3.030			

Note. SS = sum of squares. MS = mean square. n^2 = partial eta squared.

Table 23

Multiple Comparisons—Advanced Science Including AP Science Courses

(I) Urbanicity locale	(J) Urbanicity locale	(I-J) Mean difference	Std. error	Sig.	95% confidence interval Lower bound	Upper bound
City	Suburban	-.5211	.3071	.327	-1.314	.272
	Town	.7590	.3839	.199	-.233	1.751
	Rural	.9467*	.2830	.005	.216	1.678
Suburban	City	.5211	.3071	.327	-.272	1.314
	Town	1.2801*	.3538	.002	.366	2.194
	Rural	1.4678*	.2406	.000	.846	2.089
Town	City	-.7590	.3839	.199	-1.751	.233
	Suburban	-1.2801*	.3538	.002	-2.194	-.366
	Rural	.1877	.3330	.943	-.673	1.048
Rural	City	-.9467*	.2830	.005	-1.678	-.216
	Suburban	-1.4678*	.2406	.000	-2.089	-.846
	Town	-.1877	.3330	.943	-1.048	.673

Note. The mean difference is significant at the 0.05 level.

Table 24

Tukey HSD[a,b] Advanced Science Including AP Science Courses

Urbanicity locale	*N*	Subset for alpha = 0.05		
		1	2	3
Rural	139	3.842		
Town	34	4.029	4.029	
City	52		4.788	4.788
Suburban	84			5.310
Sig.		.936	.085	.365

Note. Means for groups in homogeneous subsets are displayed.
[a]Uses harmonic mean sample size = 59.048.
[b]The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Research question 5. Controlling for teacher quality and discipline rates, to what extent does school size, economically disadvantaged percentage, the percentage of minority students, and urbanicity factors predict access to advanced mathematics and science course offerings in Virginia public high schools?

This question was examined in four parts, investigating the extent that school size, economically disadvantaged percentage, minority student percentage, and urbanicity factors predicted: advanced mathematics, excluding AP mathematics course offerings, advanced mathematics, including AP mathematics course offerings, advanced science, excluding AP science course offerings, and advanced science, including AP science course offerings. Teacher quality and discipline rate were two independent variables that were controlled in each question. In addition, public high schools in Virginia with a suburban urbanicity code served as the referenced group.

Multiple regression analysis advanced mathematics excluding AP mathematics course offerings. A multiple regression analysis was executed to predict advanced mathematics, excluding AP mathematics course offerings, in Virginia public high schools based upon school size, economically disadvantaged percentage, the percentage of minority students, and urbanicity factors, controlling for teacher quality and discipline rates. The null hypothesis was that there is no relationship or correlation among school size, economically disadvantaged percentage, minority student percentage, urbanicity, and advanced mathematics course offerings excluding AP mathematics courses, controlling for teacher quality and discipline rates. The data revealed a statistically significant regression equation F (8, 300) = 7.330, $p < .001$, $R^2 = .163$. The data also indicated that school size, economically disadvantaged percentage, the percentage of minority students, and urbanicity locale combined to explain 16.3% of the total variability in advanced mathematics course offerings, excluding AP mathematics courses, in Virginia public high schools, controlling for discipline rate and teacher quality, $R^2 = .163$ and Adjusted $R^2 = .141$.

The data revealed a positive statistically significant correlation between the linear combination of the independent variables and the number of advanced mathematics course offerings excluding AP mathematics courses, $R = .404$. Rejecting the null hypothesis, this regression analysis also illustrated that school size, economically disadvantaged percentage, the percentage of minority students, and urbanicity locale combined accounted for a statistically significant amount of variance in advanced mathematics course offerings, excluding AP mathematics courses, in Virginia public high schools, F (8, 300) = 7.330, $p < .001$, $R^2 = .163$. The model equation is: $\hat{y} = 0.939 + 0.001(x_1) + 0.001(x_2) - 0.002(x_3) - 0.364(x_4) - 0.280(x_5) - 0.205(x_6) - 0.007(x_7) + .030(x_8)$ where x_1 represents school size (based on fall 2012 membership enrollment), x_2 represents school economically disadvantaged percentage, x_3 represents the percentage of minority students (based on Black and Latino student enrollment), x_4 represents urbanicity locale city, x_5 represents urbanicity locale town, x_6 represents urbanicity locale rural, x_7

represents school discipline rate, and x_8 represents teacher quality. A review of the regression coefficients to determine if they differ significantly from zero revealed that school size, based on fall 2012 enrollment, was the only independent variable that was statistically significantly different from zero, holding all other variables constant $p = .000$, which means $p < .001$. This suggests access to one additional advanced mathematics course offering, excluding AP mathematics courses, in Virginia public high school for every increase in school size by 1,000 students, holding all other variables constant (see Table 25).

Table 25

Summary of Multiple Regression Analyses for Predictors of Advanced Mathematics Excluding and Including AP Mathematics Course Offerings (N = 309)

	Advanced Mathematics excluding AP Mathematics Course Offerings			Advanced Mathematics including AP Mathematics Course Offerings		
Variable	*B*	*SE B*	*β*	*B*	*SE B*	*β*
Constant	0.939	2.924		-1.515	3.851	
School size	.001*	.000	.337*	.001*	.000	.401
EDP	.001	.006	.008	-.011	.008	-.098
MSP	-.002	.005	-.025	-.002	.006	-.025
City	-.364	.291	-.087	-.127	.383	-.021
Town	-.280	.338	-.056	-.364	.446	-.051
Rural	-.205	.251	-.065	-.335	.331	-.074
Discipline rate	-.007	.005	-.082	-.008	.007	-.064
Teacher quality	.030	.029	.057	.071	.038	.095
R^2	.163			.287		
F	7.330*			15.119*		

Note. Controls are discipline rate and teacher quality. Suburban public high schools are the referenced group. N = 309. EDP = economically disadvantaged percentage; MSP = the percentage of minority students. *$p < .001$

Multiple regression analysis for advanced mathematics including AP mathematics course offerings. In order to investigate this question, a multiple regression analysis was executed to determine the likelihood that school size, economically disadvantaged percentage, the percentage of minority students, and urbanicity factors predict access predict student access to advanced mathematics courses including AP mathematics courses, controlling for teacher quality and discipline rates. The null hypothesis was that there is no relationship among school size, economically disadvantaged percentage, the percentage of minority students, urbanicity, and advanced mathematics course offering including AP mathematics courses, controlling for teacher quality and discipline rates. The data revealed a statistically significant positive correlation between the linear combination of the independent variables and the number of advanced mathematics course offerings including AP mathematics courses, $R = .536$, $p < .001$.

The data also revealed that school size, economically disadvantaged percentage, the percentage of minority students, and urbanicity locale combined to explain 28.7% of the total variability in advanced mathematics course offerings, including AP mathematics courses, in Virginia public high schools, controlling for discipline rate and teacher quality, $R^2 = .287$ and Adjusted $R^2 = .268$. Rejecting the null hypothesis, this regression analysis also illustrated that school size, economically disadvantaged percentage, the percentage of minority students, and urbanicity locale combined accounted for a statistically significant amount of variance in the number of advanced mathematics course offerings, including AP mathematics courses, in Virginia public high schools, F (8, 300) = 15.119, $p < .001$, $R^2 = .287$. The model equation is: $\hat{y} = -1.515 + 0.001(x_1) - 0.011(x_2) + 0.002(x_3) - 0.127(x_4) - 0.364(x_5) - 0.335(x_6) - 0.008(x_7) + 0.071(x_8)$, where x_1 represents school size (based on fall 2012 membership enrollment), x_2 represents school economically disadvantaged percentage, x_3 represents the percentage of minority students (based on Black or Latino student enrollment), x_4 represents urbanicity locale city, x_5 represents urbanicity locale town, x_6 represents urbanicity locale rural, x_7 represents school discipline rate, and x_8 represents teacher quality. A review of the regression coefficients to determine if they differ significantly from zero revealed that school size, based upon fall 2012 enrollment, was the only independent variable that is statistically significantly different from zero holding all other variables constant, $p < .001$. This suggests an increase by one course in the number of advanced mathematics course offerings, including AP mathematics courses, in Virginia public high school as school size increases by 1,000 students, holding all other variables constant.

Multiple regression analysis for advanced science, excluding AP science course offerings. A multiple regression analysis was executed to determine the likelihood that school size, economically disadvantaged percentage, the percentage of minority students, and urbanicity factors predict access predict student access to advanced science courses, excluding AP science courses, controlling for teacher quality and discipline rates. The null hypothesis was that there is no relationship among school size, economically disadvantaged percentage, the percentage of minority students, urbanicity, and the number of advanced science course offerings, including AP science courses, controlling for teacher quality and discipline rates. The data revealed a correlation between the linear combination of the independent variables and the number of advanced science course offerings, excluding AP science courses, $R = .180$. The data also revealed that school size, economically disadvantaged percentage, the percentage of minority students, and urbanicity locale combined to explain 3.2% of the total variability in advanced mathematics course offerings, including AP mathematics courses, in Virginia public high schools, controlling for discipline rate and teacher quality, $R^2 = .032$ and Adjusted $R^2 = .006$.

