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THE EFFECT OF THE ADVANCED PLACEMENT TRAINING AND INCENTIVE  
PROGRAM ON INCREASING ENROLLMENT AND PERFORMANCE ON  
ADVANCED PLACEMENT SCIENCE EXAMS

A Dissertation submitted in partial fulfillment of the requirements for the degree of  
Doctor of Philosophy at Virginia Commonwealth University.

by

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## List of Abbreviations

- ADM- Average Daily Membership
- AP- Advanced Placement ©
- APTIP- Advanced Placement Training and Incentive Program
- CB-College Board
- ETS- Educational Testing Service
- GRE- Graduate Record Examinations
- IB- International Baccalaureate
- NAEP National Assessment of Educational Progress
- NCES National Center for Education Statistics
- NCLB No Child Left Behind
- NMSI- National Math and Science Initiative
- PISA Program for International Student Assessment
- QSE- Qualifying score (score of 3, 4, or 5)
- STEM- Science, technology, engineering, and math
- TIMMS- Trends in International Mathematics and Science Study

## ABSTRACT

### THE EFFECT OF THE ADVANCED PLACEMENT TRAINING AND INCENTIVE PROGRAM ON INCREASING ENROLLMENT AND PERFORMANCE ON ADVANCED PLACEMENT SCIENCE EXAMS

By Susan Brady Ramsey

A Dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Virginia Commonwealth University.

Virginia Commonwealth University, 2012

Major Director: Dr. Charol Shakeshaft, Professor and Department Chairman, Educational Leadership

The purpose of this study is to examine the effectiveness of the National Math and Science Initiative's Advanced Placement Training and Incentive Program (APTIP) on the number of students taking AP science courses and their performance. The study evaluated 39 schools over a six-year period in six states that participate in the APTIP. The National Math and Science Initiative provided data for cohort I. A general linear model for repeated measures was used to evaluate the data. Data was evaluated three years prior to the intervention and three years during the intervention, which will actually continue for two more years (2012 and 2013) since cohort I schools were awarded five years of support. Students in APTIP schools enrolled in more AP science exams (AP

Biology, AP Chemistry, AP Environmental Science, and AP Physics-B) over the course of the intervention. The quantity of students earning qualifying scores increased during the intervention years. APTIP is a multi-tiered program that includes seven days of teacher training, three six-hour student prep sessions, school equipment, reduced exam fees, and monetary incentives for students and teachers. This program positively impacted the quantity of enrollment and qualifying scores during the three years evaluated in this study. Increases in the number of female and African American students' test takers their and qualifying scores were seen in all three years of the APTIP intervention.

This study supports the premise that the first step to increasing the Science, technology, engineering, and math (STEM) pipeline is giving access to advanced courses to more students in high schools.



## CHAPTER 1

### INTRODUCTION

#### **Background**

A decade into the 21<sup>st</sup> century, the United States is competing in a highly technical global economy. Mathematicians, scientists, and engineers are an essential for our country to maintain prosperity, economic stability, and national security (Friedman, 2005; National Academy of Sciences [NAS], 2007). According to the authors of *Rising above the gathering storm: Energizing and employing America for a brighter economic future* (Rising)(2007), our future depends on having a large and deep pool of diverse citizens in science, technology, engineering, and mathematics (STEM) fields.

The United States takes deserved pride in the vitality of its economy, which forms the foundation of our high quality of life, our national security, and our hope that our children and grandchildren will inherit ever greater opportunities. That vitality is derived in large part from the productivity of well-trained people and the steady stream of scientific and technical

innovations they produce. Without high-quality, knowledge-intensive jobs and the innovative enterprises that lead to discovery and new technology, our economy will suffer and our people will face a lower standard of living (Rising, 2007 p. 1)

Citizens of the United States are not obtaining STEM degrees at the same volume as compared to other countries. (Chen, 2009; Kuenzi, Matthew, & Mangan, 2007; National Research Council (NRC), 2002). This is a cause for concern because it is evident that other countries are preparing their citizens to be competitive in a technical and global economy (National Science Board [NSB], 2008; Rising, 2007). The National Science Foundation (NSF) (2008) reported that only 16.8 % of degrees awarded in the United States were in STEM fields compared to 64% in Japan, 52.1% in China, and 40.6% in Korea (NSB, 2008). In the United States, one-third of all doctoral degrees were awarded to foreign students with a concentration of those doctorates in STEM fields (NSF, 2009). Research shows that countries that have more highly trained citizens are better prepared economically. Companies will gravitate to areas where a competent workforce is located (Friedman, 2005). In 2004, China graduated six hundred thousand engineers and India graduated three hundred and fifty thousand engineers. This outpaced the United States who graduated seventy thousand engineers (*Rising Above the Gathering Storm*, 2007). Consequently, Friedman (2005) in *The World is Flat*, explores American businesses that have followed the workforce to India including General Electric, Texas Instruments, and Intel to name a few.



## Science Education in the United States

The National Assessment of Educational Progress (NAEP), Trends in International Mathematics and Science Study (TIMMS) and Program for International Assessment (PISA) are three studies often cited as barometers measuring the robustness of science education in the United States (Gonzales et al., 2008). With a grant from Carnegie Corporation in 1964, a committee was developed to design a national assessment in the United States to gauge students' performance. NAEP began administration in 1969 with small cohorts and expanded to voluntary participation in 1990 (NCES, 2011). NAEP NAEP scores stagnated from 2000 to 2005 with only 18% of the 12<sup>th</sup> grade students obtaining proficient or better. The TIMMS was first administered in 1995 to 4<sup>th</sup> and 8<sup>th</sup> graders in math and science. The TIMMS, a global assessment, utilizes a 0-1000 point scale with an average score of 500 at grade level (Gonzales et al., 2008). From 1995 to 2007, the US showed no improvement in science scores in 4<sup>th</sup> grade students 542 and 539 respectively or 8<sup>th</sup> grade students, 513 and 520, respectively (p.33). The Organization for Economic Cooperation and Development (OECD) developed the PISA in response to requests by their members to have regular data on the educational performance of students around the world to influence and reform their public policies (Gonzalez et al, 2008). More than 60 countries have participated since its inception in 2000. In 2006, PISA ranked the United States 17<sup>th</sup> in science literacy out of 30 countries (Gonzales et al, 2008). The United States' mediocre rankings suggest that our students are not prepared to enter the post K-12 environment. Secretary of Education, Arnie Duncan articulates the issue clearly in his comments in USA Today (2010) "We live in a

globally competitive knowledge based economy, and our children today are at a competitive disadvantage with children from other countries," Duncan said. "That is absolutely unfair to our children and that puts our country's long term economic prosperity absolutely at risk." In the same USA Today (2010) article, The Secretary-General of the Organization for Economic Co-operation and Development (OECD), the organization that administers the PISA, Angel Gurría suggests that high performing nations will be the leaders of tomorrow.

### **Widening the Pipeline**

In order to increase the number of students in STEM fields in college, we must graduate a larger number of students from high school with rigorous math and science skills (Labov, 2006; NAS, 2007). In science education research, the pipeline metaphor has been used to represent how students get to STEM fields in college (Burkam & Lee, 2003; NAS, 2007). In order for the pipeline to have sufficient numbers of students to adequately feed STEM fields in college, it must be widened in the K-12 environment with a larger, more diverse spectrum of students (Kuenzi et al, 2007; NAS, 2007). As an example of the equity issue, Table 1 shows the graduation rates of African American students in 2008 and 2010 in the six states that have the APTIP compared with AP qualifying scores. Alabama showed 31.7% of their graduation class as African American students and yet only 7.1% of African Americans received a qualifying score on an AP exam in the same year with only 9.5% of African Americans even taking an AP science exam. Virginia graduated 24.2% African American students in 2008, but only 6.1% of African American students received a qualifying score on an AP exam in the same year

(College Board Report to the Nation, 2008; College Board Report, 2010).

Table 1

African American High School Enrollment and Qualifying AP Scores for 2008 and 2010

	% HS Enrollment	% Scores 3+	% HS Enrollment	% Scores 3+
	2008	2008	2010	2010
AL	31.7	7.1	32.4	8.3
AR	21.3	3.7	21.1	4.9
CT	12.3	2.0	12.0	2.4
KY	9.5	2.9	10.4	3.3
MA	7.4	2.2	7.5	2.4
VA	24.2	6.1	24.3	6.9
US	14.4	3.5	14.6	3.9

\*Includes all AP test

Adelman (1999) found the most significant predictor of college success is a rigorous high school curriculum with an emphasis on math, science, reading, and writing. Burkam and Lee (2003) evaluated student courses taken in math and science and found only 12% of high school seniors were completing the highest-level course in math and only 22% were completing the highest-level science courses. Morgan and Klaric (2007) found that students who took AP science and math courses were more likely than non-AP students to major in math and science fields, with a more significant indicator of persistence for African Americans, Hispanics, and females.

For most AP courses, the percentages for African American and Hispanic AP students taking related courses (*sic* in colleges) are at least four times the corresponding percentages for non-AP students. The ratios of the AP students and non-AP student percentages for females are most striking for students majoring in chemistry, computer science, and physics (Morgan & Klaric, 2007, p.9).

Gonzalez, O'Connor, and Miles (2001) compared a subset of students who took AP math and science exams to the total number of students involved in the TIMMS assessment and found that students who received a three or better on an AP science and math courses ranked 1<sup>st</sup> in the TIMMS study opposed to the ranking of 17<sup>th</sup> for all students (Gonzales et al, 2008). Dodd, Fitzpatrick, Ayala, and Jennings (2002) found additional benefits of taking AP courses which included, increased grade point average in subsequent courses in the same content in post secondary education (p.33), thus supporting potential persistence and success in the subject area.

Advanced Placement is seen as a vehicle that can increase college readiness and preparedness. Math and science courses require skills above minimum state standards and the assessments that test those standards. In order for students to be successful in prepared for STEM fields in the post K-12 environment, they must have exposure and skills that go beyond the state endorsed performance measures. *Vital Signs: Reports on*

*the condition of STEM learning in the U.S.* released by Change the Equation (2012) compared state's definition of proficient with NAEP's definition of proficient and found that Virginia's science assessment set the lowest bar for their state assessment compared to other states according to the NAEP's definition of proficient. Fordham Institute released *The State of State Science Standards* (Lerner, Goodenough, Lynch, Schwartz, and Schwartz, 2012) and rated Virginia as an A- (9 out of 10) for their standards. While these reports seem conflicting, they are not. *Vital Signs* (Change the Equation Report, 2012) compared state assessments while the Fordham report is compared state standards. High standards lack depth and impact on instruction when the assessments that test those standards lack rigor or sets a low bar. . The use of AP courses and exams is a mechanism of introducing rigorous standards with a rigorous assessment that help prepare students with the skills for the challenges of college coursework.

The focus of the programs highlighted in *Rising Above the Gathering Storm* (2007) identified several programs that have demonstrated increased rigor in mathematics and science education at the K-12 level. One of the programs highlighted was the Advanced Placement Training and Incentive Program (APTIP) in Texas administered by Advanced Placement Strategies, Inc. (APS, 2008). In response to *Rising Above the Gathering Storm*, the National Math and Science Initiative (NMSI) was formed in 2007 through private-public partnerships and a large donation by Exxon Mobil. NMSI scaled two model programs, APTIP and U-Teach, to the national level. NMSI serves as a holding company that monitors the implementation of these programs and provides continued support to the implementation entities, which are non-profit organizations in

each state. The goals of the APTIP are to increase enrollment and performance for a wide spectrum of students by opening access to AP English, math, and science courses for any student willing to accept the challenge of an AP course (NMSI, 2009). NMSI sets data driven goals and then monitors and reports the data to the state's managing organizations and the donors to ensure that progress is being attained (NMSI, 2009).

### **Preparation Issues and Components of the NMSI APTIP**

The NMSI APTIP is a comprehensive program that includes seven days of teacher training, three six-hour student study sessions, school equipment, reduced exam fees, and monetary incentives for students and teachers (Figure: 3) for a set number of years ranging from three to five years. The original model, started by the O'Donnell Foundation and later administered by Advanced Placement Strategies (APS), was developed by teachers from their practical experiences in the classroom rather than being grounded in theory (G.Fleischer, personal communication, October 27, 2010). Research on the APTIP by third parties is sparse. Jackson (2010) found that students in the APTIP had higher SAT and ACT scores and higher college enrollment rates for Hispanics and African Americans. Jackson evaluated the college outcomes of 11<sup>th</sup> and 12<sup>th</sup> graders exposed to the APTIP who attended any college in Texas using a difference-in-difference strategy. Jackson (2010) arrived at this conclusion in his study by comparing students in the same schools with similar test scores before and during the APTIP.

While research surrounding the APTIP has been limited, NMSI presents compelling and verifiable data on their program schools on the increase of students' enrollment and performance numbers in AP math, English, math, and science AP

exams, especially in under-served populations that have historically low enrollment and positive performance (NMSI, 2009). In 1995, ten Dallas schools began the program with 88% minority and 64% free and reduced eligible students (NMSI, 2009). The year preceding the grant's inception 1994, these ten schools tallied 157 qualifying scores (3,4, or 5) on AP English, math, and science exams. In the first year of the APTIP in Dallas, the number of qualifying scores increased to 361. By 2007, the same schools had 1,466 qualifying scores in English, math, and science, almost eight times the original AP qualifying scores the year preceding the grant (NMSI, 2009).

Jackson (2010) found that preparation was a large factor in participation of minorities in upper level math and science classes and ultimately in STEM fields in college. Increasing preparation in high school through AP courses can widen the STEM pipeline. The first step to enhancing performance for a larger spectrum of students would be to increase AP course enrollment.

