Outcomes-Based Evaluation of the AP Training and Incentives Program

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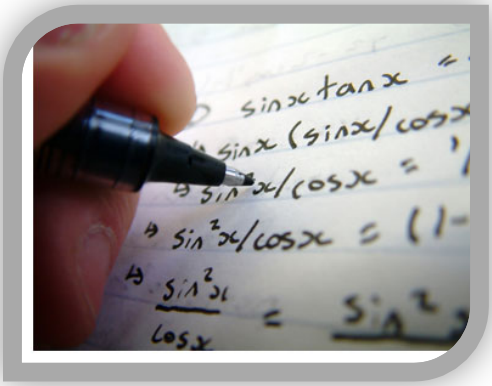
Executive Summary



Our report evaluates the Advanced Placement Training and Incentives Program (APTIP) currently in place in 65 Virginia high schools. These schools received grants provided by Virginia Advanced Study Strategies (VASS), an educational non-profit seeking to raise student participation and achievement in Virginia high school AP programs in English, Math, and Science. This report examines the effects of program participation on student achievement. The evaluation analyzes two levels of outcomes: individual student AP exam scores as well as aggregate school-level variables from 2007-2011. Our analysis shows that since implementation, the number of students taking AP courses has increased, as well as the raw number of qualifying scores. Demographic data indicate that for each year of program participation AP student demographics become more reflective of the racial demographics within the school. We also provide specific suggestions for a more robust evaluation scheme and suggestions for program improvement.

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Introduction

In today's increasingly diverse global market, the United States must be vigilant in assuring our workforce remains competitive and our students graduate from high school prepared to tackle rigorous college coursework and a technology-driven economy. The STEM subjects— science, technology, engineering, and math— are crucial for American innovation.

In order for the United States to remain a powerful and influential nation, American students must be proficient in STEM subjects. However, in the most recent round of international benchmarking examinations of 31 industrialized nations, students from the United States placed 17th in science and 25th in mathematics.[1] We must do more to ensure our students can perform at or above international averages to guarantee the continued economic prosperity of our country.

To prepare students for a science- and technologically-driven job market, students need foundational critical thinking skills and access to rigorous coursework. STEM careers require that students take advanced level science and math courses in postsecondary institutions. This is especially true in Virginia. Recent research estimates that Virginia's demand for STEM jobs is increasing at a higher rate than any other state in the nation— by 2018, the demand for a STEM-trained workforce will increase 17 percent to over 374,000 STEM jobs, 93 percent of which require postsecondary training and education.[2] In Virginia in particular it is crucial to ensure that students graduate high school prepared to take on rigorous coursework in postsecondary institutions in order to prepare them for the increasingly STEM-focused job market they will enter upon graduation.

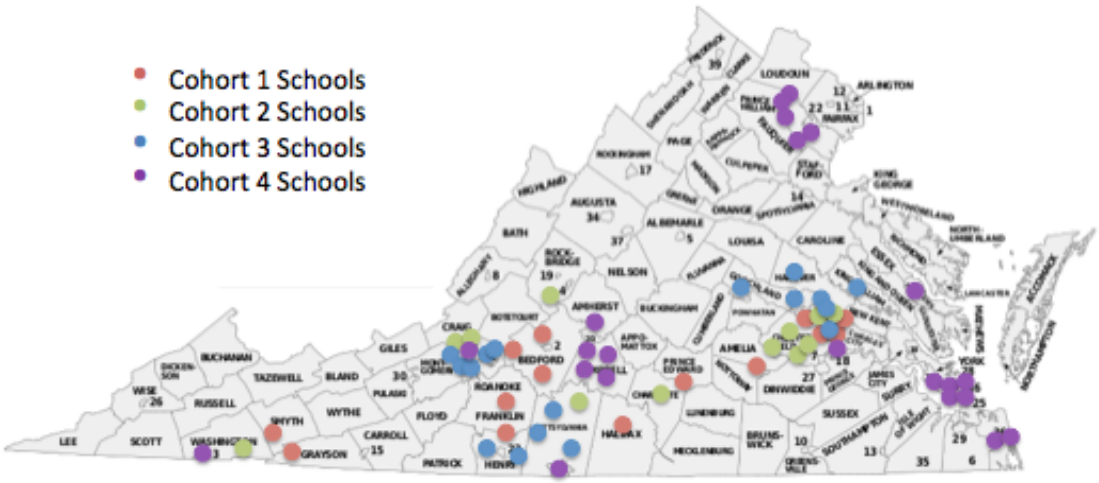
Virginia Advanced Study Strategies & APTIP

Virginia Advanced Study Strategies (VASS), a non-profit organization formed in 2007 in partnership between the state of Virginia and the National Math and Science Initiative (NMSI), strives to increase enrollment and rigor in high school STEM Advanced Placement (AP®) courses. Their stated goal is:

> To encourage high school students throughout the Commonwealth to prepare for exciting careers in math and science by enrolling in challenging Advanced Placement classes. Businesses throughout the nation are very concerned to find that too few students in the United States are accepting the challenge to become scientists, engineers, and technicians, thus putting our nation's position as an international leader at risk. Using seed money from NMSI and several Virginia businesses, Virginia Advanced Study Strategies supports the development of new AP classes and strengthening of existing programs.[3]

The Advanced Placement Training and Incentive Program (APTIP) as implemented through VASS in select Virginia high schools consists of three prongs:

1. Advanced teacher training in curriculum, instruction, and assessment to help prepare for AP classes and exams. Intensive training each summer is followed-up by communication and support throughout the school year.
2. Cash incentives of $100 per qualifying score (a score of a 3, 4, or 5) on the AP exams for students and their teachers, plus a cash bonus for teachers and administrators for meeting benchmark goals.
3. Provision of resources and materials necessary for AP classrooms.



The first cohort selected to participate in the APTIP program consisted of 13 high schools. They began receiving VASS funds for the 2008-09 school year and are now in the fourth year of their five year grant. Most of the schools selected for participation the first year had historically low AP course offerings and participation rates, are of lower socioeconomic status, and are in rural areas.

There have been three subsequent cohorts, each receiving the five-year grant and beginning the work of increasing AP enrollment and achievement for Virginia students. VASS now works with 65 Virginia high schools.

VASS supports AP courses and exams in English, Math, and Science (hereafter referred to as AP courses)—math and science to support the goal of increased proficiency of Virginia students in STEM subjects, and English to bolster the critical thinking and problem-solving skills required for advanced college coursework.

Math	Science	English
•Calculus AB •Calculus BC •Statistics	•Biology •Chemistry •Computer Science •Environmental Science •Physics B •Physics C: Electricity & Magnetism •Physics C: Mechanics	•English Language & Composition •English Literature & Composition

Is VASS Meeting Its Goals?

In the fall of 2011, VASS commissioned a team of graduate student researchers from The College of William & Mary's Thomas Jefferson Program in Public Policy to conduct an analysis of various aspects of student outcomes in program schools to determine the magnitude of the program's impact.

Our charge is threefold. One component of the project attempts to assess the short-term impact APTIP has on student participation and performance in AP testing. The second component examines the long-term impact after students leave high school and enter college. However, due to data constraints, we rely heavily on the available literature for our analysis of how AP prepares students for success in higher education and beyond. The last component is the development of a more robust evaluation scheme for VASS to implement for improved analysis in the future. To assess short-term impacts on students in program schools we developed the following set of guiding research questions:

Program Goal: Increase Enrollment in AP Courses

- Does participation in APTIP increase the percent of students enrolled in AP courses?
- Which AP tests do students take in program schools?
- Have the demographics of students taking AP courses changed since program implementation?
- Are more students taking multiple AP exams in program schools?

Program Goal: Raise the Number of Qualifying Scores on AP Exams

- Have the number of students earning qualifying scores in program schools increased since APTIP implementation?
- Has the distribution of scores shifted since implementation?
- What affects the likelihood of students earning qualifying scores on AP exams?

Program Goal: Improve Student Readiness for College

- How do AP students fare compared to their peers in college?
- What are the benefits in higher education of earning a qualifying AP score?

Data Description

The data for this project come from a number of sources. We obtained AP scores for individual exams and aggregated them into school-level variables. We tested outcomes on several indicators, including the number of students enrolling in and taking AP courses and exams as well as student AP scores. We adjusted several numbers to percentages of total students to control for school size.

We also controlled for population density of school districts using a ranked scale variable from the National Center of Education Statistics (NCES)— a one represents a rural location, farthest from urban centers, and a 12 represents a large city. We obtained controls for demographics from the Virginia Department of Education (VDOE) for the 2010-2011 school year and NCES for previous years. In order to control for the average socioeconomic status by school, we used the percent of students eligible for free or reduced lunch as a proxy. We obtained anonymized student AP scores from VASS for the past four school years.

Table 1a: Summary Statistics of Student Characteristics in Program Schools

	Average Total Students	Average % AP Students	% QS (3, 4, or 5)	% Free/ Reduced Lunch	AP Score Mean	Average # of Tests
Cohort 1						
2007-08	1201	5%	43%	34%	2.35	82
2008-09*	1192	13%	34%	37%	2.16	175
2009-10	1192	16%	34%	41%	2.17	236
2010-11	1164	19%	34%	40%	2.20	288
Cohort 2						
2007-08	1331	7%	36%	34%	2.17	120
2008-09	1275	6%	43%	35%	2.35	149
2009-10*	1341	13%	44%	39%	2.38	243
2010-11	1292	18%	42%	41%	2.34	330
Cohort 3						
2007-08	1034	4%	36%	28%	2.22	59
2008-09	1018	5%	33%	30%	2.07	68
2009-10	1007	7%	39%	36%	2.28	77
2010-11*	1001	12%	41%	34%	2.33	196
All Other VA High Schools						
2007-08	1212	6%	41%	30%	2.06	142
2008-09	1211	8%	43%	31%	2.26	152
2009-10	1214	7%	40%	35%	2.10	152
2010-11	1203	7%	42%	35%	2.13	162

Note: * = First Year of Program Implementation

Table 1a summarizes key indicators for each cohort as compared to all other Virginia high schools over the past four years. Program schools are comparable in size to other Virginia high schools, although cohort 3 schools are slightly smaller. Likewise, VASS schools are similar in terms of percent of students eligible for free or reduced price lunch. We see that the average percentage of AP students and the number of tests taken in all cohort schools far exceeds Virginia averages after program implementation. However, cohort 1 remains well below all other Virginia schools in the percent of qualifying scores; cohorts 2 and 3 are much closer to Virginia averages. VASS schools are also similar in terms of average AP scores on the spring exams.

Table 1b: Student Demographics in Program Schools and Virginia

	Average % White	Average % Black	Average % Asian	Average % Hispanic	Average % Other
Cohort 1					
2007-08	59%	38%	2%	1%	1%
2008-09	53%	43%	1%	1%	0%
2009-10	53%	43%	2%	2%	1%
2010-11	53%	42%	2%	2%	1%
Cohort 2					
2007-08	67%	26%	2%	3%	1%
2008-09	67%	27%	3%	3%	1%
2009-10	65%	27%	3%	4%	1%
2010-11	62%	27%	3%	5%	3%
Cohort 3					
2007-08	66%	29%	2%	2%	1%
2008-09	66%	31%	1%	2%	0%
2009-10	66%	30%	1%	2%	1%
2010-11	65%	28%	2%	2%	2%
Virginia Averages					
2007-08	63%	25%	4%	6%	2%
2008-09	58%	26%	6%	8%	2%
2009-10	58%	26%	6%	8%	2%
2010-11	56%	24%	6%	10%	4%

Table 1b shows the demographic breakdown in each cohort compared to Virginia averages. Cohort 2 and 3 schools tend to have larger proportions of white students than average Virginia schools. Similarly, all cohorts have a larger percent of African Americans than the average Virginia high school by differing degrees. This overrepresentation comes at the expense of Asian and Hispanic students, who are significantly underrepresented in VASS schools.

Increasing Enrollment in AP Courses

For years, AP courses were geared toward the most academically elite students—those who had always demonstrated keen intellects and diligent work ethics. These students were presumed to be on a path toward attending four-year universities and AP courses were often viewed as a means of padding a college application. However, research provides compelling evidence that the highest value-added from access and exposure to AP courses can be enjoyed by more of the student population; "a much larger proportion of students are likely to be successful ...given the opportunity and support needed to succeed".[4] One of VASS' main goals has been to increase AP enrollment by supporting students who have traditionally not been encouraged to take rigorous courses.