Failing to reject the null hypothesis, this regression analysis revealed that school size, economically disadvantaged percentage, the percentage of minority students, and urbanicity locale combined did not account for a statistically significant amount of variance in advanced science course offerings, excluding AP science courses, in Virginia public high schools, F (8, 300) = 1.249, p = .270, R^2 = .032.

Multiple regression analysis for advanced science, including AP science course offerings. A multiple regression analysis was executed to determine the likelihood that school size, economically disadvantaged percentage, the percentage of minority students, and urbanicity factors predict access predict student access to advanced science courses including AP science courses, controlling for teacher quality and discipline rates. The null hypothesis was that there is no relationship among school size, economically disadvantaged percentage, minority student percentage, urbanicity and the number of advanced science course offerings, including AP science courses, controlling for teacher quality and discipline rates. The data revealed a correlation between the linear combination of the independent variables and the number of advanced science course offerings, including AP science courses, R = .540. The data also revealed that school size, economically disadvantaged percentage, the percentage of minority students, and urbanicity locale combined to explain 29.2% of the total variability in advanced science course offerings, including AP science courses, in Virginia public high schools, controlling for discipline rate and teacher quality, R^2 = .292 and Adjusted R^2 = .273. Rejecting the null hypothesis, this regression analysis also illustrated that school size, economically disadvantaged percentage, the percentage of minority students, and urbanicity locale combined accounted for a statistically significant amount of variance in advanced science course offerings including AP science courses in Virginia public high schools, holding all other

Table 26

Summary of Multiple Regression Analyses Predictors of Advanced Science Excluding and Including AP Science Course Offerings (N = 309)

	Advanced science excluding AP science course offerings			Advanced science including AP science course offerings		
Variable	*B*	*SE B*	ß	*B*	*SE B*	ß
Constant	1.032	1.759		-2.421	3.158	
School size	.000	.000	.142	.001*	.000	.403
EDP	.004	.004	.085	-.010	.007	-.109
MSP	.001	.003	.019	-.001	.005	-.019
City	-.166	.175	-.071	.216	.314	.044
Town	-.051	.204	-.018	.001	.365	.000
Rural	-.135	.151	-.077	-.332	.271	-.090
Discipline rate	-.002	.003	-.047	-.002	.006	-.023
Teacher quality	.010	.018	.035	.063*	.031	.101
R^2	.032			.292		
F	1.249			15.445*		

Note. Controls are discipline rate and teacher quality. Suburban public high schools are the referenced group (*N* = 309). EDP = Economic disadvantaged percentage; MSP = the percentage of minority students. *$p < .001$.

variables constant F (8, 300) = 15.445, $p < .001$, $R^2 = .292$. The model equation is: $\hat{y} = -2.421 + 0.001(x_1) - 0.010(x_2) - 0.001(x_3) + 0.216(x_4) + 0.001(x_5) - 0.332(x_6) - 0.002(x_7) + 0.063(x_8)$, where x_1 represents school size (based on fall 2012 membership enrollment), x_2 represents school economically disadvantaged percentage, x_3 represents the percentage of minority students (based on Black and Latino student enrollment), x_4 represents urbanicity locale city, x_5 represents urbanicity locale town, x_6 represents urbanicity locale rural, x_7 represents school discipline rate, and x_8 represents teacher quality. A review of the regression coefficients to determine if they differ significantly from zero revealed that school size, based upon fall 2012 enrollment, is statistically significantly different from zero, holding all other variables constant, $B = .001$, $p < .001$. This suggests an increase by one course in advanced science course offerings, including AP science courses, in Virginia public high school for every increase in school size by 1,000 students, holding all other variables constant.

Teacher quality, as defined by percentage of core academic teachers meeting federal highly qualified standards, was statistically significantly different than zero and therefore, a significant predictor of advanced science course offerings, including AP science courses, in Virginia public high schools, holding all other variables constant, $B = 0.063$, $p = .047$. This suggests an increase in advanced science course offerings, including AP science courses, in Virginia public high school for every one unit increase or 1% increase in teacher quality percentage, holding all other variables constant. Overall, school size, economically disadvantaged percentage, the percentage of minority students, and urbanicity locale combined to explain 29.2% of the total variability in advanced science course offerings, including AP science courses, in Virginia public high schools, controlling for discipline rate and teacher quality (see Table 26).

Summary

A broad review of all research questions revealed school size to be a statistically significant predictor of advanced mathematics course offerings, excluding and including AP, course offerings in Virginia public high schools. School size was more strongly correlated with the number of advanced mathematics course offerings, including AP mathematics courses and accounted for 28.7% of variance in comparison to only 16.3% of variability in advanced mathematics course offerings, excluding AP mathematics courses. Among advanced science course offerings, school size was found to only be statistically significant predictor of advanced science, including AP science course offerings, in Virginia public high school. It accounted for approximately 29.2% in variability.

Similarly, in isolation, economically disadvantaged percentage was found to be a statistically significant predictor of student access to all advanced mathematics and advanced science course offerings with the exception of advanced science, excluding AP science course offerings. The correlation was strongest for advanced mathematics, including AP mathematics course offerings, followed by advanced science, including AP science course offerings. However, the amount of variance accounted for in each analysis was weak, 11.2% and 9.6% respectively. Table 27 provides a summary of the statistical analysis.

The data also revealed that the percentage of minority students, in the simple and multiple regression analyses, was not a statistically significant predictor of student access to advanced mathematics and science course offerings, excluding and including AP mathematics and science courses.

Table 27

Research Questions Summary Data

Research questions	R^2	*F*	df numerator	Df denominator	*p*	r	H_o
RQ1							
School size and AdvMath w/o AP Math	.142	50.873	1	307	.000	.377*	Reject
School size and AdvMath w/AP Math	.249	102.026	1	307	.000	.499*	Reject
School size and AdvScience w/o AP Science	.023	7.097	1	307	.008	.150*	Reject
School size and AdvScience w/AP Science	.257	106.255	1	307	.000	.507*	Reject
RQ2							
EDP and AdvMath w/o AP Math	.052	16.896	1	307	.000	-.228*	Reject
EDP and AdvMath w/AP Math	.116	40.133	1	307	.000	-.340*	Reject
EDP and AdvScience w/o AP Science	.000	.143	1	307	.706	-.022	Fail to reject
EDP and AdvScience w/AP Science	.094	31.780	1	307	.000	-.306*	Reject
RQ3							
MSP and AdvMath w/o AP Math	.000	0.000	1	307	.988	.001	Fail to reject
MSP and AdvMath w/AP Math	.000	0.001	1	307	.971	.002	Fail to reject
MSP and AdvScience w/o AP Science	.004	1.090	1	307	.297	.059	Fail to reject
MSP and AdvScience w/AP Science	.002	0.743	1	307	.389	.049	Fail to reject
RQ4							
Urbanicity and AdvMath w/o AP Math	.070	7.707*	3	305	.000		Reject

Table 27 - continued

Research questions	R^2	F	df numerator	Df denominator	p	r	H_o
Urbanicity and AdvMath w/AP Math	.114	13.065*	3	305	.000		Reject
Urbanicity and AdvScience w/o AP Science	.018	1.854	3	305	.137		Fail to reject
Urbanicity and AdvScience w/AP Science	.119	13.773*	3	305	.000		Reject
RQ5							
School size, EDP, MSP, urbanicity locale and AdvMath w/o AP Math	.163	7.330*	8	300	.000	.404	Reject
School size, EDP, MSP, urbanicity locale and AdvMath w/AP Math	.287	15.119*	8	300	.000	.536	Reject
School size, EDP, MSP, urbanicity locale and AdvScience w/o AP Science	.032	1.249	8	300	.270	.180	Fail to reject
School size, EDP, MSP, urbanicity locale and AdvScience w/AP Science	.292	.15.445*	8	300	.000	.540	Reject

Note. AdvMath w/AP = Advanced mathematics including AP mathematics course offerings; EDP = economic disadvantaged percentage; MSP = minority student percentage. Effect size[a] in simple regression, effect size measured by R^2 and multiple regression by partial eta squared.

Chapter Five. Conclusions and Implications for Future Research

This chapter provides a general summary of the research findings and meaningful conclusions based upon the statistical analysis from Chapter 4. In addition, implications for educational leaders and recommendations for further research are discussed in this chapter. This chapter concludes with reflective thoughts from the researcher regarding these findings.

Brief Overview of the Problem

A review of national data from College Board and ACT suggest an increase in student enrollment in more rigorous high school courses; however, there still exists a persistent gap in student access to and participation in college and career-readiness course work, such as advanced mathematics and science courses at or above Algebra II and Chemistry, respectively. Student access to and completion of advanced mathematics and science course work has been found to be associated with postsecondary successes, such as high school graduation, college participation, college degree attainment and financial earnings. Given our nation's request to remain an economic powerhouse in the world, producing college and career ready graduates is vital to America maintaining strong international, national, state, and local economies.

Despite these findings, many researchers have discovered disparities in student access to college and career opportunities in high school such as advanced mathematics and science courses through the nation based upon school factors such as school location, school size, and ethnic demographic composition of the school. The OCR (2012) reported disparities in access to higher-level mathematics and science courses in schools with high minority enrollment in comparison to high schools with low minority enrollment. The Commonwealth of Virginia has a college and career readiness initiative (VCCRI) focused on ensuring that college and career standards are taught in Virginia high schools and increasing students' preparedness for postsecondary opportunities prior to graduation (VDOE, 2010). Given the emphasis on producing college and career-readiness graduates at the national and state level, it was vital to examine the extent that student access to advanced mathematics and science course offerings, as a college and career-readiness indicator, in Virginia public high schools varies based upon school size, economic disadvantaged percentage, minority student percentage, and urbanicity locale.