### **Problem Statement**

In order to secure our economic future and maintain a high quality of living in the United States, steps must be taken to widen the STEM pipeline with more students and include students that are more demographically representative of population in the United States.

### **Purpose**

The purpose of this study is to examine the effectiveness of the NMSI APTIP on the number of students taking AP science courses and exams and their performance, particularly African American students and female students.

## Research Questions

This study includes the effect of the NMSI Advance Placement Training and Incentive Program (APTIP) on enrollment and performance of students on Advanced Placement (AP) science exams as well as a more specific analysis of two sub-groups of students that are underrepresented, African American and female students. A general linear model of repeated measures evaluated AP science exam test takers and their performance before and during the APTIP intervention.

The following research questions were addressed:

1. Does participation in the National Math and Science Initiative (NMSI) Advanced Placement Training and Incentive Program (APTIP) increase Advanced Placement science exam test takers?
2. Does participation the NMSI APTIP program increase performance (scores of 3, 4, or 5) of students on AP science exams?
3. Are more females enrolled and African American students taking AP science examscourses in schools that participate in the NMSI APTIP program than prior to the intervention? compared to the state and national trends for the same sub-groups?
4. Are females and African American students experiencing increased performance on AP science exams in schools that participate in the NMSI APTIP program compared to performance before the intervention?the state and national trends for the same sub-groups of students?



## **Operational Definitions**

**Advanced Placement Science courses:** courses offered by the College Board include: 1) biology, 2) chemistry, 3) environmental science, 4) physics-B (trigonometry based), 5) physics-C (Calculus-based) mechanics, and 6) physics-C (Calculus-based) electricity and magnetism. For the purpose of this study, both of the AP physics-C courses will not be evaluated. only physics-B will be evaluated. Due to math requirements and pre-requisites, so few students enroll in and take the calculus based physics-C exams (mechanics and electricity & magnetism). Physics-C is a smaller program offered in few schools, thus the sample size would be too small to provide valuable and reliable data. Physics-B will be the only AP physics exam that is evaluated in this study.

**Incentives:** reduction of exam fees and monetary rewards to students and teachers. .

**Enrollment:** the number of test takers who sit for the exam. In the NMSI schools this should be every child enrolled in the course, but minor variations occur and obtaining an exact enrollment number is beyond the capabilities of this study.

**Qualifying score and performance will be interchangeable terms for this study:** AP exams are scored on a scale from one to five. For the purposes of this study, scores of three, four, or five would be deemed a qualifying score and positive performance.

**Pipeline:** Students in K-12 education enrolled in science courses that contain the rigorous skills needed to continue in those courses in college.

## CHAPTER 2

### REVIEW OF LITERATURE

The purpose of this literature review was to examine the Science, Technology, Engineering, and Mathematics (STEM) crisis in the United States, explore science educational reform and its implications on the STEM shortage, and the use of Advanced Placement science courses to widen the STEM pipeline. Using the search term *Advanced Placement*, searches were performed in Academic Search Complete, Education Research Complete, Educational Resources Information (ERIC), and Lexus Nexus. To narrow the search, the term *Advanced Placement* was further qualified to include the terms “*African American, minority, gender, female, science, pipeline, and STEM.*”

In this chapter, I reported on the history of the AP Program and the use of AP science courses as an educational reform to prepare students for STEM fields in college, especially minorities and females. Data and available literature on the original APTIP model program and the NMSI APTIP model were reviewed. Searches of the College Board website including data and reports from 2006 to 2011 were accessed, as well as research regarding Advanced Placement that the College Board hosts on their website.

#### **The STEM Crisis in the United States**

Concerning the STEM crisis in the US, the American Association of State Colleges and Universities (2005) urged government, colleges, and universities to take actions in order to protect national security, the US standard of living, and human equity.

Our nation also faces threats to its continued prosperity and global economic leadership. We face a long-term energy crisis, and we face growing competition from other nations – such as China and India – that are investing strategically in their manufacturing capabilities, expanding into service industries, and, most significantly, building state-of-the art research institutes and universities to foster innovation and compete directly for the world’s top students and researchers (*National Defense Education and Innovation Initiative Meeting America’s Economic and Security Challenges in the 21<sup>st</sup> Century*, 2006, p.7)

Several business coalitions, universities, academic organizations, government, educational non-profits, and K-12 educational entities have proposed corrective actions to the STEM crisis in the United State. Coble and Allen (2005) reported the salvation of our nation depends on “an education system capable of producing a steady supply of young people well prepared in science and math (p.2)”; a sentiment echoed by the members of the National Summit on Competitiveness (2005), the Committee on Science, Engineering, and Public Policy (*Rising*, 2007), and the Business Roundtable (2005). American Association of State Colleges and Universities (2005) urged the United States to make a “renewed commitment to math and science education” (p.3).

## Science Education

The volume of college-going students increased following World War II. The world stage added popularity to obtaining a college education as service members took advantage of armed forces incentives, including the GI Bill (Rutherford, 1998). When the Soviet Union launched Sputnik into space in 1957, the United States was stunned that another country had the technological capacity to surpass US scientific skills (Cavanagh, 2007; Harris & Miller, 2005). The Sputnik launch, an apparent symbol of the superiority of Soviet technology over the US, galvanized government intervention in K-12 education (Lewis, 2005). This event compelled the nations' policy makers to focus on math and science education in order to compete with other nations, protect our national security, and provide economic success and stability (Rutherford, 1998). The National Defense Act of 1958 was signed into legislation to increase the pipeline of students in science, mathematics, and foreign language and ease the financial burden of obtaining those degrees in their fields (Harris & Miller, 2005). Post-Sputnik science and math education received both public scrutiny and support. Scientists began to impact K-12 science education by making recommendations to K-12 education that continue to be practiced today in science classrooms including: laboratory experiences, student research experiences, and science competitions (Rutherford, 1998). One informal measure of success for these science education curriculum changes was NASA's landing on the moon in 1969 (Cavanagh, 2007). In 1979, President Carter divided the Department of Health, Education, and Welfare into the Department of Education and The Department of Health and Human Services.

In 1981, the Secretary of Education formed the National Commission on Excellence in Education to examine the condition of education in the United States. The report, *A Nation at Risk: The imperative for educational reform: a report to the Nation and the Secretary of Education* (1983), opened with a dire statement about the United States. “Our nation is at risk. Our once unchallenged preeminence in commerce, industry, science, and technological innovation is being overtaken by competitors throughout the world”. As a result of a *Nation at Risk* (1983), science education went through additional curricula changes. However, states lacked consistency on how science education was delivered in their states. Constitutionally, through the 10<sup>th</sup> Amendment, K-12 education is governed by the individual states, but a portion of the states’ educational budget is funded through the federal government (Labov, 2006; USDOE, 2009). The first decade of the twenty-second century has seen the fruition of state standards in science benchmark testing to assess those standards.

### **Why should science rigor be increased in high schools?**

Standards-based curriculum and high stakes assessments based on the standards in response to No Child Left Behind (NCLB) have lead to a focus on adequate yearly progress (AYP), which all students must pass for school accreditation and thus is a measurement of minimal competency. Since states govern their own educational system, they are beholden to the political machine in power and this changes with elections. The federal government can make demands on school divisions through fiscal coercion. Under NCLB, states were required to develop standards for core courses, align standards in the classroom, and assess students on those standards (Labov, 2006). The most

notable change was to date is the standards movement and ultimately the development of benchmark testing (Cavanagh, 2007; Rutherford, 1998).

Under NCLB, states must meet participation benchmarks for all sub groups as well as performance benchmarks that increase every year until 2014. In 2014, participation and performance for all sub groups will be required to be at 100%. Sub-group categories are also set by the states based on their demographics and must be approved by the USDOE (2010). High student participation and performance are a necessity in order to maintain federal funding (Labov, 2006; USDOE, 2000; 2006; 2010). NCLB mandates adequate yearly progress (AYP) and states must show improvement from year to year on their state created assessments. The creation of NCLB created a scale for courses that schools must move up from year to year until they reach 100%. The relationship between making AYP and federal funding has lead to setting a bar that most students are capable of reaching, but is too low to adequately prepare students for the academic rigors of college especially in science and math (Rutherford, 1998).

The United States Department of Education compared state standards to the 2003 National Assessment of Educational Progress (NAEP) and found a range of 67 points between states in what they defined as proficient. NAEP and NCLB define proficiency differently. NAEP assigns three rankings to their scores: basic, proficient, advanced (Hull, 2008). While basic, proficient, and advanced are terms used in states' standards developed to meet the criteria of NCLB; their definitions are not equivalent (Hull, 2008; Labov, 2006; Change the Equation, 2012). NAEP standards are higher than state standards with few students being able to attain advanced status (Hull, 2008). NAEP

results have shown little change after the implementation of state standards (NCES, 2010; Mullis, Martin, & Robitaille, 2009).

Assessments that focus on factual based knowledge are more cost efficient to administer and score than assessments that seek to measure a deeper, more conceptual understanding of science and its application and synthesis. In addition to scoring issues, application and synthesis are more challenging to measure on a high volume assessment (Labov, 2006). Application and synthesis require more individualized student responses like essays or projects while multiple choice exams can be uniform and scored quickly. Thus, it is in the best interest of the state to develop standards and assessments that can be met by a large portion of the students, be administered efficiently, and are cost effective (Labov, 2006).

College bound students require a more rigorous curriculum in order to be prepared for postsecondary course work (Labov, 2006; Rising, 2007). State standards fall short of preparing students for the challenges of science in college because they must be low enough for all of the student body to meet the proficient benchmark in order for schools to receive federal accreditation (Labov, 2006). Higher education experts have little impact on state standards, which has resulted in a misalignment for college-bound students who are not well prepared to accept the rigors in colleges consider baseline standards for their content (Labov, 2006; American Association of State Colleges & Universities, 2005). The ultimate litmus tests for a successful K-12 science program will be evident when a student enters postsecondary education and can or cannot do the work necessary to be successful (Labov, 2006).

## **History and Growth in the Advanced Placement Program**

The federal government under The Constitution does not explicitly discuss education. The 10<sup>th</sup> amendment which grants powers not given to the federal government nor prohibited to the States by the Constitution to the states. Thus each state governs education within their borders. The lack of consistency in schools and between states led to the development of the College Entrance Examination Board in 1900 to look for high aptitude students to admit to universities. A product of the Progressive Era and ability grouping, the College Entrance Examination Board embodied a popular theme of the time that favored sorting students by ability, based on achievement and intelligence testing (Lacy, 2010, p.20). The Board was comprised of members from elite Northeastern colleges whose mission was to aid in the transition of students from secondary to postsecondary education and the recruitment of students who score highly on their assessments to their universities (Lacy, p.20).

Two projects emerged as forerunners of the AP program: The Kenyon Plan and the report General Education in School and Colleges (GESC): A Committee Report by Members of the Faculties of Andover, Exeter, Lawrenceville, Harvard, Princeton, and Yale (College Board, 2003; Tai, Lui, & Almarode, 2010). While the Kenyon Plan was pragmatic in its approach, the former report, General Education in Schools and Colleges, was more philosophical (College Board, 2003; Lacy, p. 26). The GESC articulated a liberal education and its' components as a means to ensuring democratic ideology. The Kenyon Plan developed achievement tests in nine subjects and the results were tested



against college freshman as a control. The GESC wanted to ensure that students could study in subjects of interest without being constrained solely to advanced studies. GESC was more concerned with fostering elite intellectual capacities and providing opportunities for students to pursue courses of interest rather than requiring a chemistry student to pursue English language in order to move forward (Lacy, p.17). The Kenyon Plan and the GESC led to the formation of the AP Program ideals. The success of the program was evident at the conclusion of a three-year pilot (College Board, 2003; Lacy, p.18). The assessments were used to sort students by ability, a popular trend of the Progressive Era.

The College Board assumed responsibility for continuing this program in 1952 with the eleven disciplines and began expanding their program to other disciplines. In 2010, Advanced Placement exams were offered in 34 subjects (College Board, 2010). The AP program was developed to strengthen the relationship between K-12 education and postsecondary education (College Board, 2003; Ewing, Huff, & Kaliski, 2010, p.85). The College Board founded the Educational Testing Service (ETS) in 1947 to manage the testing components of the SAT and later the Graduate Record Examination (GRE). ETS would later become the managing entity for the AP programs' exams.

The AP science curriculum is composed of standardized content that is administered in 60 countries to a large spectrum of students. In May, at the conclusion of the AP course, students are assessed and scored on a one to five scale in Table 7 (College Board, 2010). Independently, colleges and universities determine if and which scores qualify for college course credit at their institution (College Board, 2010).

The AP program has had realized tremendous growth. Over the last ten-years, the number of AP exams taken has increased yearly by 6% to 15%, depending on the exam type (College Board, 2010). Science exams, in particular, have experienced a robust increase in test takers and qualifying scores. In 2008, the College Board administered 98, 276 AP physics exams, a which which represents an increase of 125% when compared to 1998 when 43,630 exams were administered. AP chemistry exams shared similar increases at 44,937 exams taken in 1998 to 100,586 exams in 2008, which is a 1243 .8% increase. In 1956, 1,229 students took 2,199 exams in 104 schools in all 11 exams offered then by the College Board. In 2009, AP exams were offered in 17,374 schools and 1,691,905 students, where the total number of exams administered was 2,929,929 (College Board, 2003; 2010). In light of state standards and assessments needed to meet No Child Left Behind (NCLB) and make adequate yearly progress (AYP) to remain accredited, AP assessments have informally become a higher accountability measure of students' preparedness and skill set for courses as seen by their influence used in the college admission process and reports showing that AP students fare better in college than Non-AP students (Keng and Dodd, 2008).