Does participation in APTIP increase the percent of students enrolled in AP courses?

In an effort to determine what effects APTIP participation may have on student enrollment in AP, we performed an analysis of the percent of total students enrolled in AP courses in cohorts 1, 2, and 3 before and after program implementation. In the year prior to implementation, each cohort enrolled approximately six percent of total students in AP courses—consistent with the average for all other Virginia high schools. For all three cohorts, in the year following implementation, the average percent of students enrolled in AP more than doubled to roughly 13 percent.

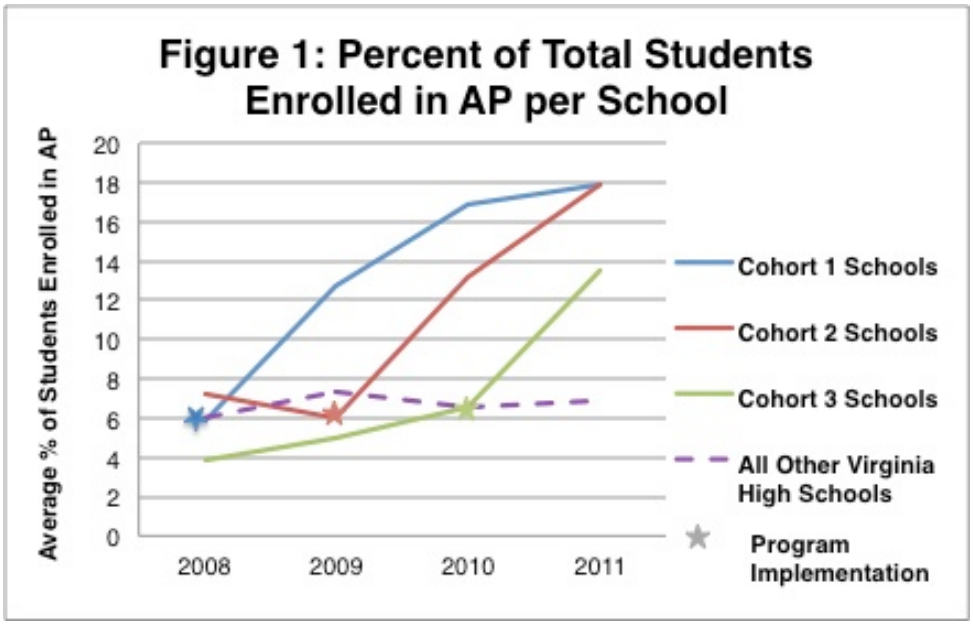


Figure 1 shows the change in the percentage of students enrolled in AP courses over time. The stars represent the year in which each cohort implemented the program. For example, cohort 1 schools joined VASS in the fall of 2008. The first AP scores reflecting program participation are from the spring 2009 examinations. In cohort 1 and 2 schools we continue to see increasing percentages of students enrolled in AP for each subsequent year of participation— after two years in APTIP, an average of almost 18 percent of cohort 2 students are now enrolled in AP courses, three times higher than the rates in all other Virginia high schools.

In all other Virginia high schools, the percentage of students enrolled in AP classes maintains a fairly constant rate from year to year— around six percent across the past four years.

Table 2: Marginal Effects on the Percentage of Students in AP Courses, 2009-2010

	Percent of Students in AP Courses
Program School	6.965***
	(2.270)
School Location: Rural	-3.692***
	(1.166)
School Location: Town	-3.316**
	(1.438)
School Location: Suburb	-2.712**
	(1.349)
% of Students that are White	-3.273
	(2.241)
District Paid for Exam Fee	3.020***
	(1.004)
% of Graduates Earning An Advanced Degree	0.283***
	(0.0629)
% of Graduates Planning On Attending a 4-year College	0.0282***
	(0.0108)
# of Students (in hundreds)	-0.00298**
	(0.00143)
% of Students on Free/ Reduced Lunch	-0.0237
	(0.0360)
Constant	-1.867
	(3.413)
Observations	249
R-squared	0.593

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Note: Results from regression using Stata 11 SE

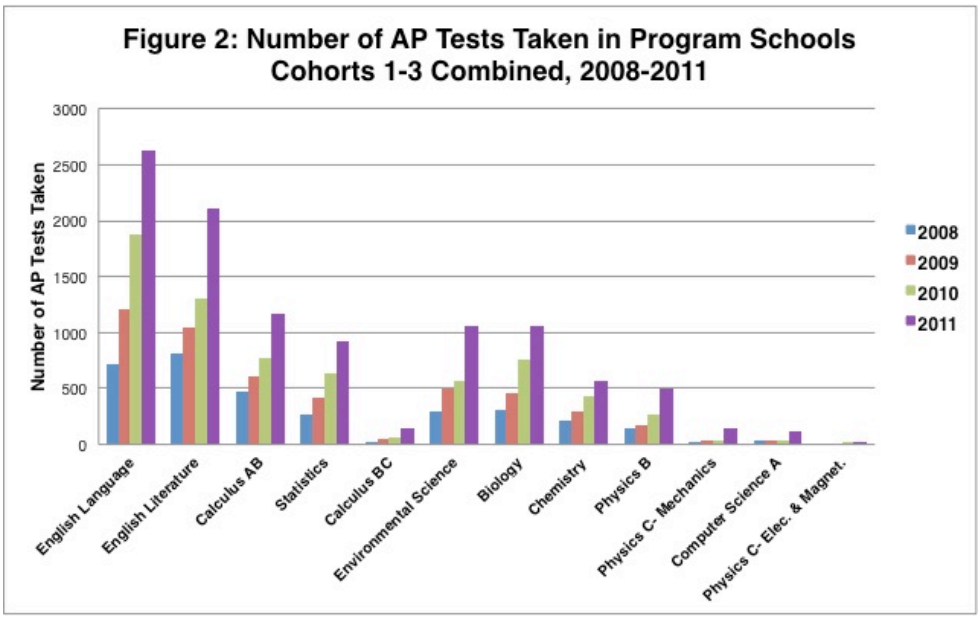
Table 2 shows the effect of multiple variables on the percentage of students enrolled in AP courses for all Virginia high schools in

2010-2011. The numbers in the right-hand column indicate the percentage point change we would expect with a unit change in the variables listed on the left. For example, if a school joins the VASS program we would expect to see, on average, a 6.97 percentage point increase in AP participation.

The size of the school and the percentage of students eligible for free or reduced lunch have a marginally negative impact on AP participation. Likewise, the percentage of students graduating with an advanced diploma and whether the school district covers the exam fee marginally raise AP enrollment, but not nearly to the extent that VASS participation does. The location of the school also plays a significant role in determining AP participation; schools located in Virginia's cities enroll students in AP courses at a level two to three percentage points higher than schools located elsewhere in the Commonwealth.

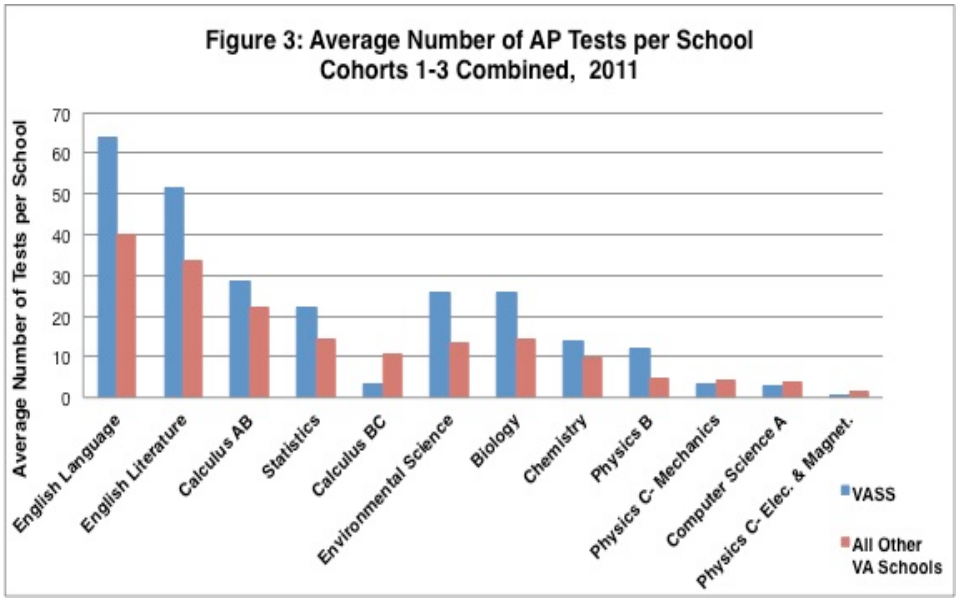
Which AP tests do students take in program schools?

We next wanted to dig beneath the surface of the increased enrollment in program schools to ascertain which VASS-supported AP courses most students gravitated toward. We also attempted to determine which courses saw the greatest increase in enrollment since program implementation.



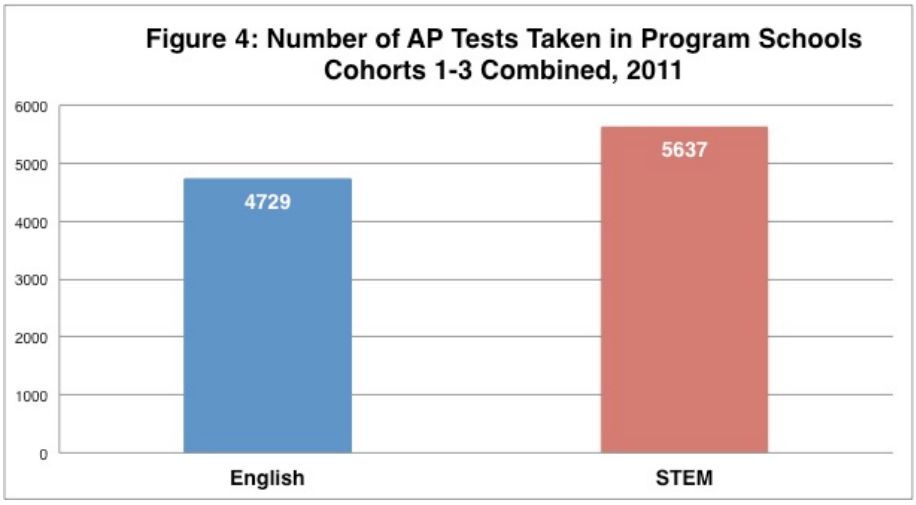
As can be seen in figure 2, in all program schools enrollment in every AP course increased substantially from 2008-2011. For instance, Calculus BC exhibited the greatest percent increase in test

takers— from 13 students in 2008 to 132 students in 2011 (an increase of 915 percent!).



We can also look at the average number of tests taken per school in each subject. Figure 3 shows that in program schools, an average of 64 students per school take the English Language AP exam, 24 more students than in all other schools in the Commonwealth. We see that program schools have higher averages of AP tests in all subjects except Calculus BC, both Physics C courses, and Computer Science.

While the two English courses clearly generate the most test-takers as individual exams, the total number of STEM AP exams taken by students in program schools exceeds the number taken in English, bolstering the VASS mission of increasing the number of students pursuing rigorous coursework in STEM subjects.



Have the demographics of students taking AP courses changed since program implementation?