Purpose of Study and Research Questions

This purpose of this study was to investigate student access to advanced mathematics and sciences courses in Virginia public high schools as an indicator of college and career readiness based on school size (fall 2012 membership enrollment), economically disadvantaged percentage (percentage of students classified as economic disadvantaged), the percentage of minority studetnts (ratio of the number of Black and Latino students combined and fall 2012 membership enrollment), and urbanicity locale. This study examined the extent of disparities in access to opportunity to learn based upon several identified factors. A national focus to produce more college and career ready graduates inherently requires access to advanced mathematics and science courses (College Board, 2012, 2013, 2014). Closing the gap in access to educational opportunity is needed in order for America to remain competitive in the world in the STEM field.

Research questions. Using descriptive statistics and regression analysis, this quantitative study addressed the following research questions:

1. To what extent does access to advanced mathematics and science courses among students in Virginia public high schools vary by school size, as defined by fall 2012 membership enrollment?

2. To what extent does access to advanced mathematics and science courses among students in Virginia public high schools vary by economic disadvantaged percentage, percentage of students classified as economically disadvantaged?
3. To what extent does access to advanced mathematics and science courses among students in Virginia public high schools vary by the percentage of minority, as defined as the percentage of Black or Latino students?
4. To what extent does access to advanced mathematics and science course offerings among students in Virginia public high schools vary by urbanicity locale (i.e., city, suburban, town, and rural)?
5. Controlling for teacher quality and discipline rates, to what extent do school size, economic disadvantaged percentage, the percentage of minority students, and urbanicity locale predict access to the number of advanced mathematics and science course offerings in Virginia public high schools?

Review of Methodology

The research methodology employed for this study included a simple regression analysis, multiple regression analysis, and ANOVA. School size, economically disadvantaged percentage, minority student percentage, and urbanicity locale were all investigated in relation to the number of advanced mathematics and science course offerings, excluding and including AP mathematics and science courses, independently. Urbanicity locale factors were examined using an ANOVA. The final analysis entailed a multiple regression analysis with suburban public high schools as the reference group and controlling for teacher quality and discipline rates.

Summary of Findings

School size, based on 2012 enrollment, was found to have significant positive correlations with advanced mathematics and science course offerings, including and excluding AP mathematics and science courses, in Virginia public high schools. Although the amount of variability for both analyses was relatively weak, disparities in access to the number of advanced mathematics and science course offerings existed when school size, economically disadvantaged percentage, minority student percentage, and urbanicity locale were considered. Furthermore, suburban public high schools throughout the Commonwealth of Virginia were indicated to offer a greater number of advanced mathematics and science courses. Other factors, such as the percentage of minority students, were revealed to have no significant difference in the number of advanced mathematics and science course offerings, excluding and including AP mathematics and science courses, in Virginia public high schools.

The findings from this study associated with school size and urbanicity locale suggest that students who attend larger schools and suburban schools have greater access to advanced mathematics and science course work than students who attend smaller or non-suburban schools across the Commonwealth of Virginia. Further analysis of school size by urbanicity locale revealed that the average size of suburban public high schools in Virginia (M = 1762, SD = 642.12) is greater than city schools (M = 1384, SD = 632) by more then 400 students. Suburban high schools are more than twice the size of public high schools located in town (M = 801, SD = 508.33) and rural areas (M = 878, SD = 530.03) across the Commonwealth of Virginia. This suggests that differences in advanced mathematics and science course offerings excluding and including AP may be attributed to a function of school size as opposed to school location or urbanicity locale. The average school size by urbanicity locale is presented in Table 28.

Table 28

Analysis of Average School Size by Urbanicity Locale

Urbanicity locale	*n*	*M*	*SD*
City	52	1384.058	632.3974
Suburban	84	1761.679	642.1247
Town	34	801.206	508.3281
Rural	139	878.022	530.0260
Total	309	1194.945	697.8305

Note. *N* = 309, Sample size. *M* = Mean. *SD* = Standard deviation.

Finding 1. School size is a predictor of the number of advanced mathematics course offerings in Virginia public high schools. In isolation**,** school size, based upon student enrollment, was positively correlated with advanced mathematics course offerings, excluding and including AP mathematics courses in Virginia public high schools, respectively. School size had a stronger positive relationship with student access to advanced mathematics course offerings, including AP mathematics courses, than advanced mathematics course offerings, excluding AP mathematics courses, in Virginia public high schools, $r = .499$ and $r = .377$, respectively. Furthermore, school size also accounted for greater variability in advanced mathematics course offerings, including AP mathematics courses, 24.9%, in comparison to advanced mathematics course offerings, excluding AP mathematics courses, which only accounted for 14.2% of variability.

When examined in the multiple regression analysis with economically disadvantaged percentage, the percentage of minority students, city, town, and rural, school size remained a statistically significant predictor of advanced mathematics course offerings, excluding and including AP mathematics courses, in Virginia public high school, after controlling for teacher quality and discipline rate. School size accounted for 16.3% and 28.7% of total variability in advanced mathematics excluding and including AP mathematics courses respectively. The beta values for both analyses ($B = .001$) suggested that as school size increases by 1000, student access to advanced mathematics courses increase by one course. This finding has statistical and practical significance. An increase in school size by 1,000 students increased student access to advanced mathematics course offerings by one course. School size is an indicator that has a positive influence on student access to college and career opportunities in Virginia public schools.

This finding is consistent with many researchers who have examined school size (Berry, 2004; Hylden, 2005) and the impact of advanced mathematics course offerings on postsecondary outcomes. This finding has great implications on postsecondary educational outcomes. For example, Adelman (2006) examined taking advanced mathematics courses in high school and postsecondary educational outcomes. The researcher found that student completion of advanced mathematics courses in high school was a strong predictor of college graduation among students, irrespective of family background. Students who completed advanced mathematics courses were twice as likely to attain a bachelor's degree than those who did not.

Researchers who have examined the student access and completion of advanced science courses, such as chemistry and physics in high school, have reported success in college completion and degree attainment in STEM related areas (Maltese & Tai, 2011). Subsequently, it is imperative that all students, irrespective of school factors such as school size, should have equal access to advanced science coursework. Considering the positive association that advanced science coursework has on student post secondary outcomes (Maltese & Tai, 2011), the findings from this study suggest that the disparities in access may negatively impact post-secondary outcomes for high school students.

Finding 2. School size was a significant predictor of the number of advanced science course offerings, including AP science courses, in Virginia public high schools. In isolation**,**

school size was also positively associated with student access to advanced science course offerings, including AP science courses in Virginia public high schools accounting for 25.7% of the total variability. School size was strongly correlated with advanced science courses, including AP science courses, $r = .507$.

When examined in the multiple regression analysis with economically disadvantaged percentage, minority student percentage, city, town, and rural, school size remained a statistically significant predictor of student access to advanced science courses, including AP science courses, after controlling for teacher quality and discipline rate, holding all other variables constant. Similar to findings associated with advanced mathematics, student access to advanced science courses including AP science courses increased by one for every increase in student enrollment by 1,000 students. School size in the public high school setting in the Commonwealth of Virginia positively impacts student access to college and career readiness opportunities.

Finding 3. Economically disadvantaged percentage is a predictor of student access to the number of advanced mathematics course offerings in Virginia public high schools. In isolation**,** EDP was negatively correlated with advanced mathematics, excluding and including AP mathematics course offerings, in Virginia public high schools, accounting for 5.2% and 11.6% of variability respectively in the number of course offerings. The negative correlations were moderately weak for both the number of advanced mathematics course offerings excluding AP mathematics courses, $r = -.228$, and advanced mathematics course offerings, including AP mathematics courses, $r = -.340$. The number of advanced mathematics courses, excluding AP mathematics courses offerings, in Virginia public high schools decreased by one course for every 55 unit or 55% increase in a school’s economically disadvantaged percentage. When AP mathematics courses were included, the number of advanced mathematics courses, including AP mathematics course offerings, in Virginia public high schools also decreased as the percentage of economically disadvantaged students increased. For instance, for every 26 units or 26% increase in a school's economically disadvantaged percentage, the number of advanced mathematics including AP mathematics courses in Virginia public high schools decrease from 7 courses to 6 courses. This suggests that students who attend schools with higher economically disadvantaged percentages have less access to advanced mathematics course offerings.

However, when examined in the multiple regression analysis with school size, the percentage of minority students, city, town, and rural, economically disadvantaged percentage was revealed not to be a statistically significant predicator of student access to these course offerings, after controlling for teacher quality and discipline rate. School size was the only variable found to be a statistically significant predicator of advanced mathematics course offerings excluding and including AP mathematics courses in the multiple regression analysis. Further analysis of economically disadvantaged percentage and school size, revealed that Virginia public high schools with higher EDP are smaller in size. A statistically significant negative correlation between economically disadvantaged percentage and school size (r = -.412, p < .001) suggests that fewer advanced mathematics course offerings, excluding and including AP mathematics courses, are due to a function of school size. See Table 6 for correlation between economically disadvantaged percentage and school size.