### **Bias in Standardized Testing**

Students from low socioeconomic status backgrounds underperform their counterparts on standardized tests (Croizet and Dutrevis, 2004). In a two-part study, test scores were not an indication of students' cognitive ability or intelligence. Croizet and Dutrevis (2004) suggest that the use of these assessments in a selection process is

inherently biased against Latinos, African-Americans, and women in math-related domains. This can impact all of the AP science courses with chemistry and physics being of special concern since math is a component in the curriculum. Studies in the early 1990s supported that females were adversely affected in the testing environment if the material pertained to science or math. While College Board makes recommendations for course pre-requisites, most schools set their own pre-requisites courses and selection process for students to enroll in an AP class. Klopfenstein (2004) cites Advanced Placement scores as one of the leading selectors for college admission thus enrollment in an AP course and success on the corresponding exam would be advantageous in getting into post secondary schools.

The preparation that students receive in AP courses leads to higher completion rate and student persistence in college (Klopfenstein, p115). Green and Griffore (2001) suggest that bias standardized testing creates a negative feedback loop for minority and low-income students since opportunities for students in K-12 education are based on these assessments. Thus, a student who scores poorly on a standardized test will lack access to more rigorous classes

“About 95% of the authors were white males who had received degrees from schools like, Harvard, Stanford, and University of California at Berkeley. Poor people do not participate in the construction of these tests, nor do they advise test makers.

Consequently, the contents of many tests can be described as biased”(Green, 2001).

Buck, Kostin, and Morgan (2002) found gender bias when analyzing the Advanced Placement Biology exam and attributed the differences to female-oriented

content versus male-oriented content. Thus, the testing bias extends beyond the actual components of the standardized exam and includes access to the course and rigorous pre-requisite classes that would prepare minorities for these courses. Several variables have been proposed to explain testing bias and the achievement gap between white students and minorities including genetic differences, cultural differences, social-psychological differences, and quality of instruction by a multitude of authors (Stemler, Sternberg, Grigorenko, Jarvin, and Sharpes, 2009). Stemler et al (p.199) suggest that standardized testing assess a small spectrum of cognitive processes and fail to assess other important skills. Stemler, et al (p.209) proposes that standardized testing move to measuring a larger spectrum of skills including practical and creative items. At the present time, the College Board is undergoing a redesign on all of its AP science exams with the first live testing occurring in May 2013 in AP Biology to capture a larger spectrum of student knowledge and skills. “All students, but particularly underrepresented minorities and women, need encouragement to pursue science activities from an early age, and continued support and mentoring through the pipeline”(American Association of State Colleges and Universities, 2005, p.3).

### **Criticisms of the Advanced Placement Program**

Students who take an AP class and earn a qualifying exam score show increased graduation rates and improved preparedness for college rigor, but AP courses and exams may or may not be the casual variable (Dougherty, Mellor & Jian, 2006; Klopfenstein & Thomas, 2006). As a group, districts and schools with large numbers of students taking and passing AP exams may be an indicator of the health of those systems and their ability

to provide a high quality, rigorous academic program (Dougherty and Mellor, p.232). Ewing, Huff, and Kaliski (2010), examined all AP science test data from 2004 to 2008 and found evidence to support the reliability of AP exam scores (p.92). However, few schools mandate that students take the exam because they must absorb the total cost of \$87 as of the spring of 2012 in order to mandate taking the exam. Students have been able to manipulate the system by enrolling in AP courses to enhance their GPA for their transcript during the college admission process, and not take the test to benefit from the additional weighted grade points offered in some divisions and schools for AP courses (Klopfenstein & Thomas, 2006, p.169).

The National Research Council (2002) criticized AP math and science courses as being fact-based and not emphasizing problem solving and critical thinking (p.199). Dougherty and Mellor (2010, p.221) caution against generalizing the interpretation of results from AP studies about all students who take AP classes. AP students, prior to the push for open access, self-selected into AP classes and represented a large number of students who would be matriculating to postsecondary education regardless of their participation in the AP program (Tai, Lui, Almarode, & Fan, 2010, p.110).

*A critical Examination of the Advanced Placement Program* was published in 2010 by a group of researchers and presents various criticisms of the AP Program and the College Board. The major criticism of the College Board's AP program were tendencies to drilling facts without cohesive connections to content does not adequately prepare a student for the rigors of college. The National Research Council (2002) suggested that AP courses be improved "to foster deep conceptual understanding (p.14-15). Students in

AP science classes tend to have a higher level of math preparation indicating that students with a stronger math background are self-selecting into AP science courses (Sadler, 2010, p.54; Sadler & Tai, 2007). Math preparation is critical in STEM degree fields and is strongly correlated to persistence in fields like chemistry and physics, thus high math ability in and of itself may be the variable positively impacting student success and not AP science classes (Sadler, 2010; Sadler & Tai, 2007; Tai, 2008).

### **Advanced Placement equals increased rigor**

Under NCLB, state administered standardized tests must be set at a level that the majority of the students' population can obtain (Labov, 1998, 1998). Two decades of science data from NAEP shows no significant improvements (NSB, 2008). Even though, states show increasing success on their state-developed standardized test. In a recent follow up to *Rising Above the Gathering Storm, Rising Above the Gathering Storm, Revisited: Rapidly Approaching Category 5* (2010) demonstrates that no real change has occurred as the United States slips further and further behind in science on a global scale. The report cites data in education, industry, research and development, and economics that the US fails to remain competitive. The High School Transcript Study conducted from 1990 to 2000 shows course means were lowest for math and science, 2.60 and 2.67 respectively compared to 14 other courses (Perkins, Kleiner, Roey & Brown, 2004). Through NCLB and AYP, minimum standards are the norm in K-12 education. While they have a place in K-12 education, they are not nearly the standards required to adequately prepare students for STEM fields.

College-bound students need more rigorous curricula and summative assessments in order to prepare for postsecondary course work (Labov, 2006). Accountability is critical to ensure program quality and thus a comprehensive high-quality summative assessment is necessary to ensure that students are prepared. Other programs reported to prepare students for STEM careers lack an evaluation tool that is uniformly applied and externally graded to assess the students' abilities on the same scale like AP. An external and norm-referenced assessment is the key component that separates AP & International Baccalaureate (IB) from every other high school program that claims to increase rigor including dual enrollment, magnet schools, and specialty centers. "The big advantage of AP courses are they are consistent in their standard content, the same exam is administered externally to all students, and the standard is known and can be accepted by parents, teachers, and admission officers" (Robinson, 2003, p.266). The consistency of AP exams allows them to be used as a basis of comparison against TIMSS to disaggregate all American students with special populations that have a larger success rate. In 2010, the US was ranked 27 out of 60 countries in physics, but students who received a score of 3 or better on an AP physics exam were ranked 4<sup>th</sup> internationally (College Board, 2010; Mullis et al, 2009).

Increasing AP enrollment and performance is seen as a way to improve the pipeline for students in STEM career paths. AP and IB are viewed by federal government, state governments, and other stakeholders as a vehicle for more rigorous preparation for students who are college bound as evidenced by their increased and

continued fiscal support of these programs by state and federal departments of education (Byrd, 2007; College Board, 2010).

In *Rising Above the Gathering Storm* (2007), members of the National Academies Committee on Science, Engineering, and Public Policy recommended that the pipeline of students taking math and science courses be enlarged by increasing enrollments in AP and IB courses. AP has become part of the plan for secondary education in the move to increase rigor. Data suggests that AP science and math courses support an increased pipeline in the potential workforce for STEM careers (Rising, 2007; 2010; American Association of State Colleges & Universities, 2005). Dougherty and Mellor (2010) state that students who perform well on AP exams are indicative of their overall academic preparedness for college, regardless of the grade awarded on their report card. Keng and Dodd (2007) found that students taking AP courses and earning credit on the AP exam had more positive college outcomes than non-AP students with similar academic abilities. AP students who earned qualifying scores tended to graduate in less time compared to students who did not take AP courses. AP students had higher grade point averages, thus making AP scores an accurate predictor of college success (Keng & Dodd, 2007). A three year comparative study of 231 AP biology students and 348 non-AP biology students showed that those who earned qualifying AP scores also earned almost a full point higher in science course grades and had more college credit hours than their non-AP counterparts (Keng & Dodd, 2007).

AP is indicative to college admissions as a benchmark of student readiness for college-level material. Colleges seek a uniform mechanism to compare students in the



admission process due to the lack of consistency among schools, districts, and classrooms in terms of grades, course content, and course availability. Honors chemistry can look different at different high schools and with no standards to measure rigor above the state standards assessments it is difficult for colleges to distinguish between the courses and more importantly a students' preparation in that course (Ewing et al, 2010).

While student transcript credentials are important to gain admission to a college, student preparation is more important in college persistence and ultimately obtaining a college degree. The U.S. Department of Education (2010) reported that one-third of students entering four year colleges require a remedial course in math. Apparent deficits, especially in math and science, are better realized before college, as required remedial courses increase time in college and reduce the chances of a students' their persistence in STEM fields (Robinson, 2003; Schneider, Swanson, & Riegle-Crumb, 1998).

Increasing AP enrollment and performance is seen as a way to improve the pipeline for students in STEM career paths. AP and IB are viewed by federal government, state governments, and other stakeholders as a vehicle for more rigorous preparation for students who are college bound as evidenced by their increased and continued fiscal support of these programs by state and federal departments of education (Byrd, 2007; College Board, 2010).

Students who enter college with a good background in science, math, and English perform better in college (Adelman, 1999). Studies support that students who place out of introductory courses perform the same or better than non-AP students in the subsequent course (Koch, Fitzpatrick, Triscari, Mahoney, & Cope, 1988; Morgan and Ramist, 1998).

Klopfenstein and Thomas (2006) found that students who took AP sciences in high school increased their chances of advancing to their second year of college. Research on the importance of rigorous courses in mathematics and science continues to support the premise that these courses are critical to persistence and success in STEM fields (Robinson, 2003; Schneider et al., 1998; Tyson, Lee, Borman, & Hanson, 2007).

### **Widening the Spectrum**

Intemann (2009) presents three rationales for increasing diversity in STEM fields: social justice, exclusion of potential talent, and increasing objectivity. A diverse workforce in STEM would promote social equity by elevating priorities of marginalized populations and thus increasing social equity for all populations (Intemann, 2009, p.251). “Homogeneous groups are not likely to produce minority opinions; heterogeneity of groups increase the likelihood of minority influence (Antonio et al., 2004 p. 2). Current demographics show that minorities, particularly female and African American students are underrepresented in advanced science and math courses in high school (NSB, 2008; NSF 2009), arguably the start of the pipeline to a STEM degree.

In recent years, the AP Program has made a push to increase equity and access to opening the door for underserved populations including: African Americans, Hispanics, and females through conferences, workshops, and yearly reports on the progress (College Board, 2012). Ultimately, College Board seeks to have test takers and qualifying scores more consistent with the demographic of the school, state, and nation (College Board, 2010; Sadler, 2010). The majority of AP teachers and students are Caucasian (College Board, 2010). Hess and Rotherham (2007) clearly articulate the two motivations for

increasing access AP programs in schools 1) equity for low performing and disadvantaged students and 2) increased rigor for top performing students being under-challenged in the era of NCLB. Low bar state assessments (Change the equation, 2012) regardless of the strength of the state standards (Fordham, 2012) do not increase skills that students need to enter, maintain, and excel in STEM fields. State assessments are creating a false sense of readiness in states with non-rigorous assessments or low cut scores on a rigorous assessment..

Even with the positive growth in AP exams, minorities and economically disadvantaged students are still underrepresented. Klopfenstein (2004) accounts for some of the disparity for minorities and economically disadvantaged students in AP courses by citing that these students do not attend college at the same rates as whites. She also cites school size as an issue because small schools are not able to support a large AP program due to financial and size constraints.

To increase access and equity in the AP program, state and federal entities offered and continue to offer opportunities for students to increase involvement in AP programs through fee subsidies and AP professional training for teachers. The Federal government expects to award state agencies \$15,374,000 for AP grants in 2010 to support low-income students and professional development (USDOE, 2006; 2010). Some states have legislated AP courses. Minnesota supports AP and IB teacher training throughout the school year by financing program costs, teacher training, and substitute teachers (Zinth & Dounay, 2006). Arkansas has the most comprehensive AP support program with AP courses in math, science, English, and social studies. These courses are

required to be offered in every school with additional AP courses phased in each year. Some fiscal support for these state programs is available, including exam fees, professional development, and other monetary incentives (USDOE, 2006; Zinth & Dounay, 2006). These incentives are being used in school systems to persuade students to take more rigorous courses and enrollments are increasing (Hoff, 2004). Klopfenstein (2004) concludes that research is warranted to determine the effect of increased money available for AP at the local, state, and federal level as well as grants, which support AP on equity and access for underrepresented populations. She hypothesizes that subsidies for the exam fee are not the barrier for underrepresented populations and cites the lack of preparation as the barrier that keeps these students from enrolling in AP classes and taking the exam once enrolled and completing the course.

Males performed higher than females in physical science and this gap widens with age (Erickson & Erickson, 1984). Physics course achievement shows the greatest gender disparity out of AP science exams (Keeves and Kottes, 1996; Zohar, 2003). In addition to the enrollment of students in AP courses, data provided by the College Board indicated a disparity between gender (Appendix 3) and ethnicity (appendix 4) on some AP science exams (College Board, 2010).