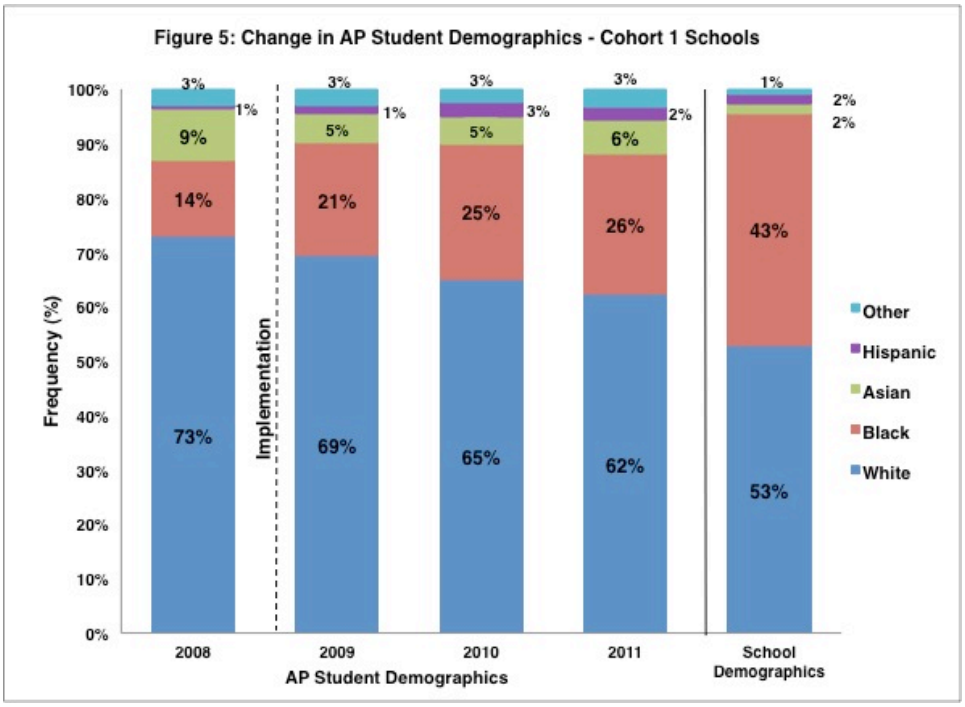


Figure 5 shows the breakdown of AP student demographics in cohort 1 schools. While the number of students in each racial category has increased dramatically every year, the proportion of white AP students fell from 73 to 63 percent over the past four years. Likewise, the percent of Asian students dropped from nine to six percent. These groups have traditionally been overrepresented in AP, enrolling in these courses in far greater proportions than their populations in schools overall. Again, it is important to understand that this trend does not indicate falling numbers of students in these racial groups enrolling in AP, but rather an increase in enrollment of traditionally underrepresented student populations. Most notably, African Americans finished the third year with an increase of 12 percentage points to 26 percent— much more representative of the overall school population.

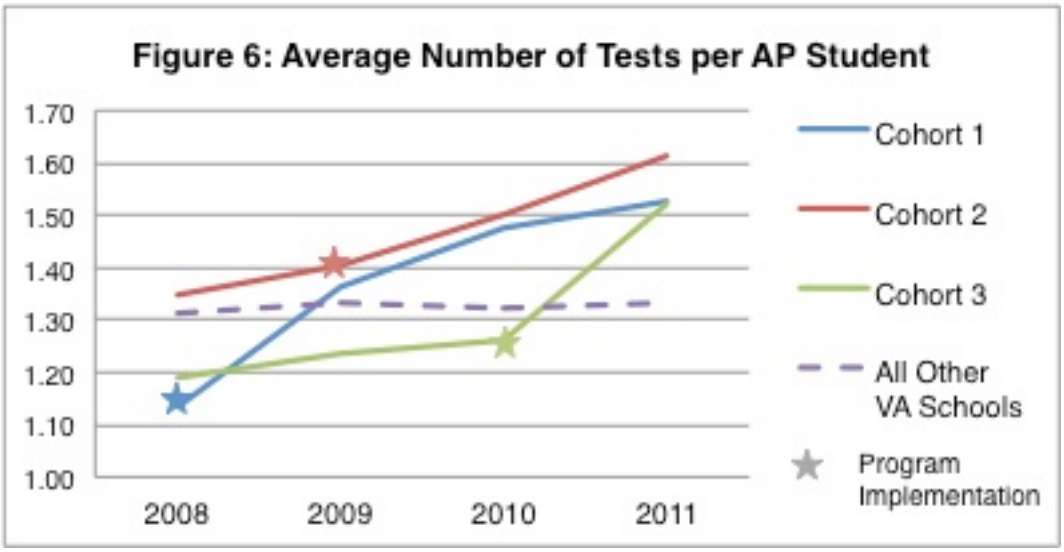
Schools in cohorts 2 and 3 demonstrate similar trends (see Figures 10 and 11 in Appendix A). While significant shifts have occurred since implementation, program schools still have work to do in order for AP student demographics to mirror overall school populations.

Are more students taking multiple AP exams in program schools?

Students have the opportunity to take multiple AP courses while in high school. Ideally, students in program schools would take a greater number and a wider variety of AP tests. Figure 6 shows the average number of tests taken per AP student in all cohort schools and all other Virginia high schools. In all other Virginia schools, the average remains relatively stable, around 1.32 tests per AP student.

Students in APTIP schools are taking more tests while in high school than their peers in non-program schools.

In the year before program implementation, students took an average of 1.13 tests in Cohort 1 schools. After just one year, the average rose by 20 percent to 1.36 tests per student. Both cohorts 1 and 3 exhibited averages well below all other Virginia schools before starting the program. After implementation, however, both averages spiked well above the other schools. Cohort 2 schools began slightly higher than other Virginia schools, but have also increased sharply since implementation.



Similar results can be found with a regression analysis (see table 4 in Appendix A for full results). Students in program schools on average take 0.11 more tests than students in non-program schools. Students in APTIP schools are taking more tests while in high school than their peers in non-program schools.

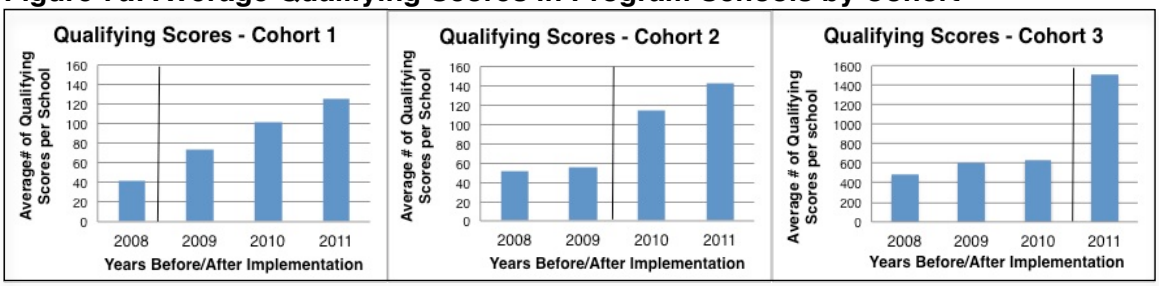
Increasing Student Achievement on AP Exams

Increasing enrollment in AP courses is only one way in which VASS hopes to improve student outcomes in Virginia high schools. It is crucial for more students to be exposed to rigorous coursework in STEM subjects than have been in the past. However, the real mark of successfully improving student outcomes comes with an increase in the number of students earning qualifying scores on their AP exams.

Have the number of students earning qualifying scores in program schools increased since APTIP implementation?

We aggregated student AP exam data for cohorts 1, 2, and 3 for 2008-2011 to determine if the number of qualifying scores increased after program implementation. Figure 7a shows the average number of qualifying scores per program school.

Figure 7a: Average Qualifying Scores in Program Schools by Cohort



Cohorts 2 and 3 illustrate the relative stasis in the average number of qualifying scores produced by program schools in the years leading up to program implementation. In no pre-program year do we see much change in the average number of qualifying scores these schools produce. However, after year one of implementation in both of these cohorts, the average number of qualifying scores more than doubled, painting a very different picture than without the support of VASS in years prior.

Cohort 1 especially, and to a degree cohort 2 as well, demonstrate the continuing increase in average numbers of qualifying scores in each additional year of program participation. Cohorts 1 and 2 exhibit healthy and steady growth in the average number of qualifying scores produced by program schools even after the first year of program implementation.

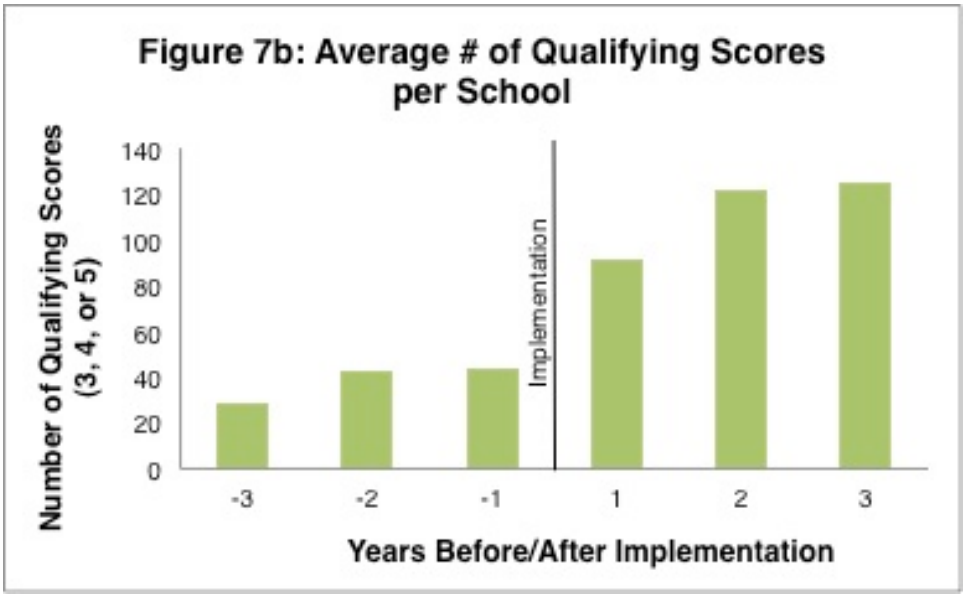


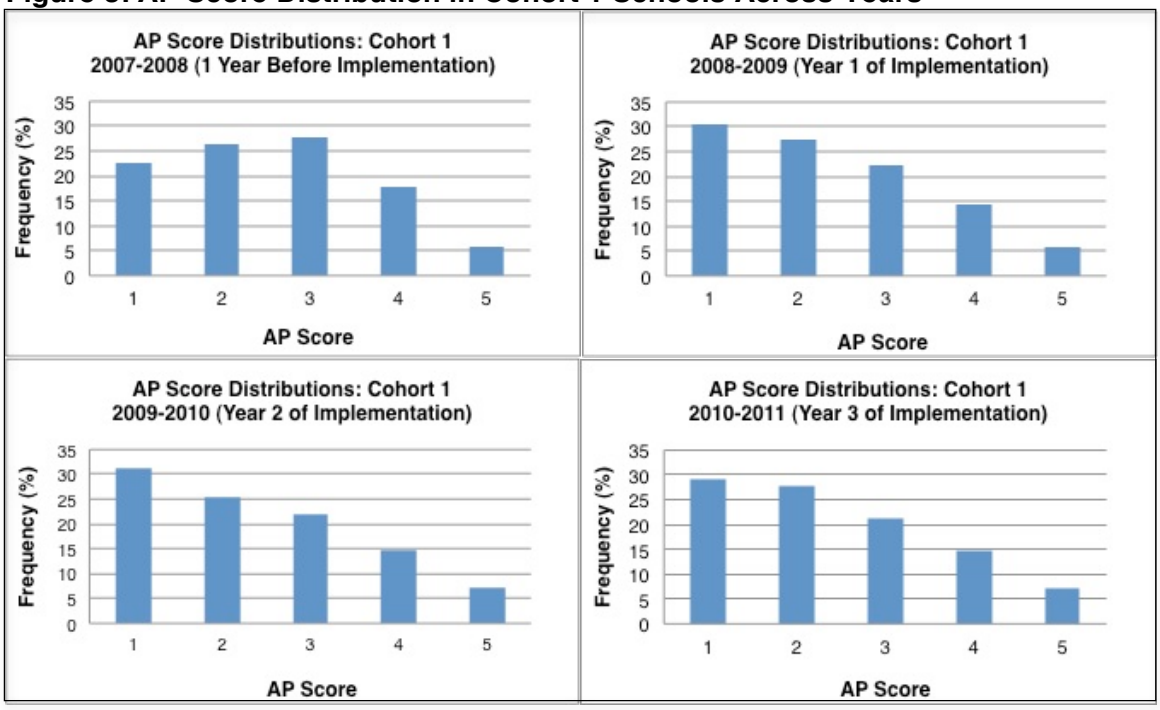
Figure 7b combines the effects across all cohorts to show the average numbers of qualifying AP scores three years prior to, and during the first three years of, program implementation.

Has the distribution of scores shifted since implementation?

It is common in educational testing to see an initial decline in performance when the metrics against which students are measured increase in rigor. Increasing available AP courses to a wider student population, especially students not usually pushed and encouraged to excel, appears to have had this effect on the distribution of student scores in program schools as students adjust to more rigorous standards of measurement.