Consistent with research on disparities in educational opportunities for students from disadvantaged backgrounds in comparison to those from non disadvantaged or high SES backgrounds (Darling-Hammond, 2010; Flores, 2007; Flowers, 2008), this finding suggests that inequitable opportunities to access to college and career readiness coursework in Virginia public high schools as the percent of economically disadvantaged students increases. Theses disparities seemingly may impact other educational outcomes such as college success and degree attainment (Achieve, 2008; Carter & Welner, 2013; Klopfenstein & Thomas, 2009).

Finding 4. Economically disadvantaged percentage is a significant predictor of the number of advanced science course offerings, including AP science courses, in Virginia public high schools. In isolation, economically disadvantaged percentage was not found to be a predictor of the number of advanced science course offerings, excluding AP science courses; however, economically disadvantaged percentage was revealed to have a moderately negative correlation with advanced science course offerings, including AP science courses, in Virginia public high schools, $r = -.306$, $p < .001$. Economically disadvantaged percentage accounted for 9.4% of variability in advanced science course offerings, including AP science course offerings. This finding revealed that student access to advanced science courses, including AP science courses, decreased by one course for every 36 units or 36% increase in economically disadvantaged percentage.

However, when examined in the multiple regression analysis with school size, minority student percentage, city, town, and rural, economically disadvantaged percentage was revealed not to be a statistically significant predicator of student access to advanced science including AP science course offerings, after controlling for teacher quality and discipline rate. School size and teacher quality were the only variables found to be statistically significant predicators of advanced science course offerings including AP science courses in the multiple regression analysis. Further analysis of economically disadvantaged percentage and school size, revealed that Virginia public high schools with higher economically disadvantaged percentages are smaller in size. A statistically significant negative correlation between EDP and school size (r =

-.412, $p < .001$) suggests that fewer advanced science course offerings, excluding and including AP science courses, are due to a function of school size. See Table 6 for correlation between economically disadvantaged percentage and school size.

This finding is consistent with research on students' access to college and career readiness opportunities. Researchers have reported that access to college and career-readiness opportunities is less when economically disadvantaged percentages are higher (College Board, 2014; Ingels & Dalton, 2008; Robinson, 2003). Robinson (2003) examined the relationship of AP course completion and student interest and pursuit of college degrees in STEM-related fields among minority and nonminority students. The researcher found that students enrolled in AP science courses (i.e., AP chemistry, biology, and physics) were more likely to pursue college degrees in STEM-related fields than non-STEM fields, including humanities, business, and fine arts. However, Robinson (2003) reported differences in enrollment of AP courses by SES and school size. Schools with high SES offered more AP courses and had greater student enrollment. Small and rural schools were also identified as not offering as many AP courses as non-small and rural schools.

Findings 5. Minority student percentage was not found to be a predictor of student access to the number of advanced mathematics and advanced science course offerings in Virginia public high schools. The percentage of minority students was not identified as a predictor of student access to advanced mathematics and science course offerings in Virginia public high schools. This excluded and included AP mathematics and science course offerings. This finding suggests that students who attend public high schools in the Commonwealth of Virginia do not experience varying access to the number of advanced mathematics and science course offering, including and excluding AP mathematics and science course offerings, based on percentage of minority students enrollment.

This finding is inconsistent with national findings from the OCR (2012), which reported greater access to college and career readiness opportunities in low minority schools than high minority schools. In addition, this finding is inconsistent with researchers who have identified disparities in the availability of AP course offerings in schools with high minority percentages and lower SES (Barnard-Brak, McGaha-Garnett, & Burley, 2011; Lleras 2008). Barnard-Brak, McGaha, & Burley (2011) found schools with lower ethnic minority background percentages had greater access to AP courses, even after controlling for school size. However, this finding indicated that the availability or number of advanced mathematics and science course offerings in Virginia's public high schools are not associated with a school's minority student percentage.

Finding 6. Suburban public high schools in Virginia offered a higher number of advanced mathematics courses, excluding AP mathematics courses, than rural, town, and city. There were differences in the number of advanced mathematics course offerings without AP mathematics courses in Virginia public high schools among different urbanicity locales. Suburban public high schools on average offered the most advanced mathematics courses, excluding AP mathematics courses, than schools with city, rural, and town urbanicity locale codes. Suburban public high schools in the Commonwealth of Virginia offered an average of five advanced mathematics courses, excluding AP mathematics courses, in comparison to city public high schools (4.308 courses), town public high schools (4.029 courses), and rural public high schools (4.158 courses). Although the amount of variability was seemingly weak accounting for about 7% of variability in the number of advanced mathematics course offerings excluding AP mathematics courses in Virginia public high schools, conducting a post hoc comparison using Tukey's HSD revealed statistically significant mean differences among urbanicity locales. For instance, using alpha level of .05, advanced mathematics, excluding AP mathematics course offerings, in Virginia public high school located in the city were significantly lower than suburban public high schools in Virginia, $p = .019$. Suburban public high schools offered statistically significantly more advanced mathematics courses without AP mathematics courses than city ($M = 5.183$, $p = .014$), than town ($M = 4.091$, $p = .005$), and than rural public high schools in the Commonwealth of Virginia, ($M = 4.076$, $p < .001$). Comparisons between city and town public high schools, city and rural public high schools, and rural and town public high schools were not identified statistically significant.

When examined in the multiple regression analysis with school size, the percentage of minority students, city, town, and rural, school size was revealed to be the only statistically significant predicator of student access to advanced mathematics courses, excluding and including AP mathematics courses, after controlling for teacher quality and discipline rate. Further analysis of urbanicity locale and school size revealed that suburban high schools are more than twice the size of public high schools located in towns ($M = 801$, $SD = 508.33$) and rural areas ($M = 878$, $SD = 530.03$) across the Commonwealth of Virginia. Consistent with findings associated with school size, this suggests that greater access to advanced mathematics courses, excluding and including AP mathematics courses, in suburban schools in comparison to non-suburban schools are due to a function of school size. See Table 28 for descriptive statistics for school size by urbanicity locale.

Consistent with literature on differences in resources, opportunity, and achievement in schools by urbanicity (Gagnon & Mattingly, 2015; OCR, 2012; Schott Foundation, 2009), this finding supports previous findings that students who attend suburban schools have great access to educational opportunities than those who attend rural, urban, and town public schools.

Finding 7. Suburban public high schools in Virginia offered a higher number of advanced mathematics courses, including AP mathematics courses, than rural, town, and city. There were differences in the number of advanced mathematics course offerings, including AP mathematics courses, in Virginia public high schools among different urbanicity locales. On average**,** suburban public high schools offered the most advanced mathematics courses, including AP mathematics courses, than schools with city, rural, and town urbanicity locale codes. Suburban public high schools in the Commonwealth of Virginia offered an average of seven advanced mathematics courses, including AP mathematics courses, in comparison to city public high schools (6.212 courses), town public high schools (5.382 courses), and rural public high schools (5.576 courses). The amount of variability in the number of advanced mathematics courses offered, including AP mathematics courses, based on urbanicity locale was seemingly weak, accounting for about 11.4%. Conducting a post hoc comparison using Tukey's HSD revealed statistically significant mean differences among urbanicity locales. For instance, using alpha level of .05, suburban public high schools offered statistically significantly more advanced mathematics courses with AP mathematics courses than city ($M = 6.229$, $p = .024$), than town ($M = 5.455$, $p = .000$), and than rural public high schools in the Commonwealth of Virginia, ($M = 5.462$, $p < .000$). This finding revealed that suburban public high schools in Virginia offered one more advanced mathematics course, including AP mathematics courses, than city and two more courses than city and rural public high schools. Comparisons of mean differences between city and town public high schools, city and rural public high schools, and rural and town public high schools in Virginia were not identified statistically significant.

Differences in advanced mathematics course offerings, excluding and including AP mathematics courses, are consistent with research findings examining geography of opportunities to learn (Schott Foundation, 2009; Tate 2008). Tate (2008) and Schott Foundation (2009) indicated that school location was an important factor or determinant of educational opportunities and reported less access to educational opportunities for students who attended public schools located in urban or city areas. Similar to findings Number 6 and Number 7, educational opportunities were greatest in suburban schools. Consistent with research findings on access to advanced mathematics and science or rigorous curriculum, student access to advanced mathematics and science course offerings were the least for students who attend rural schools and greater in suburban and urban schools (Anderson & Chang, 2011; Daniel-White, 2007; Lleras, 2008; Planty, Provasnik, & Tate 2008). Access was greatest in terms of course offerings in suburban schools.

Finding 8. There were no differences among urbanicity locales and the number of advanced science course offerings, excluding AP science courses in Virginia public high schools. There were no statistically significant differences in advanced science course offerings excluding AP science courses, in Virginia public high schools. An examination and comparison of mean differences using Tukey's HSD identified no statistically significant differences between the number of advanced science courses, excluding AP science courses, among urbanicity locales. Using alpha level of .05, suburban public high schools (M = 2.429) offered relatively the same number of advanced science courses, excluding AP sciences courses, as city (M = 2.269, p = .731), town (M = 2.235, p = .699), and rural public high schools in the Commonwealth of Virginia, (M = 2.144, p = .089). Suburban public high schools, city public high schools, town public high schools, and rural public high schools were all identified to offer an average of two advanced science courses, excluding AP science courses, in Virginia. This finding suggests that irrespective of urbanicity locale, high school students in the Commonwealth of Virginia have access to two advanced science courses excluding AP science courses, on average.