### **The History of NMSI and APTIP**

In 2005, the Senate and House of Representatives asked the National Academies to assemble a panel of experts to initiate a study to assess the situation of science and technology in the United States (*Rising*, 2007). The National Academies formed the Committee on Prospering in the Global Economy of the 21<sup>st</sup> Century: An Agenda for

American Science and Technology comprised of Nobel Laureates, university presidents, CEO's of fortune 100 corporations, and former presidential appointees. The committee was asked to study two questions: What are the top 10 actions that federal policymakers could take to enhance the science and technology enterprise so that the United States can successfully compete and prosper in the global community of the 21st century? What strategy could be used to implement each of those actions (*Rising*, 2007 p.4)?

The committee began by looking at previous papers on this topic and summarizing the research to inform their process. The nineteen-page bibliography included referred articles, books, National Research Council papers, and National Academy documents. The committee formed five focus groups consisting of experts in research, innovation and workforce issues, higher education, K-12 education, national security, and homeland security. Each focus group was asked to recommend three actions that the group considered necessary for the United States to be secure, to compete, and to prosper in the 21<sup>st</sup> century.

In 2005, the National Academies Press published *Rising Above the Gathering Storm*, the culminating paper on this process. The committee made four recommendations :recommendations: 1) Ten Thousand Teachers, Ten Million Minds, and K-12 Science and Mathematics, 2) Sowing the Seeds Through Science and Engineering Research, 3) Best and Brightest in Science and Engineering Higher Education, and 4) Incentives for Innovation (p.31). The report identified the APTIP Advanced Placement Incentive and Training Program (APTIP) administered by APS Advanced Placement Strategies, Inc. in Dallas Texas as a vehicle for increasing students

in the STEM pipeline. The APTIP, boasted a significantly greater positive impact for minorities and females making it a program that stands to make gains where other programs, including interventions by the College Board have failed in increasing access and equity for more students (APS, 2008; NMSI, 2009).

With funding from Exxon Mobile, the Dell Foundation, and the Bill and Melinda Gates Foundation, NMSI scaled the APTIP by awarding funding to seven states in a competitive grant process in 2007. The states included: Washington, Virginia, Connecticut, Massachusetts, Kentucky, Arkansas, and Alabama (NMSI, 2009). Washington was unable to accept the grant due to pressure from local teachers' unions and consequently was unable to participate in the 5-year incentive program (Shaw, 2008). The most controversial component of the APTIP is the incentive monies for students, teachers, and administrators with positive performance. NMSI provided seed money to six states to supports: money for training, equipment, staff development, and incentives to students and teachers to promote open access to AP English, math and science courses. In 2009, schools in the APTIP in the six states had a 51.4% increase in qualified scores in AP English, math, and science compared to a typical increase of 5-7% in those states and compared to the national increase in those subjects of 6% (NMSI, 2009).

### **Increasing the STEM pipeline**

Rigorous preparation in math and science will lead to a larger population of students capable of pursuing and persisting in STEM fields in college. The National Research Council (2002) found that improving staff development, removing non-rigorous courses, and developing a community supportive of advanced study were effective

strategies for increasing student participation in advanced course work (Executive Summary, p.5). The APTIP includes many of the National Research Council's recommendations (figure 3). Staff development, development of an AP culture within the school community to encourage more students to pursue and persist in advanced coursework, course alignment in grades 6 to 12 that eliminates low-level course options, and support with additional seat time and structured tutoring are all elements in the APTIP (NMSI, 2009). Incentives, which include reduced or free exam fees, monies for qualifying scores and weighted credit are being used in school systems to persuade students to take more rigorous courses and enrollments are increasing and to offset exam fees (Hoff, 2004).

As the United States experiences marked economic issues with higher unemployment, inflation, and loss of industry to other countries, policy makers are looking critically at the educational system to provide the answers and the solution to maintaining our position in a global economy. "Increasing course completions in advanced mathematics and science may therefore help enlarge the college graduate pool and the workforce in these fields as well as increase women's participation in occupations in which they have been traditionally underrepresented" (NSF, 2008, ¶1, p -17).

APTIP data suggest that increasing enrollment and performance on AP science exams will increase the pipeline of students capable of entering STEM fields with an even greater positive impact on minorities and females.

## **Reiteration of the Problem**

The United States is not preparing enough students in STEM fields and those students that we are preparing lack demographic representation of the school, state, and country population. Increasing student participation and performance in AP science and math courses increases students' skills and widens the pipeline of students prepared to enter STEM fields in college. State standards fall short of adequately preparing students for the rigors of college because they are attached to graduation rates. More rigorous standards are needed to prepare students for college, especially in subject areas like math and science where students in the United States are not comparing favorably against students in other countries. In addition to requiring higher standards, a measurement tool is needed to assess their mastery. AP courses and exams are rigorous standards with an external assessment. The NMSI APTIP has increased minority participation and performance on AP science exams and thus is a potential vehicle for widening the STEM pipeline and increasing diversity (Jackson, 2011).

## **Purpose**

Therefore, the purpose of this study is to examine the effectiveness of the NMSI APTIP on the number of students taking AP science courses and exams and their performance, , particularly African American and female students with a focus on examining the gender and ethnicity of those test takers prior to the implementation of the program and during the implementation of the program..



## CHAPTER 3

### METHODOLOGY

This chapter provides a description of the research design including the sample, and the population as well as the proposed procedure and data analysis. The nature of the research questions lends it self to a quantitative study since I sought to measure the quantity of students that were impacted by the APTIP.

#### **Research Design**

This study was an is an abbreviated time series ex post facto design using secondary data obtained from the National Math and Science Initiative at sixty-five schools across six states that participated in the APTIP in Cohort 1. In 2007, NMSI offered their APTIP program through a competitive grant process to six states: Alabama, Arkansas, Connecticut, Kentucky, Massachusetts, and Virginia (NMSI, 2009). Each state was required to administer and manage the APTIP through a not-for-profit agency within the state. Each state’s organization was given guidelines by NMSI and sent a “request for proposal” to schools within their state. The state not-for-profit agencies managing the APTIP selected the schools in their states. Alabama, Arkansas, Connecticut, Kentucky,

Massachusetts, and Virginia selected 12, 10, 9, 12, 11, and 14 schools, respectively for a total of 68 schools in cohort I 1 with additional cohorts added each year as funding permits (NMSI, 2009). Three schools were eliminated from the data. Two schools removed themselves from the program after year 1 and one school is a magnet schools whose data reports back to individual schools not in the cohort. Data presented in this study included 39 of the 65 cohort I schools. Schools were only included in this study if they had at least one AP science test taker in AP Biology, AP Chemistry, AP Environmental Science, or AP Physics-B in one of the three years prior to the intervention. This research looked at 39 of schools from Cohort 1 over a five-year period. . The data were retrieved for three years, 2006, 2007, 2008, before the grant was implemented and then for the threetwo years, 2009, and 2010, and 2011 after during the implementation of the APTIP grant also referred to as the intervention. Using a computer program called Statistical Package for Social Science (SPSS) version 19, descriptive statistics as well as a general linear model (GLM) for repeated measures were used to evaluate the data based on the research questions. National, state, and NMSI APTIP schools test takers and performance data on AP science exams will be evaluated by an interrupted time series data analysis.

This analysis will included all students enrolled in AP science courses in the 6 39 schools participating in the APTIP. Although no statistics were run on National and State data, both are presented to suggest trends. as well as comparisons between state and national data. Females and African American students' enrollment and performance will be evaluated using a General Linear Model with repeated measure, but numbers for

African American student performance was presented in raw data, since the sample was too small and violates an assumption for the General Linear Model of  $N > 30$ . a

The following research questions were addressed:

1. Does participation in the National Math and Science Initiative (NMSI) Advanced Placement Training and Incentive Program (APTIP) increase Advanced Placement science exam test takers?
2. Does participation the NMSI APTIP program increase performance (scores of 3, 4, or 5) of students on AP science exams?
3. Are more females enrolled and African American students taking iAn AP science examscourses in schools that participate in the NMSI APTIP program than prior to the intervention? compared to the state and national trends for the same sub-groups?
4. Are females and African American students experiencing increased performance on AP science exams in schools that participate in the NMSI APTIP program compared to performance before the intervention?

### **Sources of Data**

The College Board collects data on Advanced Placement exam test takers and performance of students as well as demographic data that includes: gender, ethnicity, and grade level. All, are available online at the state and national level on the College Board website. The National Math and Science Initiative provided data on schools participating

in cohort one from 2006-2011. Schools will be categorized by their National Center Education Statistics (NCES) classification as city, rural, town, and suburban

### **Sample**

In 2007, six non-profit organizations in six states were awarded grants by NMSI to administer the Advanced Placement Training and Incentive Program (APTIP) by NMSI. Each non-profit began a competitive grant process within their own state to identify schools that would participate in the grant. For the 2008-2009, 68 schools were selected to participate in the five-year grant in six states. Three schools were eliminated from this study. Two schools were eliminated because they left the grant after the first year of the program and one school was eliminated because it is a magnet school where data was coded back to the students' home school and thus not available for this study. Data on AP science test takers and their performance will be gathered for three years in the 65 cohort I schools before the grant was awarded to their school in 2006, 2007, 2008 and post-data will be collected for 2009, 2010 and 2011 to compare test takers and performance during grant implementation. Out of the 65 schools in cohort I, 39 schools were used in this study. 26 schools were eliminated from the statistical analysis of this study because they did not administer an AP science exam in AP Biology, AP Chemistry, AP Environmental Science, or AP Physics-B to any student between 2006-2008. However, raw data on AP science exams in all 65 schools in Cohort I will be used to show trends.

Collecting student course enrollment data would have been ideal, but unfortunately student enrollment in course fluctuates throughout a given year and was not

available for the pre-grant years, so the enrollment variable is for students who actually took the AP science exam in May. This variable is referred to in the study as test takers and will be used in all six years as the comparative variable for enrollment.

### **Procedure**

AP Science exam data in AP Biology, AP Chemistry, AP Environmental Science, and Physics-Bb were requested from College Board NMSI for students in Cohort I. Physics-Cc courses were not evaluated in this study. Calculus is a necessity in the physics-c courses and thus students enrolling in this course must have had calculus or be co-currently enrolled in order to register for this course. Unfortunately, the number of students sitting in a calculus class in high schools across the country is low and the pool of possible students that can enroll in the course is limited and often not offered at schools due to low enrollment or lack of credentialed teacher. Physics-C mechanics and Physics-C electricity and magnetism are two AP exams that were not included in this study due to the low numbers of students enrolled in these programs at the national level as well as in the 65 program schools. Schools would be categorized city, rural, town, and suburban as classified by the US Department of Education across the six states. Test taker and performance data from AP science exams 2006, 2007, and 2008 will be compared to test taker and performance data after the implementation during the APTIP of the grant in 2009, 2010 and 2011. The secondary data was requested from the National Math and Science Initiative and exempt status was granted through the Virginia Commonwealth University Institutional Review Board in February of 2010

## **Data Analysis**

Descriptive statistics will be used to summarize the data at the national and state level as well as within Cohort I of the APTIP. School names were removed from the data. Student test takers from 2006-2011 administrations (2006-2011) of the Advanced Placement exams, which were administered the first two full weeks of May, were analyzed for the number of test takers and their performance before the intervention and after during the intervention of the NMSI APTIP in the 39 schools. In order for student data to be included in this study, the school must have had at least one AP science test taker in AP Biology, AP Chemistry, AP Environmental Science, or AP Physics-B in the three years prior to the intervention. Using the Department of Education (DOE) classification system, the 39 schools represent the following demographics: 10 city, 8 rural, 9 suburban, and 12 town schools. The data were retrieved for three years, 2006, 2007, 2008, before the grant was implemented and three years, 2009, 2010, and 2011 during the implementation of the APTIP grant also referred to as the intervention. Using a computer program called Statistical Package for Social Science (SPSS) version 19, descriptive statistics as well as a general linear model (GLM) for repeated measures were run to evaluate the data based on the research questions

This analysis included test taker data from all students enrolled in AP science courses in the 39 schools participating in the APTIP. Females and African American students' enrollment and performance were evaluated using a General Linear Model with repeated measures, but numbers for African American student performance were presented in raw data, since the numbers were so low they would violate an assumption

of  $N < 30$  for the GLM. In social science and education, causality is a useful working methodology to evaluate programs and their impact on school reform (Glass, et al, 1975; 2008).

A standardized interval was used in the general linear model using repeated measures since the exam is administered only once a year in May over the course of two-week period. The Educational Testing Service (ETS) scores the AP exams and keeps data on the scoring process and its' reliability and validity. The instrument is uniform and thus provides a reliable method of comparison between students and populations of students (Glass, et al, 1975, 2008).

### **Limitations**

Not all schools implemented the APTIP with the same fidelity. Prerequisites and gate keeping on the part of teachers, school counselors, and administrators can limit the enrollment of students in the AP classes. School culture and support of other courses in the building could pose challenges to the APTIP's success. Schools applied to participate in the APTIP, so a degree of self-selection exists. However, the driving force behind applying for the APTIP may be unanimous or the decision a small group of people or even one person, so some schools could have embraced the APTIP in different degrees.

The instructor of the AP course can greatly impact enrollment and student success. Teacher-student rapport can greatly contribute to student enrollment and student retention in a class that is challenging, especially if the challenge is significantly above the state standards and what the student has been previously exposed. In a grade obsessed secondary environment, students are hard pressed to enroll in a class with a teacher who

may injure their grade point average. Redistricting or other unknown school or division policies that impact enrollment could compromise the validity of the study. Electives offered in the building can also impact students' desires or willingness to take AP. If an easy alternative science class or a dual enrollment science course is offered, then a student may be more inclined to enroll in a sure thing that guarantees a good grade or credit.