Examining cohort 1 schools, we see a relatively normal distribution of AP scores in the year prior to program implementation as compared to the three years during which these schools have participated in the program. As can be seen in figure 8, in the first year of implementation, the distribution of AP scores exhibited a fairly regressive pattern. Ones and twos comprised over 55 percent of all AP scores. This pattern continued into year two; however, by year three the mass of the distribution began shifting toward higher scores. Specifically, the decrease in the percent of exams scored as ones is offset by an increase in the percent of exams with scores of two. While it is somewhat encouraging to see smaller proportions of student exams scored at the bottom of the AP scale, there still has not been a substantial increase in the percentage of qualifying scores earned.

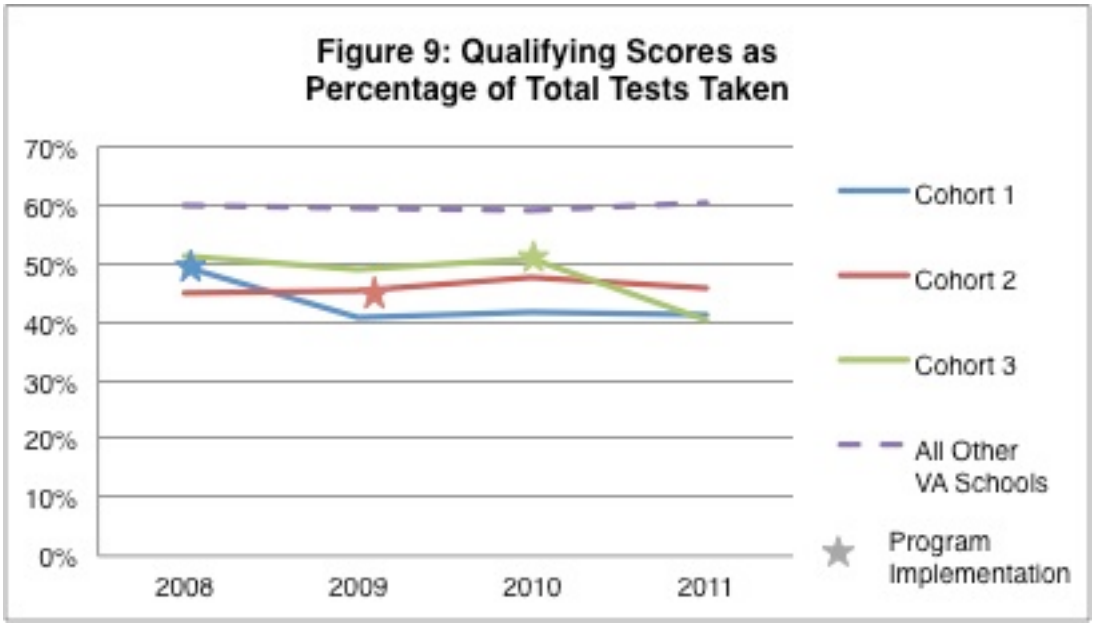
Figure 8: AP Score Distribution in Cohort 1 Schools Across Years



Cohort 2 schools tell a somewhat different story— the score distributions have not changed substantially since implementation. The percent of students who scored a five on the exam has increased slightly; the year before implementation (2008-09), 4.5 percent of students taking AP exams earned a score of five, but after two years of program participation that has risen to 6.3 percent.

Cohort 3 schools' score distributions in general look similar to those of cohort 1. The percent of students earning a one on an exam jumps from 26.4 percent in the year before implementation to 34.4 percent in the first year of the program. For associated graphs, see figures 12 and 13 in Appendix A.

We can also look at this another way by comparing the number of qualifying scores to the total number of tests taken. Figure 9 shows that in all other Virginia high schools, around 60 percent of AP students earn qualifying scores on their exams (this number remained relatively constant over the past four years). We also see that all three cohorts begin and end with a lower percentage of qualifying scores earned. For cohorts 1 and 3, the percentage of qualifying scores drops eight and 11 percentage points respectively, after program implementation, and cohort 1 does not seem to improve over time. Only cohort 2 schools maintain a relatively steady rate over time.



Although the total number of qualifying scores has increased every year since implementation, VASS should strive to focus more resources on improving the scores of students. Additional measures should be taken to ensure that students not only enroll in AP courses, but earn successful scores on their exams.

What affects the likelihood of students earning qualifying scores on AP exams?

To determine what affects the likelihood of students earning a qualifying score, we ran a probit regression model including all Virginia students (in both program and non-program schools) who took an AP exam in the 2009-10 school year. The marginal effects of several variables are shown in Table 5 in Appendix A.

Notably, students in Cohort 1 tend to have a lower likelihood of earning a qualifying score than students in cohort 2 or all other Virginia schools.

For all AP students, both gender and race have significant effects on a student's probability of earning a qualifying score. Males have a higher chance than females of earning a qualifying score and white students have a higher likelihood of earning a qualifying score than all other racial groups.

Additionally, students taking science and math courses have a lower chance of earning a qualifying score than students who take English. Sophomores and juniors have greater probabilities of earning qualifying scores than seniors.

Table 3: Predicted Probabilities of Earning a Qualifying Score, 2009-2010			
	Cohort 1	**Cohort 2**	**All Other VA Schools**
Male	55%	62%	63%
Female	47%	55%	56%
White	56%	63%	64%
Black	27%	34%	35%
Hispanic	42%	49%	51%
Asian	50%	57%	58%

Table 3 shows the predicted probability of a student with certain characteristics earning a qualifying score in cohort 1, cohort 2, and all other Virginia schools. We see that all students in cohort 1 have a lower probability of earning qualifying scores than students in cohort 2 or all other VA schools. Students in cohort 2 have similar predicted probabilities to students in all other VA high schools.

Improving Student Readiness for College

One of the areas VASS asked us to evaluate included the long-term impact on students after they leave high school and enter college or careers. Due to a lack of available data tracking students' progress through Virginia colleges and universities, we turned to the literature to explore the ways in which scholars have tied AP course-taking and AP scores to student success in postsecondary settings. In our recommendations section we suggest developing a data tracking system to broaden the possibilities for future evaluation of VASS program effects.

Several of the research questions we developed assumed a high value return on investment for grants earmarked specifically for Advanced Placement courses. In order to ensure the veracity of this assumption, we performed a review of the literature on Advanced Placement courses and exams. The following are findings from some of the seminal research conducted since the inception of the College Board's offering of Advanced Placement exams in 1954-55.

How do AP students fare compared to their peers in college?

Research demonstrates that students who take AP courses and sit for the exams increase their overall academic success and enjoy higher college graduation rates.[5] Studies conducted in the earliest years of AP demonstrated the now widely accepted effects of AP course-taking on students' continuing success in postsecondary education.

Two of the earliest studies of students' performance in college by Wilcox (1962) and Burnham and Hewitt (1971) demonstrate the validity of the exam scores in predicting student success at the college level.[6] By studying a group of students from Yale University, Burnham and Hewitt found that AP students had higher levels of academic achievement and took more college courses in their AP subjects than non-AP students throughout their time at the university. This aligns with one of VASS' stated goals: increase the number of students taking advanced coursework in postsecondary schools in the STEM subjects and English.

AP students had higher levels of academic achievement and took more college courses in their AP subjects than non-AP students.

More recent studies on a larger scale reinforce the assertion that students who take AP courses in high school tend to take more and

do better in advanced coursework in their postsecondary education than non-AP students. In 1993, Morgan and Crone studied approximately 3,000 students at the University of California who took AP courses in three STEM subjects – Biology, Calculus, and Chemistry. They found that AP students pursued study in those subject areas at a greater rate than non-AP students.[7] Overall, research suggests that AP students consistently outperform their non-AP peers in college courses.

Initially offered only to a select few, studies show AP provides greater benefits when opened to a wider student population. A series of empirical studies provides clear evidence that the placement of only the highest ability students into rigorous courses, such as AP, is without much merit.[8] One study claims that a "much larger proportion of students are likely to be to be successful in many AP courses if identified early and given the opportunity and support needed to succeed".[9] VASS seeks to provide these opportunities and support by expanding AP course offerings to schools with historically low numbers of AP students.

What are the benefits in higher education of earning a qualifying AP score?

Morgan and Crane's study also demonstrated that students with qualifying scores on their AP exams received higher grades in subsequent college courses than non-AP students enrolled in those same courses. Morgan, in a study conducted with his colleague Ramist, found that students with qualifying AP scores were better prepared academically than their peers and benefited from advanced standing in college courses.[10] For these reasons, many have called AP scores the best predictor of student enrollment in and graduation from four-year institutions of higher education.[11]

Interviews with Curriculum Specialists

In order to better understand the program from a teacher's point of view, we conducted several interviews with Curriculum Specialists in Henrico County. These interviews helped not only to solidify our knowledge of how the program operates, but they also helped elucidate some of the difficulties that can arise in implementing any training model. We have included some of these suggestions in our recommendations.

All of the specialists we interviewed agreed that they had received positive feedback from teachers who underwent training. Above all, teachers talk about how dramatically the program helps them increase the rigor in their classrooms and also positively impacts the school expectations as a whole. For example, Henrico County now attempts to include at least one free response question on every end of course exam in middle and high schools— requiring higher levels of analysis. Additionally, they reported that teachers found the program easy to implement and that it helped promote staff development. The program also encourages teachers to focus on developing critical thinking skills rather than merely teaching to the test.

The program helps teachers dramatically increase the rigor in their classrooms and positively impacts expectations school-wide.

However, they also noted that it is difficult for teachers to transition the content they cover in program training to the material they are required to cover for Virginia's Standards of Learning (SOL). In Henrico County, schools in low-income areas have seen higher turnover rates for teachers, which negatively impacts program fidelity. Likewise, some teachers change the courses they teach in order to accommodate more AP classes, and without in-field certification, may not be as qualified to teach the new classes.

Suggestions for Future Research & Evaluation

One opportunity for further research is exploring the connection between implementing APTIP in high schools and outcomes for participating students in postsecondary education and entry into the workforce.

In order to fully evaluate program impacts on outcomes after high school, there must be some way to link data for participating students to post-secondary institutions in the Commonwealth and ideally, nationwide. This will allow for evaluation of the program's impact not only on how students perform in college, e.g. freshman GPA, need for remediation, college completion rates, etc., but also whether they choose STEM majors and careers.

In this first analysis of APTIP, we were unable to evaluate the three components of the program in isolation—this presents a tremendous jumping-off point for additional research.

First, we can estimate the specific impacts of the teacher training if more specific data were collected on training attendance and teacher demographics. For example, newer teachers could be more amenable to implementing a new program, but they also could have less experience in the classroom. Surveys should be administered to teachers pre-and post-training to evaluate program impacts on their content knowledge and subject-specific pedagogy. It would be interesting to see how these different factors impacted student performance.

Second, students, teachers, and administrators receive a variety of financial incentives for qualifying AP scores. To understand the impact these incentives have on student enrollment and achievement, research must include new variables measuring teacher and administrator bonuses.

Third, to determine the potential benefit schools receive from classroom resources made available through grant funds, future evaluators must capture the amount of money spent on materials for each AP subject.

Finally, analysis should be conducted after the five-year grant expires. This will help measure the lasting impact of the program after initial funding ceases.

Recommendations

To maximize the impact VASS funds have in program schools it is important that the resources provided assist teachers in keeping pace with trends in technology in STEM fields. Additionally, the resources that schools receive must be tailored to the needs of each individual school and classroom. For instance, schools receiving chemistry lab equipment could be in greater or equal need of a classroom set of a particular novel. Overall, schools would benefit from more discretion in appropriating funds for classroom materials, ensuring more efficient allocation.

Teachers often cite administrator support implementing new programs as a fundamental component of success. As such, program schools could gain from requiring all faculty eligible to receive incentives, administrators as well as teachers, to attend training sessions. This could help ensure program fidelity– administrators might better monitor teachers and assist them in implementing the program if they are familiar with it themselves. Additionally, this might also help ensure that AP becomes a lasting part of the school culture— even after grant funds have expired.

While enrollment has increased substantially in program schools, VASS should strive to focus more resources on improving the scores of students. Additional efforts should be taken to ensure that students not only enroll in AP courses, but also earn qualifying scores on exams.