Finding 9. Suburban public high schools in Virginia offered a higher number of advanced science courses, including AP science courses, than town and rural, but not city public high schools. There were differences in the number of advanced science course offerings including AP science courses in Virginia public high schools among different urbanicity locales. Suburban public high schools on average offered the more advanced science courses, including AP science courses, than schools with rural and town urbanicity locale codes. However, suburban did not offer more advanced science courses, including AP science courses, than city schools. Suburban public high schools in the Commonwealth of Virginia offered an average of five advanced science courses, including AP science courses, in comparison to rural public high schools (3.842 courses), town public high schools (4.029 courses), and city public high schools (4.788 courses). The amount of variability in the number of advanced science courses offered, including AP science courses, based upon urbanicity locale was seemingly weak, accounting for about 11.9%. Conducting a post hoc comparison using Tukey's HSD revealed statistically significant mean differences among suburban and town public high schools, suburban and rural high schools, and city and rural high schools. For instance, using alpha level of .05, suburban public high schools offered statistically significantly more advanced science courses, including AP science courses, than town (M = 4.029, p = .002) and rural public high schools in the Commonwealth of Virginia, (M = 3.842, $p < .001$). Similarly, city public high schools (M = 4.788 courses) offered statistically significantly more advanced science courses, including AP science courses, than rural public high schools in the Commonwealth of Virginia (*M* = 3.842, *p* = .005). This finding revealed that suburban public high schools in Virginia offered 1 and 1.5 more advanced science course, including AP science courses, than town and rural public high schools respectively. City public high schools also offered one more advanced science, including AP science courses, than rural public schools. Comparisons of mean differences between city and town public high schools, rural and town public high schools, and suburban and city public high schools in Virginia were not identified statistically significant.

When examined in the multiple regression analysis with school size, minority student percentage, city, town, and rural, school size and teacher quality were revealed to be the only statistically significant predicators of student access to advanced science courses, including AP science courses, after controlling for teacher quality and discipline rate. Further analysis of urbanicity locale and school size revealed that suburban high schools are more than twice the size of public high schools located in towns (*M* = 801, *SD* = 508.33) and rural areas (*M* = 878, *SD* = 530.03) across the Commonwealth of Virginia. This suggests that greater access to advanced science courses including AP science courses in suburban schools in comparison to non-suburban schools are due to a function of school size. See Table 28 for descriptive statistics for school size by urbanicity locale.

Consistent with findings from Robinson (2003), rural and town high schools offered less AP science courses than suburban public high schools. Robinson (2003), in an examination of AP science course participation, indicated that schools with high SES offered more AP courses and had greater student enrollment. Small and rural schools were also identified as not offering as many AP courses as non-small and rural schools. This finding was also consistent with findings associated with advanced mathematics course offerings with AP mathematics courses.

Planty, Provasnik, and Daniel-White (2007) indicated that rural schools were less likely to offer AP coursework than city and suburban schools.

Finding 10. Controlling for teacher quality and discipline rates, school size was identified significant predictors of the number of advanced mathematics course offerings, excluding and including AP mathematics courses, in Virginia public high schools, holding all other variables constant. Using suburban as the reference group and controlling for teacher quality and discipline rates, school size, economically disadvantaged percentage, the percentage of minority students, and urbanicity locale were found to have a moderately strong correlation to advanced mathematics courses, excluding AP mathematics courses, R = .404. These variables were all examined simultaneously via a multiple regression analysis and the variability in access to advanced mathematics courses, excluding AP mathematics courses was 16.4%. School size was found to be a significant predictor of advanced mathematics course offerings, excluding AP mathematics courses, in Virginia public high schools, holding all other variables constant. Student access to advanced mathematics courses, excluding AP mathematics, increased by one per 1000 increase in student enrollment.

Similarly, school size, economically disadvantaged percentage, the percentage of minority students, and urbanicity locale were found to be a statistically significant predictor of advanced mathematics courses, including AP mathematics courses, controlling for teacher quality and discipline rate. These variables when examine simultaneously revealed a positive moderately strong correlation to advanced mathematics course offerings, including AP mathematics courses, R = .540. School size, economically disadvantaged percentage, the percentage of minority students, and urbanicity accounted for 29.1% of variability. School size was found to be a significant predictor of advanced mathematics course offerings, including AP mathematics courses, in Virginia public high schools, holding all other variables constant. Student access to advanced mathematics course, including AP mathematics increased by one as student enrollment increase by 1,000.

Factors associated with student access to and participation in college and career ready coursework, such as advanced mathematics and science course offerings, are widespread and not unique to one variable. Many researchers have reported the underrepresentation and underachievement of students in advanced coursework or access to and participation in rigorous curricula, such as advanced mathematics and AP coursework, are attributed to a series of factors (Achieve, 2008; College Board, 2014; Ferguson, 2007; Gregory, Skiba, & Noguera, 2010; Lleras, 2008; Monk & Haller, 1993; OCR, 2012; Taliaferro & DeCuir-Gunby, 2008). This finding is consistent with opportunity gap literature that has identified critical factors that have perpetuated disparities by school size (Gagnon & Mattingly, 2015; Monk & Haller, 1993) and school location (Taliaferro & DeCuir-Gunby, 2008; Schott Foundation, 2009). School size matters in Virginia and is a factor that independently and in relation with other factors impact student access in the Commonwealth of Virginia.

Finding 11. Controlling for teacher quality and discipline rates, school size and EDP were identified significant predictors of the number of advanced science course offerings, including AP science courses, in Virginia public high schools, holding all other variables constant. Using suburban as the reference group and controlling for teacher quality and discipline rates, school size, economically disadvantaged percentage, the percentage of minority students, and urbanicity locale were found to have a moderately strong correlation to advanced science courses, including AP science courses, r = .540. These variables were all examined simultaneously via a multiple regression analysis and the variability in access to advanced science courses, including AP science courses was 29.2%. School size was found to be a significant positive predictor of advanced science course offerings, including AP science courses in Virginia public high schools, holding all other variables constant. Student access to advanced science course offerings, including AP science courses, decreases by one course in Virginia public high schools based on economically disadvantaged percentage, holding all other variables constant. In addition, teacher quality was found to be a positive predicator of advanced science course offerings, including AP science courses, holding all other variables constant. Examining the advanced science course offerings, excluding AP science courses, revealed no statistically significant relationship.

Similar to findings in disparities in the number of advanced mathematics course offerings, research supports gaps in access to advanced courses and curricula, including AP science courses, based upon school composition factors such as size and location (Lleras, 2008; school size and school location. Considering the literature on the association of student completion of advanced coursework on postsecondary outcomes, this finding suggests that students who attend larger high schools in Virginia may on average have greater access to postsecondary opportunities such as college participation, participation in STEM related programs, and even degree attainment in STEM related fields (Achieve, 2008; ACT, 2013a; Ingels & Dalton, 2008; Lleras 2008). Ingels and Dalton (2008) examined trends in advanced mathematics and science courses Student participation and completion of advanced mathematics and science coursework is steadily increasing (College Board 2013, 2014). Ingels and Dalton (2008) reported that the availability of these courses was more of determining factor or consideration among senior planning to go to college than expenditures, financial aid, and, reputation. Considering this information, this finding highlights an importance in Virginia to ensure equal access to all despite factors such as school size, location, and economically disadvantaged percentage.

Implications for Practice

Based upon findings from this study, there are a series of implications for division leaders, school leaders, and even policy actors and policymakers.

Division leaders should:

- Closely monitor school size and resources within each school to ensure all students have equal access to college and career readiness coursework all high schools within the division.
- Provide dual enrollment or virtual opportunities for dual-enrollment students in schools with low enrollment, in rural, town, and cities as well so that they have equal access to opportunities as their peers who attend large or suburban high schools in Virginia.

School leaders should:

- Engage division leadership, teachers, and parents, about factors that impact college and career course offerings in schools and collectively develop an action plan to address disparities.
- Engage division leadership, teachers, and parents, about factors that impact college and career course offerings in schools and collectively develop an action plan to address disparities due to the impact that these opportunities have on postsecondary outcomes such as college success and even financial earnings.

Policymakers should:

- Investigate ways to ensure that the college and career readiness course offerings among groups, irrespective of poverty level, are equitable.
- Consider providing additional resources for students in high poverty areas and non-suburban public high schools so that they will have equal access to college and career readiness opportunities as their suburban peers.
- Work with appropriate stakeholders at the federal, state, and local levels to address poverty ways to mitigate poverty related issues. This should reduce or lessen the effect of SES and thereby increasing student access to college and career readiness coursework.

State leaders should:

- Work with school leaders to provide online opportunities to mitigate the challenges associated with economically disadvantaged percentages in school communities throughout the Commonwealth of Virginia as a means to ensure college and career ready opportunities.
- Investigate ways to reduce disparities in access to college and career opportunities between suburban public schools and divisions and non-suburban public school divisions.

Suggestions for Future Research

The findings from this study revealed school size, SES, and urbanicity locales were significant predictors of advanced mathematics and science course offerings in Virginia public high schools. Future research in this area might include the following:

- Research could be addressed to examine student access to advanced mathematics and science course offerings, excluding and including AP mathematics and science course offerings, based on course enrollment numbers. This could be accomplished by examining course enrollment numbers across the four dependent variables of this study.