College Board does not collect data on students enrolled in an AP course; their data was based on the test takers and their performance. So published data excludes students enrolled in an AP course that did not take the test and there is no way to gather that data at this time.

### **Researcher Prospective**

I taught biology, earth and space science, and physics at the high school level for seven years. I was named department chairperson in 2002 and was tasked with collecting and using data to improve the science curriculum. Our department developed a common benchmark for each course and looked critically at data to see where we could make changes in the curriculum to increase student's performance. Through this collaborative experience, it became clear that using data was a powerful tool in making effective and efficient changes that resulted in immediate and targeted results.

I left the classroom in 2006 to work as a Coordinator of Assessment and Remediation to further my use of data to implement and manage programs. My principal had a specific focus on increasing student performance on AP exams and the Scholastic Aptitude Test (SAT). I began looking at the data to make curriculum changes, but quickly



realized that the barriers in my building were more related to prerequisites and students' and teachers' perceptions about what an AP student was or should be prior to being allowed in the classroom. In 2007, my principal and I wrote the Request for Proposal for the APTIP, which is administered through Virginia Advanced Study Strategies (VASS). This seemed like a way to remove some of the barriers we were observing in our building with a support system. We wrote a proposal for our school to be included in the grant's inaugural year. When I began researching the NMSI program to write the grant, their mission seemed improbable, yet it was working. My principal encouraged me to apply for the science directors' position with VASS. I began consulting with VASS to help them select schools for their first year and was later hired full-time as the Director of Science for VASS, the non-profit awarded a 13.2 million dollar grant from the National Math and Science Initiative in 2007.

My involvement with this program has led me to continue to research the effectiveness of our program and continually make adjustments it to meet the needs of our schools. As I work with this grant across the state, I am often asked about our results and, while our data isare impressive, I wanted to look at similar cohorts and continue to objectively look at ways to improve science education. This information will be useful to schools, school divisions, and state, and federal entities in helping widen the pipeline for STEM students, especially underserved populations that would greatly enrich the diversity pool of STEM students and ultimately STEM fields that need the diversity to give them the competitive edge in our global economy. I also hoped that this research

could serve as a more comprehensive evaluation of the NMSI APTIP exclusively for science.

In the next chapter, I will review the findings of this study and provide data and statistical analysis to answer the research questions.

## CHAPTER 4

### FINDINGS

This study was conducted to determine the impact of the Advanced Placement Training and Incentive Program (APTIP) on student enrollment and performance on Advanced Placement science exams in biology, chemistry, environmental science, and physics-B. The research questions evaluated: (1) the number of Advanced Placement science test takers in schools prior to the intervention (2006, 2007, 2008) and the implementation of the APTIP (2009, 2010, 2011); (2) the number of Advanced Placement science test takers earning a score of 3, 4, or 5 on a science exam in biology, chemistry, environmental science, and physics-B pre-intervention (2006, 2007, 2008) and during the APTIP intervention from (2009, 2010, 2011); (3) the number of female and African American students test takers before and during the intervention; and (4) the performance of females and African American students before and during the intervention. The APTIP continues in cohort I schools for two more years, so I will use

the language during the intervention to discuss the three years of data used in this study for this five-year program.

In this study, I have identified 2006, 2007, and 2008 as the school years prior to the APTIP intervention. School years 2009, 2010, and 2011 were evaluated as the years during which the APTIP intervention was in place. The findings in this chapter describe the change before and during the Advanced Placement Training and Incentive Program in a cohort of schools across six states that began the program in the same year (2008-2009). The National Math and Science Initiative selected six states to participate in the national roll out of their program for the 2008-2009 school year. The not-for-profit organizations in those six states choose schools for the first cohort through a competitive interview process. The APTIP has two main goals: to increase the number of AP test takers in math, science, and English and to increase students' performance, earning a 3,4, or 5, on an AP English, math and science exam. This study only presents data on the impact of the APTIP on AP science. This chapter describes the findings of 39 schools that met the requirements for inclusion in this study.

### **AP Science Test Takers**

As seen in Table 2, the College Board has seen an increase in Advanced Placement science exam test takers in biology, chemistry, environmental science, and physics-B over the years of this study, 2006-2011.

Table: 2

Global College Board Advanced Placement Science Test Takers by Year

	2006	2007	2008	2009	2010	2011
Biology	128,696	141,321	150,724	155,553	167,873	179,544
Chemistry	84,329	93,307	96,458	100,510	109,846	116,608
Environmental	44,316	51,898	60,713	72,841	85,697	97,799
Physics-B	49,184	52,635	55,227	59,797	63,654	71,395
Total	306,525	339,161	363,122	388,701	427,070	465,346

During the study year, AP Biology, AP Chemistry, AP Environmental Science, and AP Physics-B increased from 306,525 in 2006 to 465,346 in 2011; a 52% increase over a six-year period in those four subjects combined. Over the six-years of the study, AP Environmental Science had a 121% increase in test takers followed by AP Physics-B at 52% and AP Biology and AP Chemistry at 40% and 38% increases from 2006 to 2011.

**Test Takers**

The 39 schools participating in the NMSI Advanced Placement Training and Incentive Program (APTIP) showed an increase in test takers from 2006 to 2011 as shown in Table 3. AP Environmental Science showed the most change in the APTIP schools from 111 test takers in 2006 to 1,002 test takers in 2011, consistent with the increase in AP Environmental Science shown in the College Board Global data in Table 1. In the 39 APTIP schools, AP science test takers averaged 1,239 students over the three-year period between 2006-2008 prior to the intervention. During the

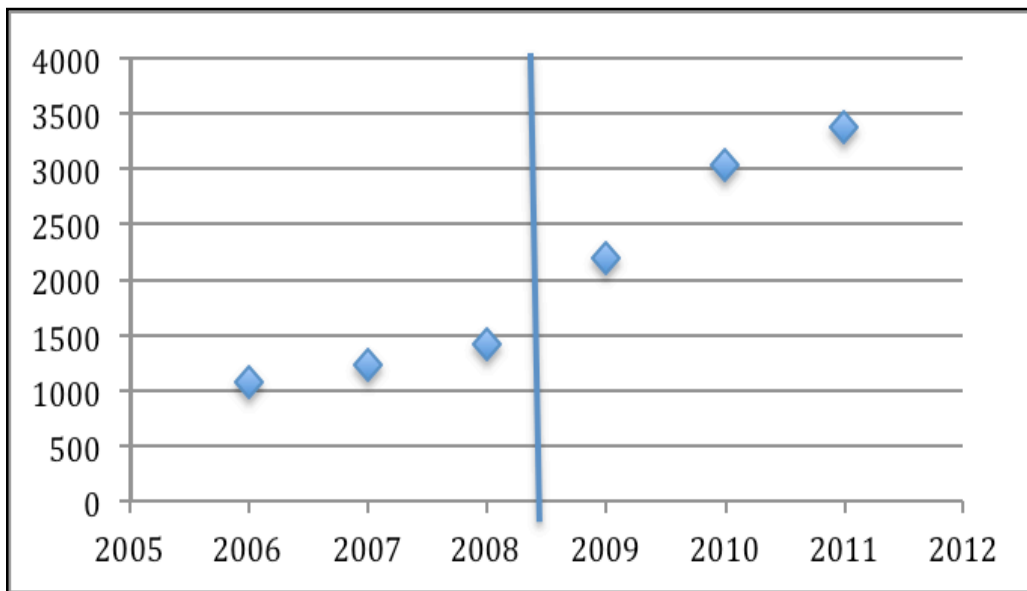
implementation of the APTIP, AP science test takers averaged 2,868 students over a three-year period in the same 39 schools.

Table 3

APTIP 39 Schools Advanced Placement Science Test Takers by Year

	2006	2007	2008	2009	2010	2011	Total
Biology	467	523	609	864	1,064	1,108	4,635
Chemistry	308	428	402	635	722	717	3,212
Environmental	111	91	149	327	732	1,002	2,412
Physics-B	185	190	254	369	516	549	2,063
Total	1,071	1,232	1,414	2,195	3,034	3,376	12,322

Figure 1: Test Takers Before and During the APTIP Intervention in 39 schools



The line between 2008 and 2009 (Figure: 1) indicates the APTIP intervention. The slope between years indicates a steeper or larger increase from year to year as the data points move higher on the y-axis. The slope between the pre-intervention years was 161 and the slope during the APTIP intervention was 591. The slope between 2008 and 2009, which shows the first year of the intervention, was 781, a marked increase in test takers. The average number of test takers prior to the intervention (2006, 2007, and 2008) was 1,239 compared to an average of 2,868 in APTIP intervention years (2009,2010, and 2011). AP Physics-B test takers nearly tripled from 185 test takers in 2006 to 549 test takers in 2011. AP Biology and AP Chemistry more than doubled and AP Environmental Science sextupled. This trend in the number of test takers supports the premise that the APTIP increased the number of AP science test takers in schools that participated in the program, but statistically how do the data compare?

Matched program and non-program schools were not available for this study, so a general linear model for repeated measures was performed on data from my sample of 39 schools participating in the APTIP program beginning in the 2008-2009 school year. A general linear model of repeated measures showed that the APTIP intervention was statistically significant in test between subjects' effects (.000) increasing the number of AP Science test takers as seen in Table 4. The schools' total test takers were divided by their average daily membership (ADM) to equate for school size. The Sum of Squares and Cross Products (SSCP) matrix showed statistical significance for the test takers ( $F=15.559$   $p<.000$ ). Multivariate tests including Pillai's Trace, Wilks Lambda, Hotelling's Trace, and Roy's Largest Root all showed a statistical significance of .000,

which indicates that any of those statistics could have been selected and shown if needed to indicate significance. In other words, there is a statistically significant difference in the number of AP science test takers during the APTIP intervention than prior to the intervention. Table 4 shows the means and standard deviations of the 39 APTIP schools after the number of test takers at each school was divided by their Average Daily Membership to equate for school size.

Table 4

Mean and Standard Deviation (sd) of APTIP Test Takers by Year After Equated by ADM

	2006	2007	2008	2009	2010	2011
Mean	.025	.030	.034	.052	.075	.083
SD	.004	.006	.007	.009	.016	.018

The data were representative of an annual assessment at the same 39 schools over a six-year period with no grouping variable. Table 5 shows a Repeated Measures ANOVA that was used to analyze the data. Within subject factor was Year, which is considered to be the trials factor with six levels (2006-2011). The data revealed that covariances and variances were proportional within groups of baseline and test years, but there was substantial change in both across the 3-year intervals. This violated the assumption of sphericity (Mauchly's Test Chi-squared= 307.880 p<. 000). Due to the violation of sphericity, results are reported using the Huynh-Feldt technique. The analysis revealed a significant effect for Year (F (1.209, 45.950 df.)= 13.870, p<.000). The means



indicated a statistically significant increase in the number of students taking an AP science exam in APTIP schools. Results are reported in Table 5.

Table 5

Repeated Measures ANOVA for 39 APTIP Test Takers by Year After Equated by ADM

Source	SS	df	MS	F
Year	.119	1.209	.098	13.870
Error	.325	45.950	.007	

Using an adjusted Tukey HSD contrasts, the difference of the means were found to have a significant range .058 (alpha= .05). Results of the Tukey contrasts indicated that there was no difference among the number of test takers in 2006 (mean= .025), 2007 (mean= .030) and 2008 (mean= .034), the years prior to the APTIP intervention. In 2009, the first year of the intervention, there were significantly more test takers (mean= .052) than in each of the three years preceding the APTIP intervention, and this increase held for 2010 (mean= .075) and 2011 (mean= .083). The means listed are shown in Table 4. The degrees of freedom in the error represents an algorithm used by the Huynh-Feldt technique when sphericity is violated that corrects the degrees of freedom closer to the lower bound method to avoid excessive Type I error.

## AP Science Qualifying Scores

Research question two examined the quality of the scores received by the test takers in the APTIP. Does participation in the APTIP increase performance scores of students on AP science exams? A score of 3, 4, or 5 are often referred to as qualifying scores. Globally College Board has seen an increase in the number of qualifying scores on science exams over the same years of the study as seen in Table 6.

Table 6

### Global College Board Advanced Placement Science Scores of 3, 4, and 5 by Year

	2006	2007	2008	2009	2010	2011
Biology	78,190	85,453	75,045	78,321	81,792	89,883
Chemistry	48,251	51,730	53,103	55,481	59,423	62,815
Environmental	22,331	26,820	32,491	36,325	42,705	48,158
Physics-B	29,360	31,213	32,848	35,675	36,912	42,917
Total	178,132	195,216	193,487	205,802	220,832	243,773

Table 7 shows the scoring interpretation of Advanced Placement exams. Advanced Placement science exams are scored on a five-point scale with 5 being the highest possible score. Proficient scores are determined and differentiated by colleges and universities in terms of credit that can be awarded with 5 being the most likely score to be accepted for the most credit and 3 being the lowest score accepted as credit.

Table 7

College Board Advanced Placement Scoring Interpretation

<u>Score</u>	<u>College Board Interpretation</u>
5	extremely well qualified to receive college credit and/or placement
4	well qualified to receive college credit and/or placement
3	qualified to receive college credit and/or placement
2	possibly qualified to receive college credit and/or placement
1	<u>no recommendation for receiving college credit and/or placement</u>

Table 8 shows the marked increase of qualifying scores of students on AP science exams in APTIP schools. The sum of the four AP science exams the three years prior to the intervention was 1,556. During the APTIP, AP science exams totaled 3,256. The percent difference between the three years prior to the APTIP years and the three years during the APTIP was 109%.