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[1] "Staying Competitive," the National Math and Science Initiative, accessed October 3, 2011, http://www.nationalmathandscience.org/solutions/challenges/staying-competitive
[2] Carnevale, A.P., Smith, N., Melton M. (2011). *STEM*. Washington, D.C.: Georgetown University Center on Education and the Workforce. http://www9.georgetown.edu/grad/gppi/hpi/cew/pdfs/stem-complete.pdf
[3] "Who We Are," Virginia Advanced Study Strategies, accessed September 17, 2011, http://www.virginiaadvancedstudystrategies.org/
[4] Ewing, M., Camara, W.J., Millsap, R.E. (2006). *The relationship between PSAT/NMSQT scores and AP examination grades: A follow-up study.* (College Board Research Report No. 2006-01). New York: College Board.
[5] Everson, H.T., & Donnelly, S.W. (2010). *The College Board's Advanced Placement Program: A Review of the Literature*. (Advanced Programs Initiative Working Paper No. 2010-01). The Center for Advanced Study in Education. New York: Graduate School, City University of New York.
[6] Wilcox, Edward T. (1962). Sever years of advanced placement. *College Board Review*, 48, 29-34; Burnham, P.S., & Hewitt, B.A. (1971). Advanced Placement scores: Their predictive validity. *Educational and Psychological Measurement*, 31(4), 939-45.
[7] Everson, 10.

[8] Ewing, M., Camara, W.J., Millsap, R.E. (2006). *The relationship between PSAT/NMSQT scores and AP examination grades: A follow-up study.* (College Board Research Report No. 2006-01). New York: College Board.
[9] *Ibid.*
[10] Morgan, R, & Ramist, L. (1998). *Advanced Placement students in college: An investigation of course grades at 21 colleges.* (Statistical Report No. 98-13). Princeton, NJ: Educational Testing Service.
[11] Everson, see generally.

Appendix A: Additional Tables

Student Demographics – Cohorts 2 and 3

The graphs below illustrate the breakdown of AP student demographics in cohort 2 and 3 schools. We see that in the 2007-2008 school year, in these schools, the AP student population was overwhelmingly white, and that by the 2010-11 school year, like in cohort 1, the demographic breakdown became much more similar to the overall school demographics. Again, as in cohort 1, there was not a crowding out effect: in absolute terms, there are more students of all demographics after implementation. We also see dramatic increases in the percentage of African American students– a 150 percent increase in cohort 2 and well over a 200 percent increase in cohort 3.

Figure 10: Change in AP Student Demographics, Cohort 2 Schools

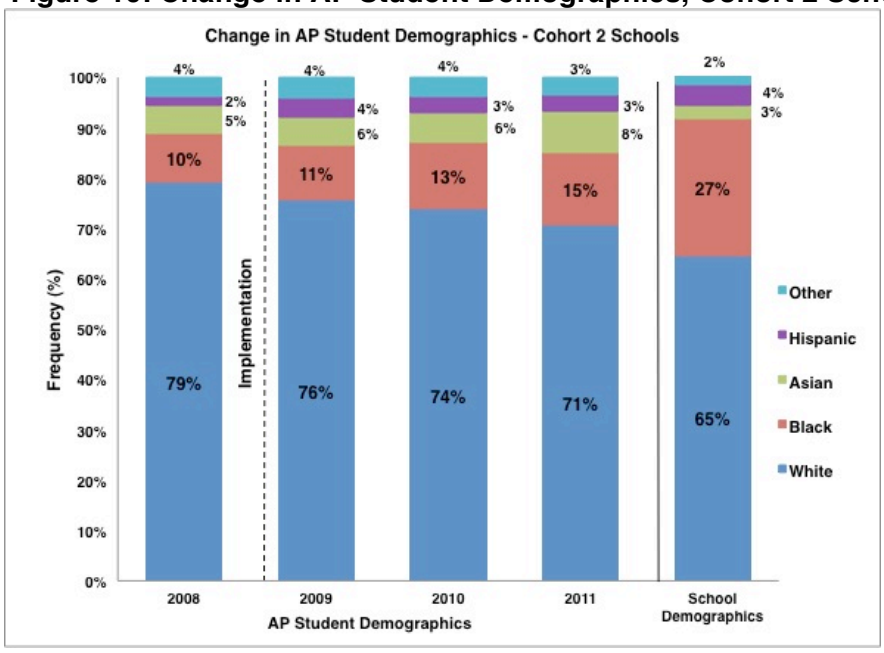
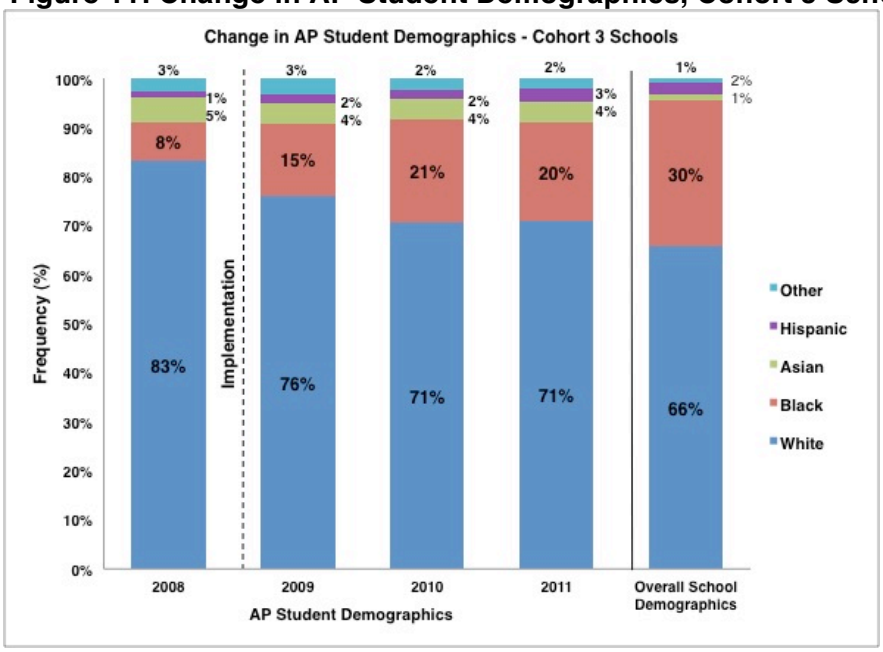


Figure 11: Change in AP Student Demographics, Cohort 3 Schools



AP Score Distributions – Cohorts 2 and 3

Cohort 2 schools tell a somewhat different story than cohort 1 schools— the score distributions have not changed substantially since implementation. The percent of students who scored a five on the exam has increased slightly; the year before implementation (2008-09), 4.5 percent of students taking AP exams earned a score of five, but after two years of program participation that has risen to 6.3 percent.

Cohort 3 schools' score distributions (see next page) in general look similar to those of cohort 1. The percent of students earning a one on an exam jumps from 26.4 percent in the year before implementation to 34.4 percent in the first year of the program.

Figure 12: AP Score Distribution in Cohort 2 Schools Across Years

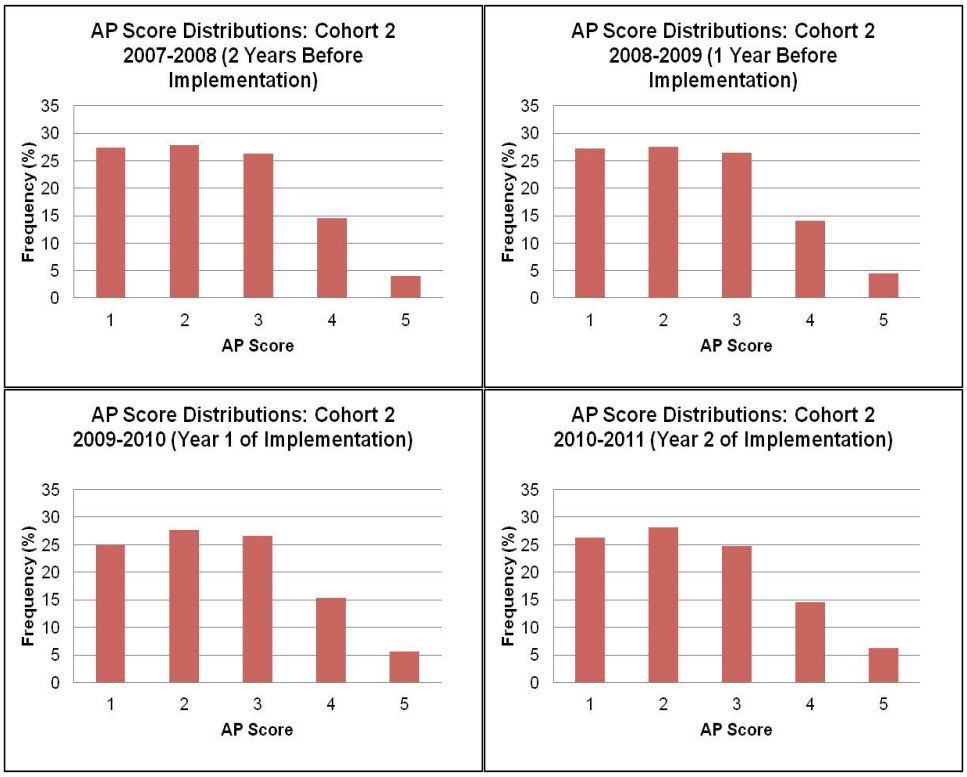
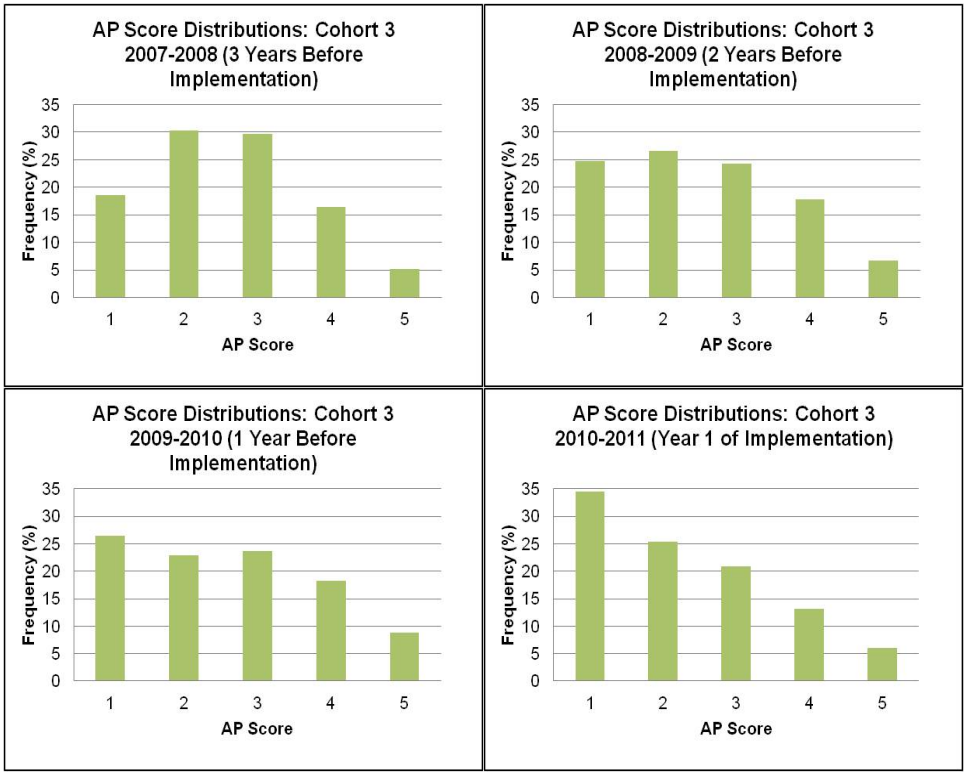


Figure 13: AP Score Distribution in Cohort 3 Schools Across Years



Number of Tests per AP Student— Regression Results

The results below show that students in program schools, on average, take 0.11 more tests than students in non-program schools. Other significant explanatory variables include: if a student attends a rural school (negative effect) and if the school has a higher proportion of students enrolled in AP courses (positive effect).