- Future research could entail a qualitative study to examine course offerings in schools with similar school demographic characteristics, but varying advanced mathematics and science course offerings by school size and urbanicity. This study only takes into account advanced science and mathematics coursework; however, further research could be conducted to include advanced coursework in English and social studies. By doing so, the researcher will gain greater insight into the association of student interest in other areas.
- A study could be conducted that considered access to college and career readiness opportunities in the Commonwealth of Virginia over time. A study could be completed that replicates this study using data from several years.
- Further research could be done to replicate this study using data for a different state, multiple states, or a different region of the United States.
- While this study investigated access to college and career readiness opportunity based upon the number of advanced mathematics and science course offerings in the master schedule, another study could consider the population of students enrolled in the courses, and the demographic factors that are present related to minority or economic status.

Conclusions

The results of this study suggest that student access to advanced mathematics and science course offerings with and without AP mathematics and science courses, as in indicator of college and career readiness, differ based upon school size, economically disadvantaged percentage, and urbanicity locale. These findings, consistent with national statistics and other research, suggest that students who attend public high schools in the Commonwealth of Virginia do not have equal access to advanced mathematics and science course offerings, including AP mathematics and science courses when school size, economically disadvantaged percentage, and urbanicity locales are considered. Other findings related to access based on the percentage of minority students are inconsistent with prior research, as there was no significant difference in the number of advanced mathematics and science course offerings, excluding and including AP mathematics and science courses, based on the percentage of Black and Latino students enrolled in Virginia public high schools.

Also, disparities in access associated with school size suggest that a student who attends a Virginia public high school with 400 students enrolled would be predicated to have less access to advanced mathematics and science course offerings than a student who attended a school with a student enrollment of 1,400. The results of this study clearly outline the extent and magnitude of those disparities in the Commonwealth of Virginia public high schools. As such, educational leaders, policy actors, teachers, parents, and students should take pragmatic steps to identify ways to eliminate these existing disparities across the Commonwealth of Virginia by offering students virtual opportunities or partnering with community colleges.

Reflections

Overall, after reading numerous research studies and reviewing national statistics that highlight continuous disparities in access to educational opportunities and achievement in K-12 education, I anticipated similar findings relative to college and career readiness opportunities in Virginia public high schools. Although the findings from this study highlighted unequal access to the number of advanced mathematics and science course offerings by school size, economically disadvantaged percentage, and urbanicity locale, the percentage of minority students was not indicated as a statistically significant predictor. Educational leaders in the state of Virginia are to be commended, as this finding is inconsistent with many research studies that have examined this issue.

As an educational practitioner, ensuring student access irrespective of urbanicity locale must remain a priority in Virginia public high schools. Additionally, the process of conducting this research study has afforded me the opportunity to review advanced mathematics and science course offerings in my school and school division from a different perspective. Furthermore, I have a deeper appreciation for the value in using regression analyses to investigate the extent and magnitude of relationships between two or more variables.

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Appendix A

Urbanicity and Urban Centric Locale Code Categories: Definitions and Comparison

Locale Code	Description
City, Large	Territory inside an urbanized area and inside a principal city with population of 250,000 or more
City, Midsize	Territory inside an urbanized area and inside a principal city with population less than 250,000 and greater than or equal to 100,000
City, Small	Territory inside an urbanized area and inside a principal city with population less than 100,000
Suburb, Large	Territory outside a principal city and inside an urbanized area with population of 250,000 or more
Suburb, Midsize	Territory outside a principal city and inside an urbanized area with population less than 250,000 and greater than or equal to 100,000
Suburb, Small	Territory outside a principal city and inside an urbanized area with population of at least 50,000 and less than 100,000
Town, Fringe	Territory inside an urban cluster that is less than or equal to 10 miles from an urbanized area
Town, Distant	Territory inside an urban cluster that is more than 10 miles and less than or equal to 35 miles from an urbanized area
Town, Remote	Territory inside an urban cluster that is more than 35 miles from an urbanized area
Rural, Fringe	Census-defined rural territory that is less than or equal to 5 miles from an urbanized area, as well as rural territory that is less than or equal to 2.5 miles from an urban cluster
Rural, Distant	Census-defined rural territory that is more than 5 miles but less than or equal to 25 miles from an urbanized area, as well as rural territory that is more than 2.5 miles but less than or equal to 10 miles from an urban cluster
Rural, Remote	Census-defined rural territory that is more than 25 miles from an urbanized area and is also more than 10 miles from an urban cluster

Note. Adapted from "*Documentation to the NCES Common Core of Data Public Elementary/Secondary School Universe Survey Preliminary Directory File: School Year 2013-14* (NCES 2015-071)." by Keaton, 2015

Appendix B

Virginia Public High Schools Enrollment and Locale Information

Table A-1

High School Name	Fall 2012 Enrollment	Economically Disadvantaged	% Economically Disadvantaged	Minority Enrollment (# of Black & Latino Students Combined)	% Minority	Urbanicity Locale
Abingdon	869	314	36%	41	5%	3 = Town
Achieveable Dream Middle/High - Newport News PS	477	420	88%	473	99%	1 = City
Albemarle	1791	381	21%	399	22%	4 = Rural
Alleghany	900	382	42%	76	8%	4 = Rural
Altavista	733	296	40%	189	26%	3 = Town
Amelia County Bluestone	553	204	37%	160	29%	4 = Rural
Amherst County	1392	512	37%	359	26%	4 = Rural
Annandale	2460	701	28%	1275	52%	2 = Suburban
Appomattox County	677	270	40%	175	26%	4 = Rural
Arcadia High	579	369	64%	336	58%	4 = Rural
Arlington Mill High - Arlington County	105	29	28%	89	85%	1 = City
Armstrong	974	795	82%	956	98%	2 = Suburban
Atlee	1618	59	4%	154	10%	4 = Rural
Auburn	379	379	100%	18	5%	4 = Rural
B.T. Washington	1293	965	75%	1143	88%	1 = City
Bassett	1225	669	55%	298	24%	4 = Rural
Bath County	271	101	37%	12	4%	4 = Rural
Battlefield	2537	263	10%	584	23%	4 = Rural
Bayside	1929	753	39%	1026	53%	1 = City
Bethel	1934	674	35%	1371	71%	1 = City
Blacksburg	1161	1161	100%	107	9%	1 = City
Bland High	182	65	36%	3	2%	4 = Rural

Bluestone High	641	302	47%	310	48%	4 = Rural
Brentsville District	846	98	12%	146	17%	4 = Rural
Briar Woods	1994	141	7%	380	19%	4 = Rural
Broad Run	1836	259	14%	434	24%	2 = Suburban
Broadway	999	362	36%	73	7%	3 = Town
Brooke Point	1730	399	23%	599	35%	4 = Rural
Brookville	1031	267	26%	156	15%	2 = Suburban
Brunswick	610	455	75%	502	82%	4 = Rural
Bruton High	601	139	23%	197	33%	4 = Rural
Buckingham County	636	303	48%	249	39%	4 = Rural
Buffalo Gap	554	154	28%	6	1%	4 = Rural
C.D. Hylton	2319	674	29%	1284	55%	2 = Suburban
Caroline	1154	513	44%	470	41%	4 = Rural
Carroll County	895	406	45%	45	5%	4 = Rural
Castlewood	459	262	57%	7	2%	4 = Rural
Cave Spring	901	17	2%	60	7%	2 = Suburban
Central High-King & Queen County	262	145	55%	106	40%	4 = Rural
Central-Victoria	456	276	61%	205	45%	4 = Rural
Central-Wise	669	347	52%	14	2%	4 = Rural
Central-Woodstock	764	285	37%	113	15%	3 = Town
Centreville	2406	412	17%	588	24%	4 = Rural
Chancellor	1377	490	36%	512	37%	2 = Suburban
Chantilly	2660	334	13%	513	19%	2 = Suburban
Charles City County	236	107	45%	142	60%	4 = Rural
Charlottesville	1196	556	46%	516	43%	1 = City
Chatham	665	245	37%	202	30%	4 = Rural
Chesterfield Community	317	189	60%	215	68%	4 = Rural
Chilhowie	459	191	42%	22	5%	3 = Town
Chincoteague	292	110	38%	42	14%	3 = Town
Christiansburg	1120	1120	100%	119	11%	1 = City
Churchland	1390	643	46%	925	67%	1 = City
Clarke County	717	89	12%	53	7%	4 = Rural
Clintwood	385	194	50%	2	1%	4 = Rural
Clover Hill	1798	262	15%	556	31%	2 = Suburban
Colonial Beach	250	137	55%	70	28%	3 = Town