Table 8

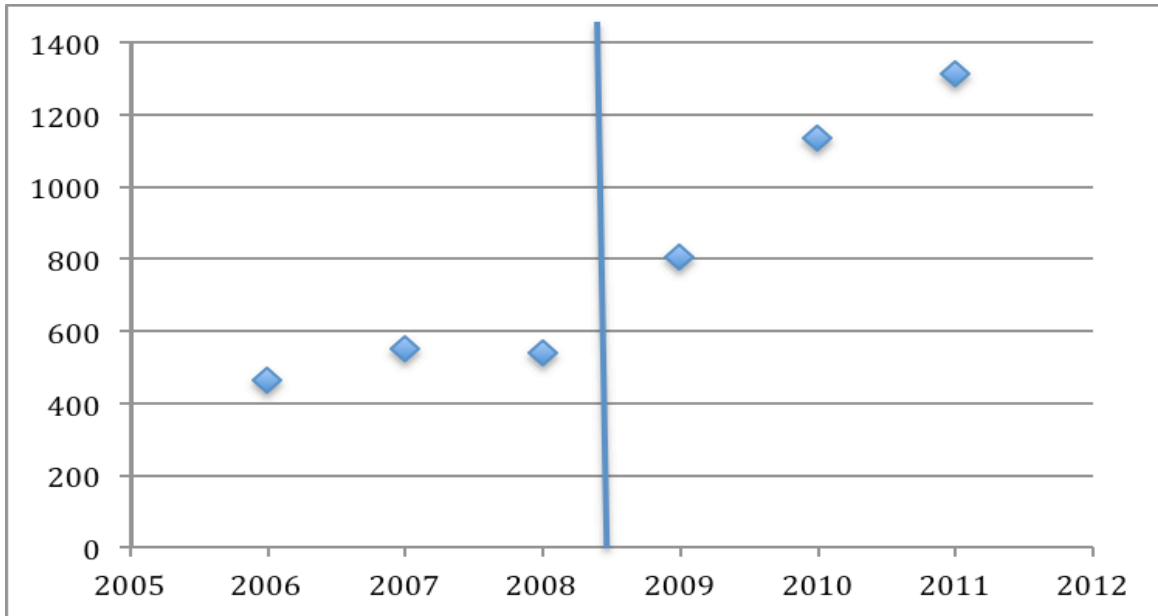
*Number for qualifying scores of 3,4, and 5 in 39 APTIP schools (n=12322)*

	2006	2007	2008	Total Before	2009	2010	2011	Total During
Biology	220	260	217	697	266	320	359	945
Chemistry	114	174	154	442	232	296	307	835
Environmental	54	36	74	164	152	294	416	862
Physics-B	77	81	95	253	157	225	232	614
Total TT	465	551	540	1,556	807	1,135	1,314	3,256

As seen in figure 2, the slope in years prior to the grant was 75 students (the difference between 2005/06 and 2007/08). The slope of the first intervention year (2007/08 to 2008/09) was 267 students. Looking at the full spectrum of the study, qualifying scores moved from 465 qualifying AP science scores in 39 schools in 2005/06 to 1314 qualifying AP science scores during the 2010/11 school year; a 183 % change in the three years of the intervention.

Figure 2

*Number of scores (3,4,5) on AP Science Exams in APTIP schools by year*



AP science performance in the 39 schools was stagnated in 2006, 2007, and 2008. Figure 2 depicts a slope of 267 students from 2008 to 2009 indicating that during the first year of intervention, 267 more students earned qualifying scores on AP science exams compared to the previous year. Comparing 2008 to the last year of the intervention, 774 more students earned qualifying scores in AP science exams. During the three years prior to intervention, 1556 students earned a score of 3,4, or 5 on an AP science exam. During the three years during the intervention, 3256 students earned a qualifying score of 3, 4, or 5.

A general linear model of repeated measures showed that the APTIP intervention was significant in test between subject effects (.000) in increasing performance (number of qualifying scores) of AP Science exams. Each of the schools performance scores were added for quantity and the number was divided by their average daily membership (ADM) to equate for school size with the means and standard deviations shown in Table 9.

Table 9

Mean and Standard Deviation (sd) of APTIP Qualifying Scores

	2006	2007	2008	2009	2010	2011
Mean	.011	.015	.014	.019	.028	.034
SD	.017	.031	.029	.031	.048	.073

With no grouping variable, this data are representative of an annual assessment at the same 39 schools over the six years of the study. A Repeated Measures ANOVA was used to analyze the data. Within subject factor was years, which is considered to be the trials factor with 6 levels (2006-2011). The data revealed that covariances and variances were proportional within groups of baseline and test years, but there was substantial change in both across the 3-year intervals. This violated the assumption of sphericity (Mauchly's Test Chi-Square = 340.854  $p < .000$ ). Due to the violation of sphericity, results are reported using the Huynh-Feldt technique. The analysis revealed a statistically significant effect for Year ( $F(1.155, 43.880 \text{ df.}) = 7.082, p < .008$ ). The means indicated a

statistically significant increase in the number of students receiving a qualifying score of 3, 4, or 5 during the APTIP across the 3-year period. Means adjusted by Average Daily Membership of school (ADM) are reported in Table 9. Table 10 shows an analysis of the nature of change across the study years indicated a linear trend ( $F(1/38)= 8.298, p<.006$ ).

Table 10

*Repeated Measures ANOVA for APTIP Qualifying Score Performance by Year*

Source	SS	df	MS	F
Year	.016	1.155	.014	7.082
Error	.084	43.880	.002	

**AP Science Female Test Takers**

Are more females students taking AP science exams in schools that participate in the NMSI APTIP program then prior to the intervention? Female test takers in the 39 APTIP schools are reported in Table 12. Since the study data includes 12,322 cases, females represented 54% of the AP Science test takers in the APTIP schools. The Global data for all females who took the four AP science exams is shown in Table 11. Table 12 shows females by course and year over the years of the study in the 39 APTIP schools. The most significant gain for females would be in AP Physics-B and AP Environmental Science. AP Physics-B is a traditionally a male dominated course.

Table 11

Global College Board AP Science Female Test Takers by Year

	2006	2007	2008	2009	2010	2011	Total
Biology	75,080	82,298	88,736	90,879	97,096	104,155	538,262
Chemistry	39,685	43,858	45,520	46,641	51,578	54,724	282,006
Environmental	24,844	29,029	33,916	40,809	47,530	53,827	229,955
Physics-B	17,330	18,436	19,261	20,878	22,353	24,726	122,984
<b>Total</b>	<b>156,939</b>	<b>173,621</b>	<b>187,433</b>	<b>199,225</b>	<b>218,557</b>	<b>237,432</b>	<b>1,173,207</b>

Table 12

Female Test Takers in 39 APTIP for AP Science by Year (n=12,322)

	2006	2007	2008	Total Before	2009	2010	2011	Total During
Biology	288	312	379	979	542	683	657	1,882
Chemistry	165	197	219	581	345	392	400	1,137
Environmental	59	62	89	210	180	409	562	1,151
Physics-B	65	73	76	214	134	192	202	528
<b>Total</b>	<b>577</b>	<b>644</b>	<b>763</b>	<b>1,984</b>	<b>1,201</b>	<b>1,676</b>	<b>1,821</b>	<b>4,698</b>



A general linear model of repeated measures showed that the APTIP intervention was significant in test between subjects' effects (.000) increasing the number of female AP Science test takers. Test takers in each school were summed and divided by their schools' average daily membership (ADM) to equate for school size. The Sum of Squares and Cross Products (SSCP) matrix showed significance for the hypothesis. Multivariate tests including Pillai's Trace, Wilks Lambda, Hotelling's Trace, and Roy's Largest Root all showed a significance of .000, which indicates that any of those statistics could have been selected if needed. A Tukey (HSD) was performed to look for Type III error using the formula  $Q$  times the square root of the mean sum of squares divided by  $N$  (39). The critical value for  $Q$  (4.07) was obtained from the Studentized Range Tables for the number of groups being compared (6 years) and the degrees of freedom for the error term, which had an alpha of .05. Table 13 shows the means of female test takers

Table 13

Mean and Standard Deviation (sd) of Female Test Takers After Equated by ADM (n=39)

	2006	2007	2008	2009	2010	2011
Mean	.014	.016	.018	.028	.042	.045
SD	.014	.020	.024	.031	.056	.062

The data are representative of an annual assessment at the same 39 schools over a six-year period with no grouping variable. A Repeated Measures ANOVA was used to analyze the data. Within subject factor was female test takers by Year, which is considered to be the trials factor with 6 levels. The data revealed that covariances and

variances were proportional within groups of baseline and test years, but there was substantial change in both across the 3-year intervals as shown in Table 13. This violated the assumption of sphericity (Mauchly's Test Chi-squared= 281.520 p<. 000). Due to the violation of sphericity, results are reported using the Huynh-Feldt technique in Table 14. The analysis revealed a significant effect for female test takers by Year (F 1.229, 46.694 df.)= 13.595, p<. 000). The means indicated a significant increase in the number of students taking an AP science test in science across the 3-year period.

Table 14

*Repeated Measures ANOVA for Female Test Takers by Year (n=39)*

Source	SS	df	MS	F
Year	.035	1.229	.029	13.595
Error	.099	46.694	.002	

### **African American Student Test Takers**

Are more African American students taking AP science exams in schools that participate in the NMSI APTIP program then prior to the intervention? The data from the APTIP in Table 11 suggest an obvious increase in African American student test takers during the APTIP intervention in all subjects. AP Environmental Science had the lowest African American student enrollment of 38 students in the three years before the intervention. During the intervention, African American enrollment increased in AP Environmental Science to 320 students; a 742 % increase in African American students.

During the intervention, AP Physics-B had the lowest African American student test takers at 191 students.

Table 15

Global College Board AP Science African American Test Takers (n=2,289,925)

	2006	2007	2008	2009	2010	2011	Total
Biology	7,018	8,023	8,995	9,943	11,041	12,047	57,067
Chemistry	3,682	4,202	4,478	4,980	5,622	6,041	29,005
Environmental	2,591	2,980	3,848	4,461	5,837	7,348	27,065
Physics-B	1,797	2,048	2,107	2,608	2,801	3,252	14,613
Total	15,088	17,253	19,428	21,992	25,301	28,688	127,750

All African American students who took an AP Science Biology, Chemistry, Environmental Science, or AP Physics-B is shown in Table 15. The proportion of African American test takers to all test takers is 0.06 meaning that African American student test takers represent 6% of the total test taker population in those AP science courses.

African American student test takers in the 39 APTIP schools for the six years of the study are shown in Table 16. As shown in Table 16, African American students represent 13% of the test taker population in APTIP schools.

Table 16

Data for African American Test Takers at APTIP Schools (n=12,322)

	2006	2007	2008	Total Before	2009	2010	2011	Total During
Biology	62	80	97	239	133	142	174	449
Chemistry	37	42	45	124	70	84	95	249
Environmental	22	8	8	38	43	124	153	320
Physics-B	20	20	7	47	44	58	89	191
Total	141	150	147	438	290	408	511	1,209

Table 17 shows the adjusted African American student test takers when adjusted with Average Daily Membership by school size for means and standard deviations over the six-year period. The division of the test takers by the ADM is a limitation of the data in Table 17 and 18 since I do not have the demographic data on each school and the number of African American students in each school. Thus, the data in those tables may be skewed. During the APTIP, African American test takers increased from 2009-2011.

Table 17

Mean and Standard Deviation (sd) of African American Test Takers by Year

	2006	2007	2008	2009	2010	2011
Mean	.004	.004	.005	.007	.012	.014
SD	.008	.009	.011	.014	.033	.032

A Repeated Measures ANOVA was used to analyze the data. Within subject factor was Year, which is considered to be the trials factor with 6 levels. The data revealed that covariances and variances were proportional within groups of baseline and test years, but there was substantial change in both across the 3-year intervals. This violated the assumption of sphericity (Mauchly's Test Chi-squared= 307.880 p<. 000). Due to the violation of sphericity, results are reported using the Huynh-Feldt technique. The analysis revealed a significant effect for Year (F (1.209, 45.950 df.)= 13.870, p<. 000). The means indicated a significant increase in the number of African American students taking an AP science test in science across the 3-year period. Results are reported in Table 17

Table 18

*Repeated Measures ANOVA for African American Test Takers by Year*

Source	SS	df	MS	F
Year	.004	1.118	.003	4.456
Error	.032	42.487	.001	

**Females Earning Qualifying Scores (3 or >) on AP Science Exams**

The test taker increase is not surprising given the amount of incentive and support the APTIP provides, but what do the scores look like in the APTIP schools when the

College Board releases them in July. Table 19 shows qualifying scores for all females who took the four AP science exams between 2006-2011. Globally, more girls received qualifying scores in AP Biology than the other AP sciences with physics having the lowest number of qualifying scores for females over the six years.

Table 19  
Global College Board Female AP Science Qualifying Score (3, 4 & 5) (n= 1,237, 242)

	2006	2007	2008	2009	2010	2011	Total
Biology	42,315	46,093	40,378	41,803	42,523	47,430	260,542
Chemistry	20,105	21,437	21,871	21,984	24,338	25,676	135,411
Environmental	11,157	13,097	16,340	17,612	20,798	23,394	102,398
Physics-B	8,887	9,247	9,658	10,563	10,751	12,573	61,679
Total	82,464	89,874	88,247	91,962	98,410	109,073	560,030

Females experienced a steady increase in qualifying scores during the APTIP as indicated in Table 20. Female scores in AP Physics tripled from 20 qualifying scores in 2006 to 61 qualifying scores in 2011. AP Chemistry more than doubled from 2006 to 2011. AP Environmental Science showed the largest increase from 31 female qualifying scores in 2006 to 201 qualifying scores in 2011. However, the AP Environmental Science exam is growing at a faster rate than the other AP sciences.