Table 4: Marginal Effects on the Average Number of Tests per AP Student, 2009-2010

	Average # of Tests per AP Student
Program School	0.109*
	(0.0586)
School Location: Rural	-0.110***
	(0.0385)
School Location: Town	-0.0372
	(0.0559)
School Location: Suburb	-0.0483
	(0.0357)
% of Students that are White	0.0672
	(0.0764)
District Paid for Exam Fee	-0.0223
	(0.0434)
% of Students Enrolled in AP courses	0.0119***
	(0.00345)
% of Graduates Earning An Advanced Degree	-0.000744
	(0.00170)
% of Graduates Planning On Attending a 4-year College	0.000290
	(0.000268)
# of Students (in hundreds)	1.41e-05
	(3.77e-05)
% of Students on Free/ Reduced Lunch	-0.00206
	(0.00134)
Constant	1.296***
	(0.134)
Observations	230
R-squared	0.414

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Note: Results from regression using Stata 11 SE

Effects on the Likelihood of Earning a Qualifying Score– Probit Regression Results

To determine what affects the likelihood of students earning a qualifying score we ran a probit regression model including all Virginia students (in both program and non-program schools) who took an AP exam in the 2009-10 school year. The marginal effects of several variables are shown below. (Note: the more stars beside a number, the more statistically significant it is.)

Students in Cohort 1 tend to have a lower likelihood of earning a qualifying score than students in cohort 2 or all other Virginia schools.

For all AP students, gender and race both have significant effects on a student's probability of earning a qualifying score across all high schools. Males have a higher chance than females of earning a qualifying score and white students have a higher likelihood of earning a qualifying score than all other racial groups. Students taking science and math courses have a lower chance of earning a qualifying score than students who take English.

Additionally, sophomores and juniors have a greater probability of earning qualifying scores than seniors in Virginia. Students who attend a school in a rural area or small town have a lower likelihood of earning a qualifying score than their counterparts who attend urban schools.

Students who attend a school with a higher percentage of students graduating with advanced degrees and a higher percentage of students planning to attend four-year colleges are slightly more likely to earn a qualifying score than students in schools with low percentages for these measures.

The number of total students in a school, the percentage of students taking AP in a school, and the percentage of students on free or reduced lunch have no effect on the likelihood that students will earn qualifying scores on their AP exams.

Table 5:Marginal Effects on the Probability of Earning a Qualifying Score, 2009-2010	
	Probability of Earning a QS
Cohort 1 School	-0.223**
	(0.111)
Cohort 2 School	-0.0348
	(0.0950)
Gender: Male=1	0.186***
	(0.0183)
Race: Asian	-0.157***
	(0.0313)
Race: Black	-0.745***
	(0.0435)
Race: Hispanic	-0.354***
	(0.0373)
Race: Other	-0.242***
	(0.0359)
AP Subject: Science	-0.484***
	(0.0421)
AP Subject: Math	-0.240***
	(0.0457)
Grade: Freshman	0.516
	(0.432)
Grade: Sophomore	0.755***
	(0.0910)
Grade: Junior	0.207***
	(0.0285)
School Location: Rural	-0.255**
	(0.115)
School Location: Town	-0.222*
	(0.127)
School Location: Suburb	0.00788
	(0.0941)
% of Students that are White	0.00541**
	(0.00239)
% of Graduates Earning	0.00891*
An Advanced Degree	(0.00486)
% of Graduates Planning On	0.00476*
Attending a 4-year College	(0.00276)
# of Students	-0.000624
(in hundreds)	(0.00906)
% of Students Enrolled in	0.00385
AP courses	(0.00788)
% of Students on Free/	-0.00302
Reduced Lunch	(0.00479)
Constant	-0.645
	(0.448)
Observations	44,534
Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1 Note: Results from probit regression in Stata 11 SE	

Improvement Measures Rankings

Tables 6a and 6b provide rankings by cohort on four different measures: the absolute change in AP exam mean grade, the percentage change in students taking AP courses, the change in percentage of qualifying scores, and the absolute change in the number of qualifying scores. All changes are measured since implementation. Note that the rankings exclude Glen Allen High School from cohort 3 which was a new school the year the program was implemented. All participating schools saw an increase in the percent of AP students, but not all schools saw an increase in the average score on the year end exam. Likewise, while all schools saw an increase in the absolute number of qualifying scores, the results were more mixed for the change in percent of qualifying scores.

Table 6a: Cohort Schools Ranked by Improvement Measures

Absolute Change in Grade Mean			Percent Change of Student Enrollment		
Cohort 1			**Cohort 1**		
1	Martinsville High School	1.55	1	Martinsville High School	193.00
2	Deep Run High	0.57	2	Amelia County High	92.00
3	Prince Edward County High	0.43	3	Halifax County High	19.67
4	Marion Senior High	0.29	4	Staunton River High	3.85
5	Thomas Jefferson High	0.13	5	Thomas Jefferson High	3.20
6	Jefferson Forest High	0.07	6	Prince Edward County High	3.00
7	Franklin County High	0.00	7	Richmond Community High	2.92
8	Varina High	-0.14	8	Marion Senior High	2.73
9	Richmond Community High	-0.25	9	Varina High	1.89
10	Staunton River High	-0.39	10	Liberty High	1.33
11	Liberty High	-0.49	11	Jefferson Forest High	0.73
12	Halifax County High	-1.56	12	Deep Run High	0.71
13	Amelia County High	-2.20	13	Franklin County High	0.05
Cohort 2			**Cohort 2**		
1	Gretna Senior High	0.91	1	Parry McCluer High	23.50
2	Monacan High	0.47	2	Randolph Henry High	12.00
3	Cosby High	0.31	3	Gretna Senior High	6.25
4	Patrick Henry High (Roanoke)	0.02	4	Matoaca High	2.25
5	Matoaca High	-0.09	5	John Randolph Tucker High	1.51
6	Hermitage High	-0.10	6	Patrick Henry High (Glade Spring)	1.44
7	Lloyd C. Bird High	-0.15	7	Cosby High	0.89
8	John Randolph Tucker High	-0.19	8	Patrick Henry High (Roanoke)	0.57
9	Randolph Henry High	-0.21	9	Lloyd C. Bird High	0.55
10	Parry McCluer High	-0.41	10	Monacan High	0.51
11	Patrick Henry High (Glade Spring)	-0.60	11	Hermitage High	0.15
Cohort 3			**Cohort 3**		
1	Tunstall Senior High	1.31	1	Bassett High	16.77
2	Dan River Senior High	0.89	2	Dan River Senior High	7.50
3	Chatham High	0.62	3	Magna Vista High	4.51
4	Cave Spring High	0.07	4	Goochland High	2.71
5	Open High	0.06	5	Glenvar High	2.06
6	William Byrd High	0.03	6	Tunstall Senior High	1.89
7	Lee Davis High	0.02	7	Chatham High	1.76
8	Highland Springs High	-0.02	8	Lee Davis High	1.33
9	John Marshall High	-0.03	9	Patrick Henry High (Ashland)	1.29
10	Hidden Valley High	-0.05	10	Northside High	1.00
11	Magna Vista High	-0.10	11	Highland Springs High	0.99
12	Goochland High	-0.12	12	John Marshall High	0.78
13	Patrick Henry High (Ashland)	-0.44	13	Cave Spring High	0.67
14	Northside High	-0.52	14	Open High	0.43
15	Glenvar High	-0.55	15	William Byrd High	0.16
16	Bassett High	-0.82	16	Hidden Valley High	0.12

Table 6b: Cohort Schools Ranked by Improvement Measures

Change in Percent of Qualifying Scores			Absolute Change in # of Qualifying Scores		
Cohort 1			**Cohort 1**		
1	Deep Run High	19.32	1	Deep Run High	388
2	Martinsville High School	15.27	2	Franklin County High	147
3	Prince Edward County High	9.54	3	Jefferson Forest High	124
4	Thomas Jefferson High	2.84	4	Varina High	70
5	Franklin County High	0.59	5	Staunton River High	70
6	Varina High	-1.00	6	Marion Senior High	56
7	Marion Senior High	-1.80	7	Martinsville High School	51
8	Richmond Community High	-8.43	8	Prince Edward County High	37
9	Jefferson Forest High	-8.57	9	Liberty High	33
10	Staunton River High	-16.42	10	Richmond Community High	28
11	Liberty High	-21.55	11	Halifax County High	27
12	Halifax County High	-31.13	12	Amelia County High	23
13	Amelia County High	-81.25	13	Thomas Jefferson High	13
Cohort 2			**Cohort 2**		
1	Gretna Senior High	35.23	1	Cosby High	241
2	Monacan High	19.88	2	John Randolph Tucker High	206
3	Randolph Henry High	15.38	3	Patrick Henry High (Roanoke)	129
4	Cosby High	9.20	4	Matoaca High	105
5	Patrick Henry High (Roanoke)	0.44	5	Monacan High	89
6	Hermitage High	-0.96	6	Hermitage High	50
7	Matoaca High	-4.78	7	Gretna Senior High	41
8	Lloyd C. Bird High	-8.11	8	Lloyd C. Bird High	36
9	John Randolph Tucker High	-9.33	9	Parry McCluer High	34
10	Parry McCluer High	-29.32	10	Randolph Henry High	7
11	Patrick Henry High (Glade Spring)	-38.49	11	Patrick Henry High (Glade Spring)	6
Cohort 3			**Cohort 3**		
1	Tunstall Senior High	37.775	1	Lee Davis High	111
2	Dan River Senior High	22.857	2	Cave Spring High	111
3	Chatham High	21.807	3	Patrick Henry High (Ashland)	104
4	William Byrd High	5.2575	4	Hidden Valley High	60
5	Open High	4.3011	5	Goochland High	50
6	Highland Springs High	2.284	6	Glenvar High	36
7	Magna Vista High	1.8059	7	Bassett High	34
8	Lee Davis High	0.884	8	Tunstall Senior High	33
9	Cave Spring High	0.873	9	Magna Vista High	30
10	John Marshall High	-1.2356	10	William Byrd High	29
11	Hidden Valley High	-3.2995	11	Chatham High	25
12	Goochland High	-9.0775	12	Highland Springs High	25
13	Northside High	-10.069	13	Northside High	24
14	Patrick Henry High (Ashland)	-13.953	14	Dan River Senior High	16
15	Bassett High	-18.217	15	Open High	10
16	Glenvar High	-24.84	16	John Marshall High	2

Appendix B: Literature Review

Several of the research questions we developed assumed a high-value return on investment from focusing on Math, Science, and English Advanced Placement courses. In order to ensure the veracity of this assumption, we performed a review of the literature on Advanced Placement courses and exams. The following are findings from some of the seminal research conducted since the inception of the College Board's offering of Advanced Placement exams in 1954-55.

Primary Benefits

Research has demonstrated that students who take AP courses and sit for the exams increase their overall academic success and improve their likelihood of graduating from college.[12] Indeed, some have called AP scores the best predictor of student enrollment in and graduation from four-year institutions of higher education.[13] Studies conducted in the program's earliest years demonstrated the now widely accepted effects of AP course-taking on students' continued success in postsecondary education.

Two of the earliest studies of students' performance in college by Wilcox (1962) and Burnham and Hewitt (1971) demonstrate the validity of the exam scores in predicting student success at the college level.[14] By studying a group of students from Yale University, Burnham and Hewitt found that AP students had higher levels of academic achievement and took more college courses in their AP subjects than non-AP students throughout their time at the university. This aligns with one of VASS' goals: increase the number of students prepared to take advanced coursework in postsecondary schools in the STEM subjects and English.

More recent studies on a larger scale reinforce the assertion that students who take AP courses in high school tend to take more and do better in advanced coursework in their postsecondary education than non-AP students. In 1993, Morgan and Crone studied approximately 3,000 students at the University of California who took AP courses in three STEM subjects – Biology, Calculus, and Chemistry. They found that AP students pursued study in those subject areas at a greater rate than non-AP students. Further, they found that students who earned qualifying scores received higher

grades in subsequent college courses than non-AP students enrolled in those same courses. Overall, research suggests that AP students consistently outperform their non-AP peers in college courses.[15] This research seems to support VASS utilizing AP courses to meet a second goal: to increase the performance of Virginia students in STEM subjects.

Student Characteristics

When the College Board first introduced the Advanced Placement program, it was largely viewed as an opportunity for only the academic elite. In its earliest years, AP courses were offered only by a handful private preparatory schools or specialized schools for the gifted and talented, known for sending graduates to highly selective colleges and universities.[16] The evolution of AP courses, however, has led it to embody the same priorities that VASS values: widespread opportunity for all students to encounter and benefit from rigorous coursework and critical thinking skills before they enter the demands of higher education and the workforce.

Initially offered only to a select few, studies show AP provides greater benefits when opened to a wider student population. A series of empirical studies provides clear evidence that the placement of only the highest ability students into rigorous courses, such as AP, is without much merit.[17] One study claims that a "much larger proportion of students are likely to be to be successful in many AP courses if identified early and given the opportunity and support needed to succeed".[18] VASS seeks to provide these opportunities and support by expanding AP course offerings to schools with historically low numbers of AP students.