Colonial Forge	2015	314	16%	659	33%	4 = Rural
Colonial Heights	918	282	31%	173	19%	2 = Suburban
Cosby	2120	105	5%	325	15%	2 = Suburban
Council	136	77	57%	0	0%	4 = Rural
Courtland	1222	303	25%	372	30%	2 = Suburban
Covington	312	170	54%	73	23%	3 = Town
Craig County	392	158	40%	4	1%	4 = Rural
Culpeper County	1018	296	29%	246	24%	4 = Rural
Cumberland	425	263	62%	173	41%	4 = Rural
Dan River	652	334	51%	232	36%	4 = Rural
Deep Creek	1373	570	42%	702	51%	2 = Suburban
Deep Run	1624	63	4%	133	8%	2 = Suburban
Denbigh	1385	851	61%	912	66%	1 = City
Dinwiddie	1374	510	37%	589	43%	4 = Rural
Dominion	1378	284	21%	413	30%	2 = Suburban
Douglas S. Freeman	1738	439	25%	395	23%	2 = Suburban
E.C. Glass	1366	715	52%	646	47%	1 = City
East Rockingham	660	190	29%	45	7%	4 = Rural
Eastern Montgomery	305	305	100%	18	6%	4 = Rural
Eastern View	1195	414	35%	396	33%	4 = Rural
Edison High	1715	506	30%	863	50%	2 = Suburban
Essex	490	283	58%	260	53%	3 = Town
Fairfax	2724	553	20%	823	30%	2 = Suburban
Falls Church	1686	661	39%	879	52%	2 = Suburban
Fauquier	1198	246	21%	239	20%	4 = Rural
First Colonial	1978	430	22%	512	26%	1 = City
Floyd County	780	277	36%	38	5%	4 = Rural
Floyd E. Kellam	1853	105	6%	231	12%	1 = City
Fluvanna County	1455	392	27%	282	19%	4 = Rural
Forest Park	2479	551	22%	1051	42%	2 = Suburban
Fort Chiswell	458	201	44%	15	3%	4 = Rural
Fort Defiance	796	242	30%	58	7%	4 = Rural
Frank W. Cox	1979	320	16%	320	16%	1 = City
Franklin	304	229	75%	234	77%	3 = Town
Franklin County	2172	775	36%	271	12%	3 = Town

Frankling Military Academy-RCPS	347	285	82%	336	97%	1 = City
Freedom-South Riding	1543	107	7%	260	17%	4 = Rural
Freedom-Woodbridge	1929	1139	59%	1524	79%	2 = Suburban
Galax	501	272	54%	168	34%	3 = Town
Galileo Magnet	234	122	52%	105	45%	1 = City
Gar-Field	2492	1311	53%	1731	69%	2 = Suburban
Gate City	502	201	40%	12	2%	4 = Rural
George Mason	905	43	5%	143	16%	2 = Suburban
George Washington	1406	827	59%	1011	72%	1 = City
George Wythe-Richmond	916	724	79%	861	94%	1 = City
George Wythe-Wytheville	440	163	37%	57	13%	3 = Town
Giles	667	225	34%	25	4%	4 = Rural
Glen Allen	1527	239	16%	381	25%	2 = Suburban
Glenvar	575	54	9%	26	5%	4 = Rural
Gloucester	1799	499	28%	218	12%	4 = Rural
Goochland	745	150	20%	182	24%	4 = Rural
Grafton	1299	164	13%	202	16%	2 = Suburban
Graham	571	212	37%	34	6%	3 = Town
Granby	1949	1085	56%	1162	60%	1 = City
Grassfield	2069	220	11%	547	26%	2 = Suburban
Grayson County	742	367	49%	41	6%	4 = Rural
Great Bridge	1530	258	17%	398	26%	4 = Rural
Green Run	1735	693	40%	950	55%	1 = City
Greensville County	718	482	67%	510	71%	3 =Town
Gretna	611	320	52%	212	35%	4 = Rural
Grundy	530	278	52%	1	0%	4 = Rural
Halifax	1700	835	49%	836	49%	3 = Town
Hampton	1651	864	52%	1338	81%	1 = City
Hanover	1265	34	3%	140	11%	4 = Rural
Harrisonburg	1375	870	63%	606	44%	1 = City
Hayfield Secondary High	2871	621	22%	1379	48	2 = Suburban
Haysi	405	243	60%	5	1%	4 = Rural
Henrico	1631	869	53%	1229	75%	2 = Suburban

Heritage-Leesburg	1192	213	18%	343	29%	4 = Rural
Heritage-Lynchburg	1041	697	67%	603	58%	1 = City
Heritage-Newport News	1132	831	73%	1015	90%	1 = City
Hermitage	1652	831	50%	971	59%	2 = Suburban
Herndon	2216	522	24%	835	38%	2 = Suburban
Hickory	1819	104	6%	192	11%	4 = Rural
Hidden Valley	999	50	5%	77	8%	2 = Suburban
Highland	114	79	69%	3	3%	4 = Rural
Highland Springs	1765	1112	63%	1498	85%	2 = Suburban
Holston	289	160	55%	3	1%	4 = Rural
Honaker	533	241	45%	3	1%	4 = Rural
Hopewell	1080	652	60%	641	59%	2 = Suburban
Huguenot	1246	861	69%	1141	92%	1 = City
Hurley	241	197	82%	2	1%	4 = Rural
I.C. Norcom	1192	869	73%	1117	94%	1 = City
Indian River	1638	614	37%	871	53%	2 = Suburban
J.R. Tucker	1490	669	45%	635	43%	2 = Suburban
James Monroe	932	375	40%	499	54%	2 = Suburban
James R. Robinson Secondary	3934	373	9%	778	20%	2 = Suburban
James River-Buchanan	567	123	22%	19	3%	4 = Rural
James River-Midlothian	2062	336	16%	526	26%	2 = Suburban
James Wood	1289	293	23%	78	6%	4 = Rural
Jamestown	1211	201	17%	229	19%	2 = Suburban
Jefferson Forest	1371	226	16%	136	10%	4 = Rural
John Champe	609	58	10%	128	21%	2 = Suburban
John Handley	1188	506	43%	398	34%	1 = City
John I. Burton	328	175	53%	31	9%	3 = Town
John Marshall	837	651	78%	781	93%	1 = City
John S. Battle	615	268	44%	11	2%	4 = Rural
Kecoughtan	1772	586	33%	811	46%	1 = City
Kempsville	1708	403	24%	479	28%	1 = City
Kettle Run	1141	108	9%	143	13%	4 = Rural
King George	1310	268	20%	341	26%	4 = Rural
King William	646	226	35%	141	22%	4 = Rural

King's Fork	1464	648	44%	933	64%	4 = Rural
L.C. Bird	1679	552	33%	904	54%	2 = Suburban
Lafayette	1098	300	27%	424	39%	4 = Rural
Lake Braddock	4033	449	11%	932	23%	2 = Suburban
Lake Taylor	1277	906	71%	992	78%	1 = City
Lakeland	1175	581	49%	704	60%	4 = Rural
Lancaster	400	208	52%	179	45%	4 = Rural
Landstown	2275	506	22%	889	39%	1 = City
Langley	1962	30	2%	116	6%	2 = Suburban
Lebanon	667	264	40%	10	1%	4 = Rural
Lee High–Fairfax County	1845	681	37%	872	47%	2 = Suburban
Lee High-Lee County	732	407	56%	4	1%	4 = Rural
Lee-Davis	1562	87	6%	223	14%	2 = Suburban
Liberty-Bealeton	1210	350	29%	264	22%	4 = Rural
Liberty-Bedford	951	477	50%	130	14%	4 = Rural
Lord Botetourt	1097	148	13%	63	6%	2 = Suburban
Loudoun Valley	1142	101	9%	131	11%	3 = Town
Louisa County	1365	546	40%	308	23%	4 = Rural
Loundoun County	1394	184	13%	315	23%	2 = Suburban
Luray	492	179	36%	29	6%	3 = Town
Madison High - Fairfax	1995	126	6%	237	12%	2 = Suburban
Madison County	602	177	29%	68	11%	4 = Rural
Magna Vista	911	465	51%	353	39%	4 = Rural
Manassas Park	812	401	49%	443	55%	2 = Suburban
Manchester	1927	385	20%	704	37%	2 = Suburban
Marion Senior	716	359	50%	29	4%	3 = Town
Marshall High - Fairfax	1696	218	13%	367	22%	2 = Suburban
Martinsville	645	384	60%	410	64%	3 =Town
Massaponax	1870	547	29%	679	36%	4 = Rural
Mathews	425	125	29%	55	13%	4 = Rural
Matoaca	1890	380	20%	767	41%	4 = Rural
Maury (Matthew Fontaine Maury High)	1650	788	48%	963	58%	1 = City