Table 20

*Number of Female Qualifying Scores in 39 APTIP schools (n=4812)*

	2006	2007	2008	2009	2010	2011	Total
Biology	123	145	122	147	179	189	905
Chemistry	55	77	77	106	136	146	597
Environmental	31	24	38	64	152	201	510
Physics-B	20	20	18	49	75	61	243
Total	229	266	255	366	542	597	2255

The data in Table 21 represents an annual assessment at the same 39 schools over a six-year period with no grouping variable. A Repeated Measures ANOVA was used to analyze the data as shown in Table 22. Means and Standard deviations are reported in Table 21. Within subject factor was Qualifying Scores for females, which is considered to be the trials factor with 6 levels. The data revealed that covariances and variances were proportional within groups of baseline and test years. Sphericity was violated (Mauchly's Test Chi-squared= 272.872  $p < .001$ ). Due to the violation of sphericity, results are reported using the Huynh-Feldt technique. The analysis revealed a significant effect for Year ( $F(1.250, 47.492 \text{ df}) = 5.985, p < .013$ ). Means indicated a statistically significant increase in the number of female students earning a qualifying score on an AP science exam during the APTIP.

Table 21

*Mean and Standard Deviation (sd) of Females Earning a Qualifying Score*

	2006	2007	2008	2009	2010	2011
Mean	.005	.007	.006	.009	.013	.015
SD	.009	.017	.016	.015	.023	.036

Table 22

*ANOVA for Female Qualifying Scores*

Source	SS	df	MS	F
Qualifying Scores	.003	1.250	.002	5.985
Error	.020	47.492	.000	

**African American Students Earning Qualifying Scores on an AP Science Exams**

The last component of the final research question evaluated the change of the APTIP schools' qualifying scores for African American students. African American students saw an increase during the APTIP, but the sample of scores is so low, that I will present data and no statistical analysis



Table 23

*Global College Board AP Science African American Qualifying Scores (n=1,237,242)*

	2006	2007	2008	2009	2010	2011	Total
Biology	2,013	2,349	1,902	2,031	2,129	2,502	12,926
Chemistry	1,010	1,038	1,008	1,205	1,274	1,280	6,815
Environmental	481	613	778	847	1,009	1,324	5,052
Physics-B	524	497	599	648	694	804	3,766
<b>Total</b>	<b>4,028</b>	<b>4,497</b>	<b>4,287</b>	<b>4,731</b>	<b>5,106</b>	<b>5,910</b>	<b>28,559</b>

African American students qualifying scores AP Science exams showed mix results in the first year of the intervention with AP Biology decreasing from 26 to 14, but the other three AP contents saw increases throughout the APTIP intervention as shown in

Table 24.

*Number of African Americans earning Qualifying Scores on AP Science Exams in APTIP Schools (n=1,209)*

	2006	2007	2008	2009	2010	2011	Total
Biology	16	27	26	14	24	50	157
Chemistry	6	12	5	17	24	26	90
Environmental	1	2	0	3	23	24	53
Physics-B	2	3	2	9	8	16	4
<b>Total</b>	<b>25</b>	<b>44</b>	<b>33</b>	<b>43</b>	<b>79</b>	<b>116</b>	<b>340</b>

Table 24 reports the data on African American students' qualifying scores, but the numbers are so small during the years pre-intervention that I doubt they are helpful in inferring any statistical information about the APTIP. African American students' qualifying scores fluctuated during the grant by gender, with African American females overall showing an increase of qualifying scores over males in the six years of data that was studied.

Figure 3

African American Students Qualifying Scores by Gender

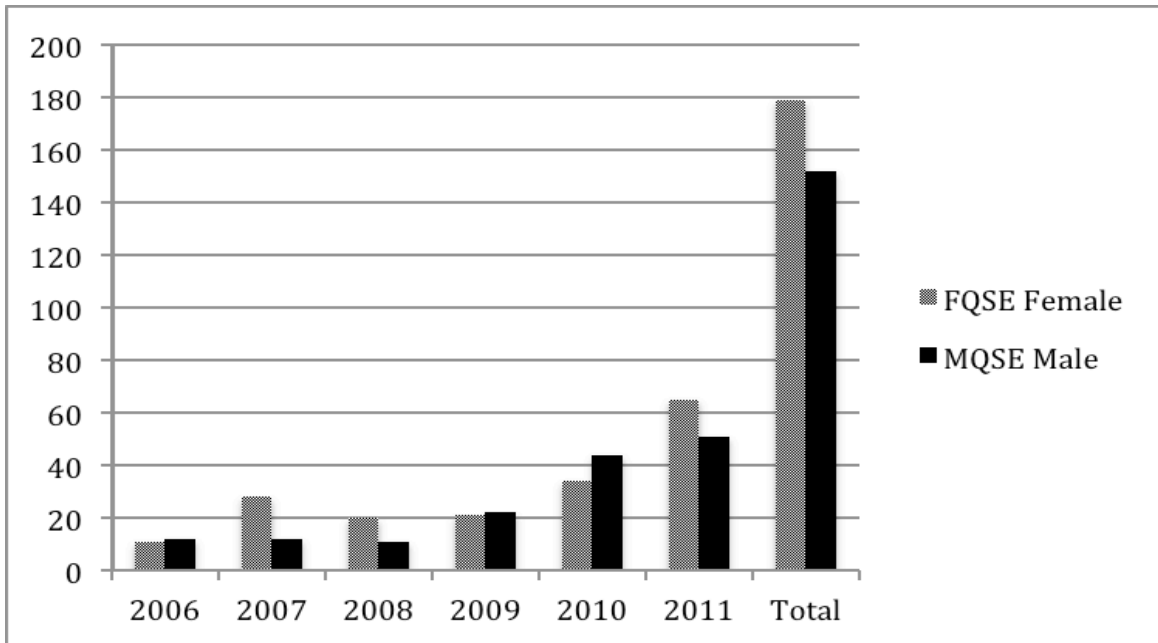


Table 25

*Mean and Standard Deviation (sd) of African American Qualifying Scores*

	2006	2007	2008	2009	2010	2011
Mean	.0007	.0015	.0013	.0012	.0028	.0004
SD	.0030	.0060	.0060	.0040	.0100	.0140

The small numbers of African American qualifying scores in AP science exams makes the statistical analysis questionable. However, comparisons can be made between the APTIP schools for African American students and Table 25 that clearly articulates that the gap is improving for all AP exams, but at a slow rate.

Data can be evaluated under various criteria. AP scores have historically been evaluated by course means or pass rates, which is the proportion of qualifying scores to the number of test takers. Both of these evaluation methods have reported lower numbers of students enrolling in these courses and/or taking the exam since schools and teachers have been evaluated under these criteria. While those two measures are not within the spectrum of this study, they are arguably performance measures that would be controversial in evaluating a program.

For the sake of presenting a complete picture of what occurred in the 39 schools in this study Table 26 shows the total number of test takers, the number of qualifying scores, means and pass rates. Pass rates for pre-intervention years 2006, 2007, 2008 are 0.43, 0.45, 0.38 respectively while pass rates during the intervention years 2009, 2010, 2011 were 0.37, 0.37, and 0.39, respectively. AP science means for the pre-intervention

years were 2.43, 2.45, and 2.24 while means during the intervention were 2.17, 2.19, and 2.30 as shown in Table 22. The relevance of which measure is most effective for evaluating the quality of a successful Advanced Placement program is controversial and philosophically divided within the educational community.

Table 26

Qualifying Scores with Means and Pass Rate in the 39 APTIP Schools

Year	Number of Test Takers	Number of Qualifying Scores	Mean	Pass Rate
2006	1,071	465	2.43	0.43
2007	1,232	551	2.45	0.45
2008	1,414	540	2.24	0.38
Total Before APTIP	3,717	1,556		
2009	2,195	807	2.17	0.37
2010	3,034	1,135	2.19	0.37
2011	3,376	1,314	2.30	0.39
Total During APTIP	8,605	3,256		

## CHAPTER 5

### DISCUSSIONS, CONCLUSIONS, & RECOMMENDATIONS

#### **Discussion**

The first research question was did participation in the APTIP increase AP science test takers. Data supported that the APTIP did increase the number of students taking an AP science exam in the four content areas, AP Biology, AP Chemistry, AP Environmental Science, and AP Physics-B, evaluated in the study. Table 3 clearly shows that prior to the APTIP intervention, the schools in the study were slowly increasing AP science test takers, but during the first year of intervention, the number of test takers was statistically significant and clearly had a larger slope shown in Figure 1, indicative of a larger rate of growth.

The second research question looked at the number of qualifying scores on AP science exams during the APTIP. More students received qualifying scores during the

APTIP. In the three years prior to the intervention, a total of 1,556 qualifying scores were earned in the 39 schools. During the APTIP, 3,256 students earned qualifying scores. The APTIP intervention doubled the number of qualifying scores on AP science exams in the 39 schools. The 39 schools represent six states and according to the US Department of Education's classification system the following demographics: 10 city, 8 rural, 9 suburban, and 12 town schools. One of the first goals of increasing the pipeline would be to have more students in the Advanced Placement classes. The APTIP's data supports that increasing enrollment and including a larger spectrum of students within AP science classes in a school could be successful.

Removing barriers to enrollment was the first step in increasing access to more rigorous courses for all students. Table 25 clearly shows that increasing the number of test takers and qualifying scores did not dilute the class since the proportion of qualifying scores to test takers was nearly unchanged between 2008, the year prior to the intervention, and during the APTIP intervention (2009, 2010, 2011). In the three years prior to the APTIP, the 39 schools had 3,717 test takers and 1,556 qualifying scores. During the APTIP, the 39 schools had 8,605 and 3,256 APTIP. 1,700 additional students received qualifying scores during the APTIP. The APTIP, exposed 8605 students to an AP science class and exam, which can in and of itself have its own benefits (Morgan and Klaric, 2007; Klopfenstein and Thomas, 2006).

Over the entire six years of the study, College Board AP science exams saw an increase in test takers, but the extent of the increase in terms of percent change in the APTIP schools was higher even though the study data represent a small portion of the

national numbers as shown in Table 27. In the first year of the intervention, the 2009 testing period, the percent change in test takers was over seven times higher in schools participating in the APTIP schools (0.55) compared to National College Board data (0.07). While the sample size used in this study is small, it does support that the APTIP may be one way to increase AP science test takers, a proposed gateway to widening the STEM pipeline for better prepared students post K-12.

Table 27

Percent Change Between Years of AP Science Test Takers Before and After Intervention

	2006/07	2007/08	2008/09 Year 1	2009/10 Year 2	2010/11 Year 3
National	0.11	0.07	0.07	0.10	0.09
APTIP Schools	0.15	0.15	0.55	0.38	0.11

\*Excludes AP Physics-C mechanics and AP Physics-C Electricity & Magnetism

In 2011, year three of the APTIP in cohort I schools, the mean increased to 0.39. While the means and pass rates did go down from a high of 2.45 pre-APTIP to a low of 2.17 during the first year of the APTIP, the number of students earning a qualifying score was 3 times higher when comparing 2006 scores to 2011 scores. The APTIP provides professional development to teachers and administrators in the schools, which might suggest a rebound in the mean in the third year of the intervention to 2.30 (Table 26) after teachers received three years of professional development, training, and support. More significantly, women tripled the number of qualifying scores in physics, doubled in

chemistry and sextupled in environmental science. African Americans receiving qualifying scores on an AP science exams doubled (2.33) going from 102 qualifying scores on AP science exams in the three years prior to the APTIP to 238 during the APTIP as shown in Table 24. So although the means went down, the actual number of students taking the test and earning qualifying scores increased. This is the most significant point of the study. If you want to increase equity, you must increase access.

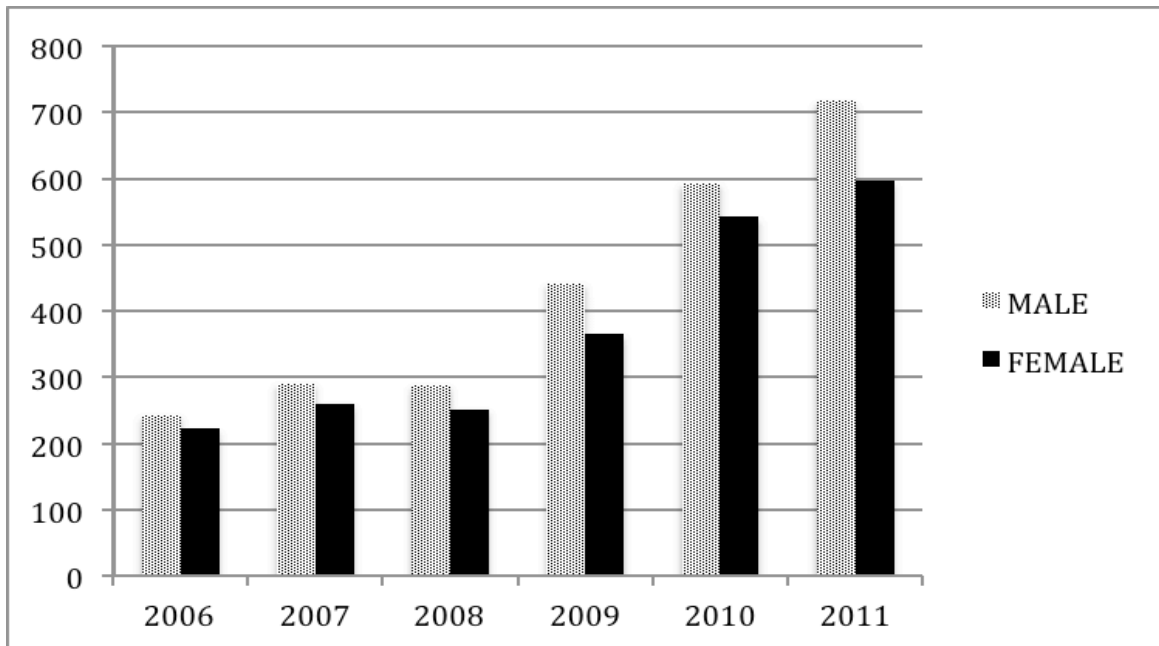
How we measure success is subjective. Does being placed in a low math class in 6<sup>th</sup> or 7<sup>th</sup> grade dictate the remainder of your math exposure? Are AP options discussed with all students? We have led our communities to believe that performing well on the state end of course assessments is indicative of content mastery and this has led to a misconception that we must repair in our schools and in our communities. Students exiting the K-12 environment with perfect scores on state assessed courses are not prepared for post-secondary courses in STEM fields. While state standards may be evaluated as high, state assessments do not necessarily reflect the rigorous skills and preparation needed by students to compete in college in STEM fields. Change the Equation (2011) ranks Virginia's end of course science assessment as the lowest while a Fordham study (Lerner et al, 2012) ranked the end of course science standards as an A-. Standards are high, but the assessment evaluating those standards is of a low quality.