Other studies focus on which groups of students can gain the most from exposure to rigorous coursework (like that provided in AP classes).[19] There is clear and convincing evidence that the academic rigor and intensity of students' high school curriculum matters most for all students and likely matters *more* for ensuring minority students' success in higher education.

School and Classroom Climate

The environment in which students learn has a profound effect on how well they absorb material. Of particular interest is whether students have adequate access to resources and sufficient attention

from the teacher. Studies have demonstrated that smaller class sizes are more advantageous for student learning. Students in AP courses tend to do better overall as the national average is 17 students per AP class while it is 24 students per non-AP class.[20] AP classes need a smaller student-to-teacher ratio in order to teach more complex and difficult material, and a valuable side-effect is that students receive more specialized instruction through their reduced class size.

In addition to the benefits of smaller class sizes, students in AP courses generally enjoy access to a greater variety of instructional materials. Many classes taught at a regular or even honors level use overhead projectors, blackboards, and textbooks. However, resources available to teachers of AP courses, especially those sponsored by programs that fund additional resources such as VASS, include Smart Boards, curricular and distance learning software, online labs, audio and video technology, and access to sufficient equipment to conduct advanced scientific labs. These resources assist students in achieving a deeper and more thorough understanding of the concepts and theories they learn in AP courses.

Teacher Characteristics

Research demonstrates that teachers with higher levels of education, more years of experience, and better access to professional development tend to provide higher quality instruction in the classroom. Recent studies have found that AP teachers have a variety of advantages in these aspects over their non-AP teaching colleagues. For example, 70 percent have Master's degrees, and 6 percent have Ph.D.'s.[21] Likewise, 81 percent of AP teachers have reached permanent certification status in the field they teach and have at least five years of teaching experience.[22]

Political Realities & Demands for Improved STEM Education

The need in the United States for greater numbers of more highly qualified scientists and engineers is growing with each passing year. For our nation to be competitive in the global economy, we must have the economic power and social influence of a robust STEM workforce.[23] The National Academies of Sciences, the

National Association of Manufacturers, and the Association of American Universities all agree that the United States faces a shortage of STEM workers and cite disturbing trends in the STEM education pipeline. U.S. students recently finished twenty-fifth in math and seventeenth in science in the ranking of thirty-one industrialized countries tested by the Organization for Economic Cooperation and Development (OECD); U.S. advanced math and physics students lag behind other students around the world in math and physics achievement; and about a third of high school math and two-thirds of physical science students have teachers who did not major in the subject in college or are not certified in that area.[24]

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[12] Everson, Howard T. *The College Board's Advanced Placement Program: A Review of the Literature*. (Advanced Programs Initiative Working Paper No. 2010-01). The Center for Advanced Study in Education. New York: Graduate School, City University of New York.
[13] *Ibid.*
[14] Wilcox, Edward T. (1962). Sever years of advanced placement. *College Board Review*, 48, 29-34; Burnham, P.S., & Hewitt, B.A. (1971). Advanced Placement scores: Their predictive validity. *Educational and Psychological Measurement*, 31(4), 939-45.
[15] Everson, 10.
[16] *Ibid.*
[17] Ewing, M., Camara, W.J., Millsap, R.E. (2006). *The relationship between PSAT/NMSQT scores and AP examination grades: A follow-up study.* (College Board Research Report No. 2006-01). New York: College Board.
[18] *Ibid.*
[19] Adelman, Clifford (1999). *Answers in the toolbox: Academic intensity, attendance patterns, and bachelor's degree attainment.* Washington, DC: U.S. Department of Education. http://www2.ed.gov/pubs/Toolbox/toolbox.html
[20] Word, E., Johston, J., Bain, H.P., Fulton, B.D., Zaharias, J.B., Achilles, D.M., et al. (2010). *The state of Tennessee's student/teacher achievement ratio (STAR) project: Final summary report 1985-2010.* Nashville, TN: Tennessee State University, Center of Excellence for Research in Basic Skills.
[21] Milewski, G.B., Gillie, J.M. (2002). *What are the characteristics of AP teachers? An examination of survey research*. (College Board Research Report No. 2002-10). New York: College Board.
[22] *Ibid.*
[23] Carnevale, A.P., Smith, N., Melton M. (2011). *STEM*. Washington, D.C.: Georgetown University Center on Education and the Workforce. http://www9.georgetown.edu/grad/gppi/hpi/cew/pdfs/stem-complete.pdf
[24] The National Commission on Mathematics and Science Teaching for the 21st Century (2000). *Before It's Too Late*. Washington, D.C.: U.S. Department of Education.

References

Adelman, C. (1999). *Answers in the toolbox: Academic intensity, attendance patterns, and bachelor's degree attainment*. Washington, DC: U.S. Department of Education.

Adelman, C. (2006). *The toolbox revisited: Paths to degree completion from high school through college*. U.S. Department of Education.

Burnham, P.S., & Hewitt, B.A. (1971). Advanced Placement scores: Their predictive validity. *Educational and Psychological Measurement*, 31(4), 939-45.

Bush, G.W. (2006, January 31). State of the Union Address. *The New York Times*. http://www.nytimes.com/2006/01/31/politics/text-bush.html.

Camara, W. J., & Millsap, R. (1998). *Using the PSAT/NMSQT and course grades in predicting success in the Advanced Placement Program*. (College Board Research Report No. 98-4). New York: College Board.

Casslery, P. C. (1986). *Advanced Placement Revised* (College Board Report No. 86-6). New York: College Board.

College Board. (2005). *AP Potential: A tool for finding additional AP students*. Retrieved October 8, 2011 from http://www.collegeboard.com/counselors/app/index.html.

College Board, (2010). *Advanced Placement Sixth Annual Report to the Nation*. Retrieved October 8, 2011 from http://www.collegeboard.com.

Conley, D.T. (2010). College and career ready: Helping all students succeed beyond high school. San Francisco, CA: Jossey-Bass.

Dodd, B. G., Fitzpatrick, S. J., De Ayala, R. J., & Jennings, J. A. (2002). *An investigation of the validity of AP grades of 3 and a comparison of AP and non-AP student groups*. (College Board Research Report No. 2002-9). New York: The College Board.

Dougherty, C., Mellor, L., & Jian, S. (2006). *The relationship between advanced placement and college graduation*. (National Center for Educational Accountability: 2005 AP Study Series, Report 1). Austin, Texas: National Center for Educational Accountability.

Dougherty, C., & Mellor, L. (2010). Preparing students for Advanced Placement: It's a prek-12 issue. In P.M. Sadler, G. Sonnert, R.H. Tai, K. Klopfenstein (Eds.), *AP: A critical examination of the Advanced Placement Program* (pp. 119-137). Cambridge, MA: Harvard Education Press.

Duffy, W.R. (2010). Persistence and performance at a four-year university: The relationship with advanced coursework during high school. In P.M. Sadler, G. Sonnert, R.H. Tai, K. Klopfenstein (Eds.), *AP: A critical examination of*

the Advanced Placement Program (pp. 139-163). Cambridge, MA: Harvard Education Press.

Everson, H.T., & Donnelly, S.W. (2010). *The College Board's Advanced Placement Program: A Review of the Literature*. (Advanced Programs Initiative Working Paper No. 2010-01). The Center for Advanced Study in Education. New York: Graduate School, City University of New York.

Ewing, M., Camara, W.J., Millsap, R.E. (2006). *The relationship between PSAT/NMSQT scores and AP examination grades: A follow-up study*. (College Board Research Report No. 2006-01). New York: College Board.

Ewing, M., Camara, J.M., Millsap, R., Milewski, G. B. (2007). *Updating AP Potential Expectancy Tables Involving PSAT/NMSQT Writing*. (College Board Research Notes-35). New York: College Board.

Ewing, M. Huff, K., & Kaliski, P. (2010). Validating AP exam scores. In P.M. Sadler, G. Sonnert, R.H. Tai, K. Klopfenstein (Eds.), *AP: A critical examination of the Advanced Placement Program* (pp. 85-105). Cambridge, MA: Harvard Education Press.

Geiser, S. , & Santelices, V. (2004). *The role of advanced placement and honors courses in college admissions*. Berkley, CA: Center for Studies in Higher Education.

Godfrey, K.E., Matos-Elefonte, M. (2010, April). *Key indicators of college success: Predicting college enrollment, persistence and graduation*. Paper presented at the annual meeting of the American Educational Association, Denver, CO.

Hargrove, L., Godin, D., & Dodd, RB. (2008). *College outcomes comparisons by AP and non-AP high school experiences* (College Board Research Report No. 2008-03). New York: College Board.

Keng, L. & Dodd, B. G. (2008). A comparison of college performances of AP and non-AP student groups in 10 subject areas (College Board Research Report No. 2008-07), New York: College Board.

Jackson, C.K. (2007). *A little now for a lot later: A look at a Texas Advanced Placement incentive program*. Retrieved October 12, 2011 from http://www.ilr.cornell.edu/cheri/workingPapers/upload/cheri_wp107.pdf.

Jeong, D.W. (2009). Student participation and performance on Advanced Placement exams: Do state sponsored incentives make a difference? *Educational Evaluation and Policy Analysis*, 31(4), 346-366.

Klopfenstein, K. (2004). The advanced placement expansion of the 1990s: How did traditionally underserved students fare? *Education Policy Analysis Archives*, 12(68).

Klopfenstein, K. (2008). *The effect of AP participation on time to college graduation: Technical report*. http://www.utdallas.edu/research/tsp-erc/publications.html.

Klopfenstein, K. (2010). Does the Advanced Placement program save taxpayers money? The effect of AP participation on time to college graduation. In P.M. Sadler, G. Sonnert, R.H. Tai, K. Klopfenstein (Eds.), *AP: A critical examination of the Advanced Placement Program* (pp. 189-218). Cambridge, MA: Harvard Education Press.

Klopfenstein, K., & Thomas, M. K. (2009). The link between advanced placement and early college success. *Southern Economic Journal*, 75(3), 873-891.

Klopfenstein, K., & Thomas, M. K. (2010). Advanced placement participation: Evaluating the policies of states and colleges. In P.M. Sadler, G. Sonnert, R.H. Tai, K. Klopfenstein (Eds.), *AP: A critical examination of the Advanced Placement Program* (pp. 167-187). Cambridge, MA: Harvard Education Press.

Lichten, W. (2000). Whither Advanced Placement? *Education Policy Analysis Archives*, 8(29). Retrieved October 25, 2011 from http://epaa.asu.edu/epaa/v8n29.html.

Lichten, W. (2007). Equity and excellence in the College Board Advanced Placement Program. *Teachers College Record*, January 16, 2007. Retrieved October 3, 2011, from http://www.tcrecord.org.

Lichten, W. (2010). Whither Advanced Placement—Now? In P.M. Sadler, G. Sonnert, R.H. Tai, K. Klopfenstein (Eds.), *AP: A critical examination of the Advanced Placement Program* (pp. 233-243). Cambridge, MA: Harvard Education Press.

Morgan, R. & Crone, C. (1993). *Advanced Placement at the University of California: An examination of the freshman year courses and grades of examinees in biology, calculus, and chemistry* (Statistical Report 93-210). Princeton, NJ: Educational Testing Service.

Morgan, R., & Klaric. J. (2007). *AP Students in College: An Analysis of Five-Year Academic Careers*. (College Board Report No. 2007-04). New York: The College Board.

Morgan, R., & Maneckshana, B. (2000). *AP students in college: An investigation of their course-taking patterns and college majors*. (Statistical Report No. 2000-09). Princeton, NJ: Educational Testing Service.

Morgan, R., & Ramist, L. (1998). *Advanced Placement students in college: An investigation of course grades at 21 colleges*. (Statistical Report No. 98-13). Princeton, NJ: Educational Testing Service.

Murphy, D., & Dodd, B. (2009). *A comparison of college performance of matched AP and non-AP student groups*. (College Board Research Report No. 2009-06). New

York: College Board.

Paek, P.L., Braun, H., Trapani, C., Ponte, E., & Powers, D.E. (2007). *The relationship of AP teacher practices and student AP exam performance*. (College Board Research Report No. 2007-05). New York: College Board.