McLean	2108	146	7%	296	14%	2 = Suburban
Meadowbrook	1646	766	47%	1415	86%	2 = Suburban
Menchville	1708	696	41%	819	48%	1 = City
Middlesex	355	149	42%	78	22%	4 = Rural
Midlothian	1476	95	6%	204	14%	4 = Rural
Millbrook	1245	334	27%	302	24%	2 = Suburban
Mills E. Godwin	1788	227	13%	236	13%	2 = Suburban
Monacan	1407	283	20%	530	38%	2 = Suburban
Monticello	1101	468	43%	248	23%	4 = Rural
Mount Vernon	1935	737	38%	1264	65%	2 = Suburban
Mountain View	234	53	23%	153	65%	4 = Rural
Murray High - Albemarle County	95	20	21%	9	9%	1 = City
Nandua	637	313	49%	352	55%	4 = Rural
Nansemond River	1512	412	27%	836	55%	4 = Rural
Narrows	304	123	40%	4	1%	3 = Town
Nelson County	597	246	41%	126	21%	4 = Rural
New Kent	950	138	15%	138	15%	4 = Rural
North Stafford	1690	463	27%	685	41%	2 = Suburban
Northampton	697	484	69%	442	63%	4 = Rural
Northside	995	87	9%	178	18%	2 = Suburban
Northumberland	430	199	46%	186	43%	4 = Rural
Northwood	270	122	45%	6	2%	4 = Rural
Norview	1788	1055	59%	1134	63%	1 = City
Nottoway	658	321	49%	297	45%	4 = Rural
Oakton	2193	191	9%	290	13%	2 = Suburban
Ocean Lakes	2264	454	20%	586	26%	1 - City
Open High- Richmond City Public Schools	173	61	35%	99	57%	1 = City
Orange County	1485	381	26%	331	22%	3 = Town
Osbourn	2125	777	37%	1285	60%	2 = Suburban
Osbourn Park	2815	626	22%	969	34%	2 = Suburban
Oscar Smith	2174	1100	51%	1280	59%	2 = Suburban
Page County	578	241	42%	11	2%	4 = Rural
Park View- South Hill	794	394	50%	324	41%	4 = Rural
Park View- Sterling	1280	630	49%	710	55%	2 = Suburban

Parry McCluer	414	116	28%	33	8%	4 = Rural
Patrick County	1038	466	45%	126	12%	4 = Rural
Patrick Henry-Ashland	1489	152	10%	243	16%	4 = Rural
Patrick Henry-Glade Springs	417	205	49%	10	2%	4 = Rural
Patrick Henry-Roanoke	1947	1290	66%	781	40%	1 = City
Patriot	2338	291	12%	607	26%	4 = Rural
Petersburg	819	434	53%	794	97%	4 = Rural
Phoebus	1159	622	54%	853	74%	1 = City
Poquoson	802	58	7%	16	2%	2 = Suburban
Potomac	1566	634	40%	1091	70%	2 = Suburban
Potomac Falls	1550	256	17%	405	26%	2 = Suburban
Powhatan	1363	223	16%	138	10%	4 = Rural
Prince Edward County	684	363	53%	415	61%	3 = Town
Prince George	1338	410	31%	540	40%	4 = Rural
Princess Anne	1877	368	20%	517	28%	1 = City
Pulaski County	1376	474	34%	108	8%	4 = Rural
R.E. Lee-Staunton	757	331	44%	155	20%	3 = Town
Radford	451	179	40%	57	13%	3 = Town
Randolph-Henry	647	305	47%	219	34%	4 = Rural
Rappahannock	345	150	43%	118	34%	4 = Rural
Rappahannock County	348	104	30%	24	7%	4 = Rural
Richlands	721	299	41%	7	1%	3 = Town
Richmond Community High- RCPS	234	109	47%	197	84%	1 = City
Riverbend	1923	354	18%	434	23%	4 = Rural
Riverheads	519	135	26%	14	3%	4 = Rural
Rockbridge County	1018	282	28%	80	8%	3 = Town
Rocky Gap High	191	71	37%	1	1%	4 = Rural
Rural Retreat	328	117	36%	8	2%	4 = Rural
Rustburg	850	332	39%	152	18%	4 = Rural
Rye Cove High	280	162	58%	1	0%	4 = Rural
Salem-Salem	1219	252	21%	149	12%	2 = Suburban

Salem-Virginia Beach	1834	441	24%	752	41%	1 = City
Sherando	1446	339	23%	240	17%	4 = Rural
Skyline	1111	462	42%	129	12%	
Smithfield	1314	310	24%	445	34%	4 = Rural
South County	2060	271	13%	564	27%	2 = Suburban
South Lakes	2400	516	22%	849	35%	1 = City
Southampton	806	324	40%	298	37%	4 = Rural
Spotslyvania	1377	406	29%	195	14%	4 = Rural
Spotswood	835	279	33%	160	19%	4 = Rural
Stafford Senior HS	1911	395	21%	421	22%	4 = Rural
Staunton River	1,110	533	48%	71	6%	4 = Rural
Stone Bridge	1824	106	6%	281	15%	2 = Suburban
Stonewall Jackson-Manassas	2474	1130	46%	1572	64%	2 = Suburban
Stonewall Jackson-Quicksburg	469	216	46%	67	14%	4 = Rural
Strasburg	668	242	36%	52	8%	3 = Town
Stuart High - Fairfax	1791	750	42%	1083	57%	2 = Suburban
Stuarts Draft	758	196	26%	48	6%	3 = Town
Surry County	278	142	51%	174	63%	4 = Rural
Sussex Central	423	297	70%	323	76%	4 = Rural
T.C. Williams	3,171	1929	61%	2225	70%	1 = City
Tabb	1115	125	11%	186	17%	2 = Suburban
Tallwood	2010	485	24%	852	42%	1 = City
Tangier Combined - Accomack County	68	28	41%	0	0%	4 = Rural
Tazewell	590	245	42%	32	5%	3 = Town
Thomas Dale	2322	465	20%	815	35%	2 = Suburban
Thomas Jefferson S &T	1846	33	2%	66	4%	2 = Suburban
Thomas Jefferson-Richmond	915	532	58%	750	82%	1 = City
Thomas Walker	285	168	59%	2	1%	4 = Rural
Tunstall	912	315	35%	160	18%	4 = Rural
Turner Ashby	1013	313	31%	112	11%	4 = Rural

Tuscarora	1740	263	15%	477	27%	4 = Rural
Twin Springs	280	161	58%	8	3%	4 = Rural
Twin Valley	258	162	63%	1	0%	4 = Rural
Union High	641	337	53%	25	4%	3 = Town
Varina	1828	822	45%	1246	68%	4 = Rural
Virginia High	662	396	60%	85	13%	1 = City
W.T. Woodson	2246	164	7%	267	12%	2 = Suburban
Wakefield	1595	720	45%	1079	68%	1 = City
Warhill	1109	290	26%	270	24%	2 = Suburban
Warren County	1036	328	32%	96	9%	3 = Town
Warwick	1532	897	59%	935	61%	1 = City
Washington & Lee	483	276	57%	276	57%	4 = Rural
Washington-Lee	2155	595	28%	891	41%	1 = City
Waynesboro	868	457	53%	253	29%	3 = Town
West Point	250	61	24%	37	15%	3 = Town
West Potomac	2351	761	32%	1160	49%	2 = Suburban
West Springfield	2309	227	10%	472	20%	2 = Suburban
Western Albemarle	1061	110	10%	91	9%	4 = Rural
Western Branch	2115	517	24%	877	41%	2 = Suburban
Westfield	2816	462	16%	779	28%	2 = Suburban
William Byrd	1182	61	5%	107	9%	2 = Suburban
William Campbell	541	263	49%	194	36%	4 = Rural
William Fleming	1453	1228	85%	1017	70%	1 = City
William Monroe	799	266	33%	106	13%	4 = Rural
Wilson Memorial	744	181	24%	45	6%	4 = Rural
Windsor	505	167	33%	119	24%	4 = Rural
Woodbridge	2862	896	31%	1415	49%	2 = Suburban
Woodgrove	1520	101	7%	123	8%	4 = Rural
Woodrow Wilson	1375	873	63%	880	64%	1 = City
Woodside	2046	966	47%	1349	66%	
York	1079	178	16%	165	15%	4 = Rural
Yorktown	1923	228	12%	412	21%	1 = City

Note. Adapted from Virginia Department of Education (2013). Urbanicity Locale adapted from NCES Common Core Data, 2013

Appendix C

Institutional Review Board Notification

VirginiaTech
Invent the Future

Quentin Ballard <bquent7@vt.edu>

IRB #15-777: Revision(s) to Protocol Requested

VT IRB Administrator <irbadmin@vt.edu> Wed, Aug 12, 2015 at 5:23 PM
To: Carol S Cash <ccash48@vt.edu>, Quentin Laquan Ballard <bquent7@vt.edu>

Dear Investigators:

Thank you for your New Application for the research protocol titled "College and Career Readiness: Access to Advanced Mathematics and Science Courses in Virginia Public High Schools".

The IRB requires a revision/response to the following items:
1. According to the Research Protocol, the data to be analyzed is "school level data" (from the response to Question 11). If the data is only being analyzed at the school level (i.e. by school) and not at the student level (i.e. student matched to student's SES to student's minority status, to student's personal course selection, etc), then it does not qualify as human subjects research.

This is because the variable of interest is school, not student (human subject).

If this is correct, IRB review/approval is not necessary. Please cancel this application and proceed forward without further IRB review.

If this is incorrect, please revise the response to Question 11 and resubmit the application to the IRB.

Respond to the above items and incorporate the changes into your online protocol, as appropriate using the IRB Protocol Management System link below:

<https://secure.research.vt.edu/irb?sLESRdwJB7U>

Note: the use of IRB Protocol Management to submit your response is required (in other words, please do not send the revised documents directly to the IRB office).

Once the IRB receives a response to the above and approves the project application, you will receive an approval letter via email.

If you have any questions about this email, please contact the IRB Administrator at irbadmin@vt.edu.

IRB office

Interested in keeping up-to-date with the Virginia Tech IRB? Click the link below to learn more:

http://www.irb.vt.edu/pages/events.htm

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This is an automated message from the Virginia Tech IRB
Protocol Management website. Do not reply to this email.
If you have any questions or concerns, please contact
the IRB office at irb@vt.edu.
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