While females represented 54% of the AP science test takers in the 39 APTIP schools, males represented 54 % of the qualifying scores. In all six years before and during the APTIP, males earned a higher number of qualifying scores overall than females and this discrepancy increased during the APTIP.



Figure 4

AP Science Qualifying Scores in 39 APTIP Schools by Gender



African American students showed a fluctuating disparity between males and females as seen in Figure 3 in Chapter 4 where females and males in 2011 showed the largest disparity with males earning 51 qualifying scores on AP science exams and females earning 65 qualifying scores on AP science exams. These results should be viewed with some skepticism since the sample size is so small over the six-year period with African American students earning a total of 331 during six testing years in the 39 APTIP schools, 94 qualifying scores during the three years prior to the intervention and 237 qualifying scores during the APTIP intervention.

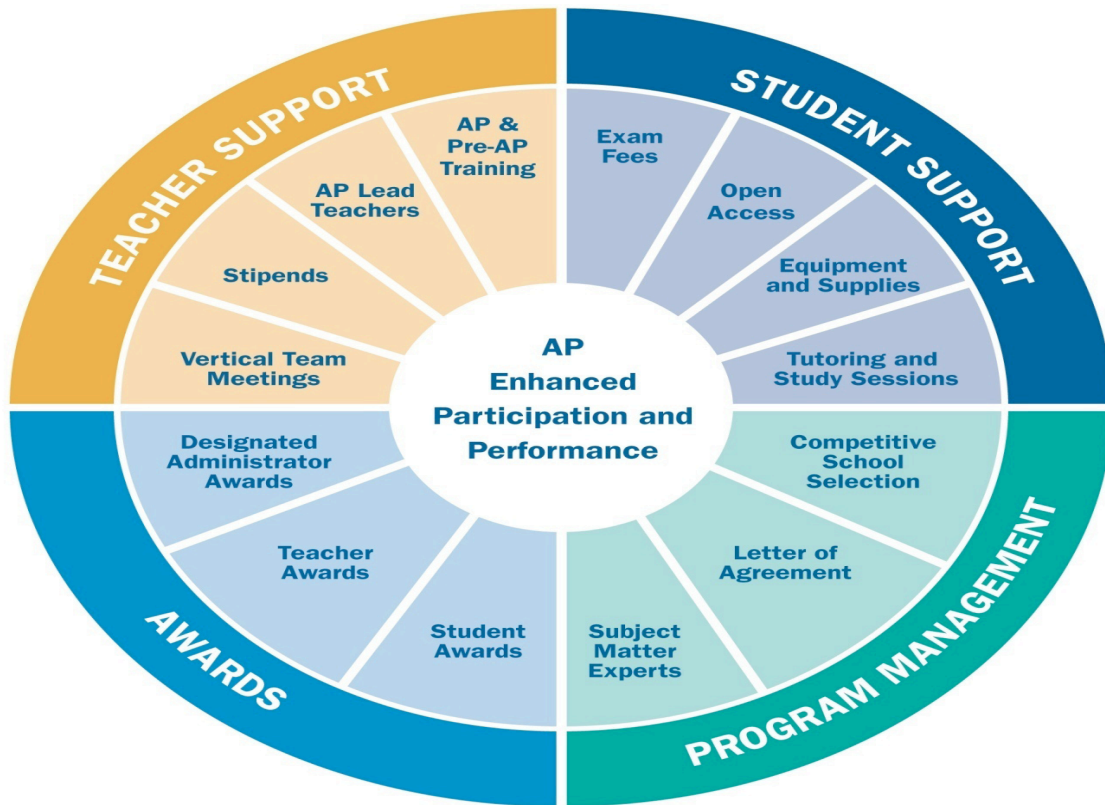
## Limitations

Not all AP science courses are offered at all 39 schools. This data shows programs that may or may not have been started during the first year of the APTIP. Schools apply to the APTIP in their states and undergo an interview process with the non-profit organizations in their states. Thus, in a sense the schools in this study self-select into this program. Although, the decision in the school that applies for the grant may or may not be unanimous, thus not all teachers are necessarily self-selecting into the APTIP.

The full spectrum of the APTIP contains multiple components as shown in Figure 5. The multiple components of the program make it difficult to isolate which variables have the greatest impact and even those variables may vary from school to school. The program includes student and teacher support as well as program management that is data focused as well as awards for students, teachers, and administrators. Which specific variables in the program have the greatest impact would need to be studied further to ascertain the impact of each variable on student success. As the five-year program ends, there is no transition plan. The grant seeks to change school culture for sustainability to focus on more students taking higher -level classes with a form of accountability that could be measured. If the school culture is changed, then the sustainability of some of the components can easily be retained without NMSI or the state organization's support.

Figure 5

Elements of the Advanced Placement Training and Incentive Program



\*Wheel developed by Massachusetts Math + Science Initiative used with permission

Cohort I encompassed a variety of demographic schools which included: 10 city, 8 rural, 9 suburban, and 12 town schools and thus should be indicative of a good cross sampling, but not all schools in cohort I met with the same success for a variety of reasons. School counseling, administration, and division policy greatly impact the actual implementation of the APTIP, so it was not as standardized across buildings as it would appear and further qualitative studies would be needed to ascertain the variables that most

impact the success of the program. Elective courses were negatively impacted as students choose AP science classes as electives, oftentimes doubling up on science. This created faculty and administrative discord in some buildings.

As more schools are added each year to the program, the programs growth may be a variable that affects the data. Individual teachers and their abilities is also a factor that greatly impacts the success of any classroom, so that is an area that was not controlled for in this study. Administrative and division focus was a variable that was not controlled for in this study and many programs conflicted with the APTIP and the APTIP did not always merit the support of the administration.

### **Recommendations**

To increase access and equity in the AP program, state and federal entities must offer and continue to offer opportunities for students to increase involvement in AP programs through fee subsidies and AP professional training for teachers. The data suggest that the STEM pipeline can be increased by working with more students instead of focusing on the high achieving and the low achieving academically students as well as low socio-economic status. More research would be needed to break the into subsets to look at students who were achieving academic results, but did not have access to AP courses due to limits such as pre-requisite course, previous grades, and motivation. The ultimate goal or success of this grant will be if students major in a science, technology, engineering, or math fields in college or enter a STEM field upon graduation.

, so to increase the pipeline for all students the middle students must be moved.

Schools should be able to apply some components of this grant to increase test takers as

well as qualifying scores. Some states have legislated AP courses. Minnesota supports AP and IB teacher training throughout the school year by financing program costs, teacher training, and substitute teachers (Zinth & Dounay, 2006). Arkansas has the most comprehensive AP support program with AP courses in math, science, English, and social studies. These courses are required to be offered in every school with additional AP courses phased in each year. Some fiscal support for these state programs is available, including exam fees, professional development, and other monetary incentives (USDOE, 2006; Zinth & Dounay, 2006). These incentives are being used in school systems to persuade students to take more rigorous courses and enrollments are increasing (Hoff, 2004).

Klopfenstein (2004) concludes that research is warranted to determine the effect of increased money available for AP at the local, state, and federal level as well as grants, which support AP on equity and access for underrepresented populations. She hypothesizes that subsidies for the exam fee are not the barrier for underrepresented populations and cites the lack of preparation as the barrier that keeps these students from enrolling in AP classes and taking the exam once enrolled and completing the course.

This study sought to evaluate the quantity of students earning a qualifying score (score of 3, 4, or 5) as the measure of performance. One of the purposes of the APTIP is to increase the spectrum of students taking AP science exams. Students who were not previously served in AP science classes were actively recruited to enroll in these classes. In many schools, pre-requisite courses were eliminated and sequencing and program changes were implemented that increased the pipeline of students in classes that would

have previously not been available to them. The quantity of test takers earning a 3, 4, or 5 is referred to as a passing score for the sake of this discussions as many colleges and universities award credit to students with scores of 3,4, or 5. Since the research questions were interested in the number of students obtaining a qualifying score and not the pass rate (proportion of passing scores (3,4,or 5) to number of test takers).

As seen in Table 22, more students received qualifying scores in schools with the APTIP, but the means did go down. How should an AP program be evaluated? For the 4888 test takers during the APTIP did being in the class make a difference or increase their skill set? Did having access to a more rigorous class positively impact these students regardless of their score? Did the difference between the 3,256 students receiving a 3,4, or 5 during the APTIP compared to the 1,556 students before the APTIP program make the program for successful? For the additional 1,700 students who earned qualifying scores in AP science during the APTIP, it made a difference for them.

## **Conclusions**

Many schools did not offer AP science courses prior to the APTIP or had years in the pre-intervention where AP science courses were not offered in the school. This suggests an added benefit of the APTIP, which would be to increase the rigor in schools where state standards are the sole measurement of student success. Not to be discounted, the accountability of students sitting for an AP science exam suggests a higher bar that will ultimately prepare more students for STEM fields as well as offer more students the opportunity to be in more rigorous classes. Dual enrollment offers an alternative to AP, but there is no accountability and the courses are not standardized among community

colleges, so lack of consistency exist when evaluating a school's dual enrollment program. In addition, resources, training, and equipment are also lacking in dual enrollment programs.

The APTIP is funded solely by business and in the current economy the likelihood of continued business support might be problematic. Also in a challenging economy, this program requires administrative creativeness in scheduling and negatively impacts electives as students choose more rigorous coursing in math and science as electives as opposed to other electives traditionally available in the school. It will require administrative support with a focus on curriculum as the main focus instead of competing issues in the building. The original model in Texas continues with some components of the program, but no transition program was developed. The idea being that the schools will embrace the grant and continue with some elements as part of their revised AP going culture established through the APTIP. This study supports the premise that the Advanced Placement Training and Incentive Program does increase test takers and qualifying scores on AP science exams. The study supported that females and African American students enrolled in more AP science courses and earned more qualifying scores on those exams prior to the APTIP.

In order to widen the STEM pipeline, we must look to educate more students. The first step is allowing more students to access rigorous courses like Advanced Placement science courses in order to have the skills and exposure to STEM content.

### **Recommendations for further research**

Matched data from similar demographic schools would be ideal in looking at the change within a building. A study that is able to follow the data on students who participated in the APTIP post high school would further substantiate that the program is widening the pipeline. Currently cohorts 2,3, and 4 are now part of the APTIP, so additional study of the data would be suggested on additional cohorts and on the last two years of data from Cohort I. Looking at attitudes of females and African American students enrolled in AP science classes as well as females and African American students who choose not to enroll in AP science classes would also be an area of great interest in terms of why females and African American students are not participating in AP science classes. Studying the administrative or counseling philosophies in schools with high success of underrepresented test takers in AP science courses would also be an area that could contribute to better understanding the gap. Looking at how students are placed into AP classes would be an area for further study. What other factors are used to place students into AP science courses? This differs by schools and divisions, so further study of placement practices would be an area that would need additional study. Teacher studies would also be an area of further study since perhaps teaching pedagogy looks different for minorities and females.



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## VITA

Susan Elizabeth Brady Ramsey was born in Charleston, South Carolina in 1971. She is endorsed and has taught earth science, biology, and physics at all levels ranging from collaborative classes to advanced placement classes. She was the department chair of science at Deep Run High School from 2002-2006. Susan was instrumental in the development of the AP science program at Deep Run High School.

Susan served as one of eight Coordinators of Assessment and Remediation in Henrico County where she worked to develop remediation and reinforcement programs for students to prepare for state and national testing platforms. She served as the AP Coordinator at Deep Run High School and worked with the faculty to use formative and summative data to drive instruction in their classrooms and develop remediation programs based on deficits found in the assessment data.

In 2006, Susan was awarded National Board Certification in Science for Adolescence and Young Adults. She holds a Masters degree in Curriculum and Instruction in secondary science from Virginia Commonwealth University and a Masters degree in Physics Education from the University of Virginia.

Susan has presented at local, state, and national conferences in science. She is a huge proponent of informed instruction and has extensive knowledge in using data to drive instruction. She is currently the Director of Science for Virginia Advanced Study Strategies a National Math Science Initiative affiliated organization and a consultant for Laying the Foundation.