Paek, P.L., Braun, H., Ponte, E., Trapani, C., & Powers, D.E. (2010). AP biology teacher characteristics and practices and their relationship to student AP exam performance. In P.M. Sadler, G. Sonnert, R.H. Tai, K. Klopfenstein (Eds.), *AP: A critical examination of the Advanced Placement Program* (pp. 167-187). Cambridge, MA: Harvard Education Press.

Sadler, P.M. (2010a). Advanced high school coursework and college admission decisions. In P.M. Sadler, G. Sonnert, R.H. Tai, K. Klopfenstein (Eds.), *AP: A critical examination of the Advanced Placement Program* (pp. 245-261). Cambridge, MA: Harvard Education Press.

Sadler, P.M. (2010b). Key findings. In P.M. Sadler, G. Sonnert, R.H. Tai, K. Klopfenstein (Eds.), *AP: A critical examination of the Advanced Placement Program* (pp. 263-270). Cambridge, MA: Harvard Education Press.

Sadler, P.M., & Tai, R.H. (2007). Advanced Placement exam scores as a predictor of performance in introductory college biology, chemistry, and physics courses. *Science Education*, 16(2), 1-19.

Sadler, P.M., Sonnert, G., Tai, R.H., & Klopfenstein, K. (Eds.). (2010). *AP: A critical examination of the Advanced Placement Program*. Cambridge, MA: Harvard Education Press.

Simms, D. (1982). Comparison of academic performance between AP and non-AP students at the University of Michigan. Unpublished manuscript. Cited in Morgan, R., & Ramist, L. (1998). *Advanced Placement students in college: An investigation of course grades at 21 colleges*. (Statistical Report No. 98-13). Princeton, NJ: Educational Testing Service.

Tai, R.H., Liu, C.Q., Almarode, J.T., & Fan, X. (2010). Advanced Placement course enrollment and long-range educational outcomes. In P.M. Sadler, G. Sonnert, R.H. Tai, K. Klopfenstein (Eds.), *AP: A critical examination of the Advanced Placement Program* (pp. 109-118). Cambridge, MA: Harvard Education Press.

U.S. Department of Education. (2009). Advanced Placement test fee program. http://www2.ed.gov/programs/apfee/index.html.

Wilcox, E. T. (1962). Seven years of advanced placement. *College Board Review*, 48, 29-34.

Willingham, W. W., & Morris, M. (1986). *Four years later: A longitudinal study of Advanced Placement students in college* (College Board Report No. 86-2, ETS RR No. 85-46). New York: The College Board.

Evaluation of Virginia's Advanced Placement Training and Incentive Program

Client: VASS
Faculty Advisor: Paul Manna
Team: Bernard Karcher, Laura Parker, Becca Wittenstein

Why Should We Care About Increasing STEM Performance?

- Increase global competitiveness
- Support advanced postsecondary coursework required for STEM careers
- Increase science and engineering workforce

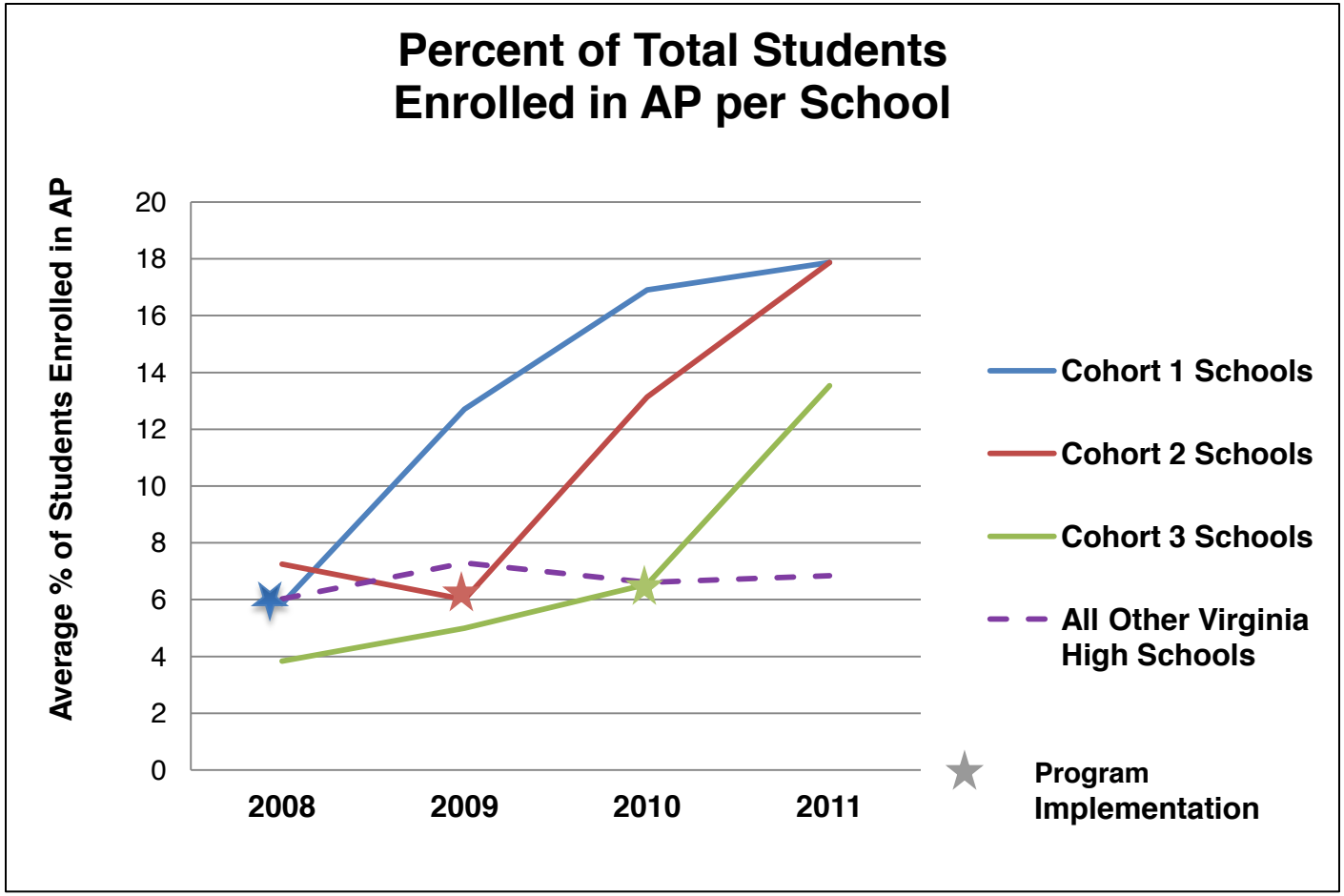
Comparison of APTIP Schools and All Other Virginia Schools

Summary Statistics of Student Characteristics in Program Schools						
	Average # of Total Students	% Free/ Reduced Lunch	% QS (3, 4, or 5)	AP Score Mean	Average % AP Students	Average # of Tests
Cohort 1						
2007-08	1201	34%	43%	2.35	5%	82
2008-09*	1192	37%	34%	2.16	13%	175
2009-10	1192	41%	34%	2.17	16%	236
2010-11	1164	40%	34%	2.20	19%	288
Cohort 2						
2007-08	1331	34%	36%	2.17	7%	120
2008-09	1275	35%	43%	2.35	6%	149
2009-10*	1341	39%	44%	2.38	13%	243
2010-11	1292	41%	42%	2.34	18%	330
Cohort 3						
2007-08	1034	28%	36%	2.22	4%	59
2008-09	1018	30%	33%	2.07	5%	68
2009-10	1007	36%	39%	2.28	7%	77
2010-11*	1001	34%	41%	2.33	12%	196
All Other VA High Schools						
2007-08	1212	30%	41%	2.06	6%	142
2008-09	1211	31%	43%	2.26	8%	152
2009-10	1214	35%	40%	2.1	7%	152
2010-11	1203	35%	42%	2.13	7%	162

Note: * = First Year of Program Implementation

Program Goal: Increase Enrollment

Question 1: Has enrollment increased since implementation of the APTIP program?

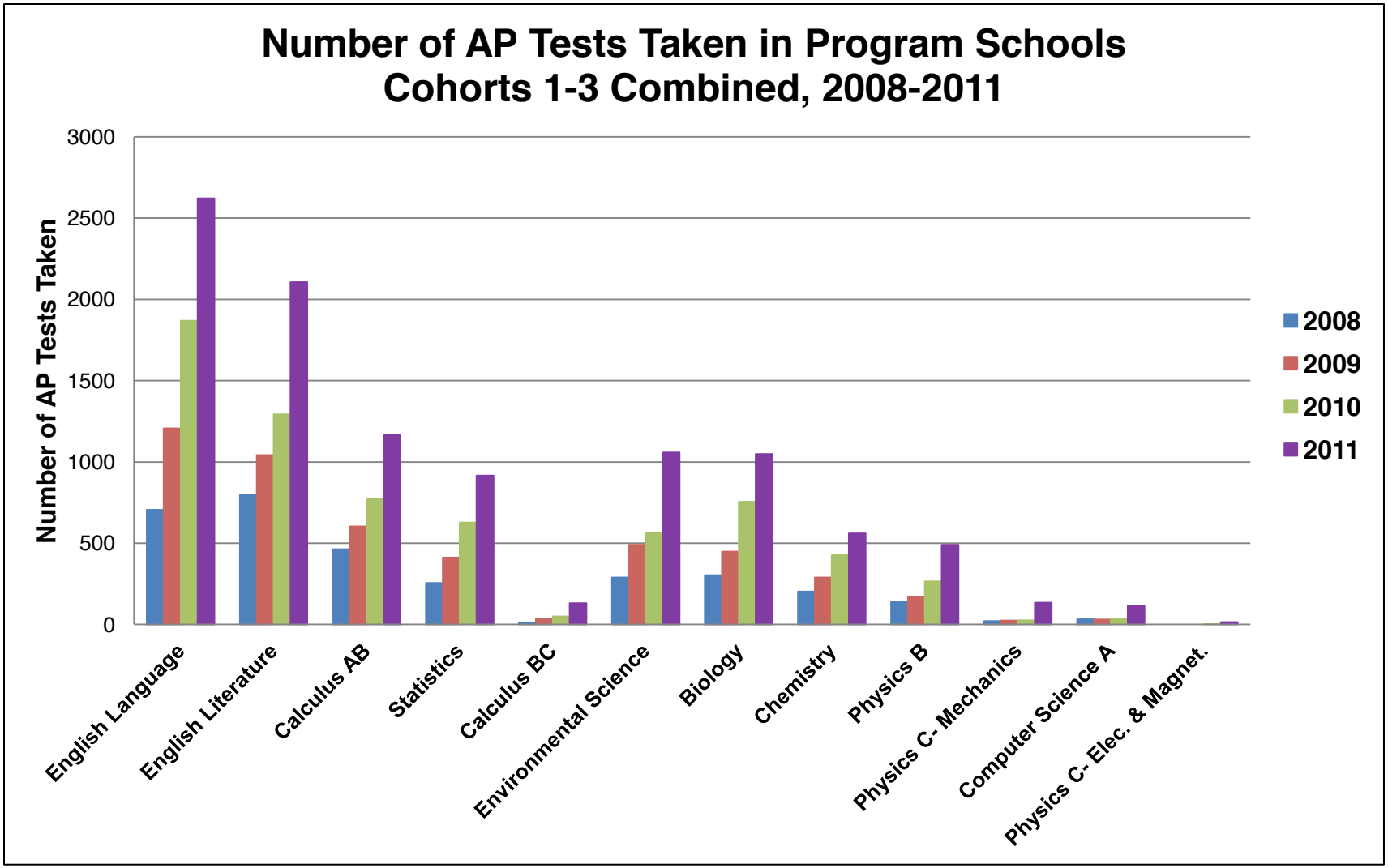


Question 2: Does participation in the program statistically increase the percent of students enrolled in AP?

Marginal Effects on the Percentage of Students in AP Courses, 2009-2010	
	Percent of Students in AP Courses
Program School	6.965***
School Location: Rural	-3.692***
School Location: Town	-3.316**
School Location: Suburb	-2.712**
% of Students that are White	-3.273
District Paid for Exam Fee	3.020***
% of Graduates Earning An Advanced Diploma	0.283***
% of Graduates Planning On Attending a 4-year College	0.0282***
# of Students (in hundreds)	-0.00298**
% of Students on Free/ Reduced Lunch	-0.0237
Observations	249

*** p<0.01, ** p<0.05, * p<0.1

Question 3: Which tests are most students taking in program schools?



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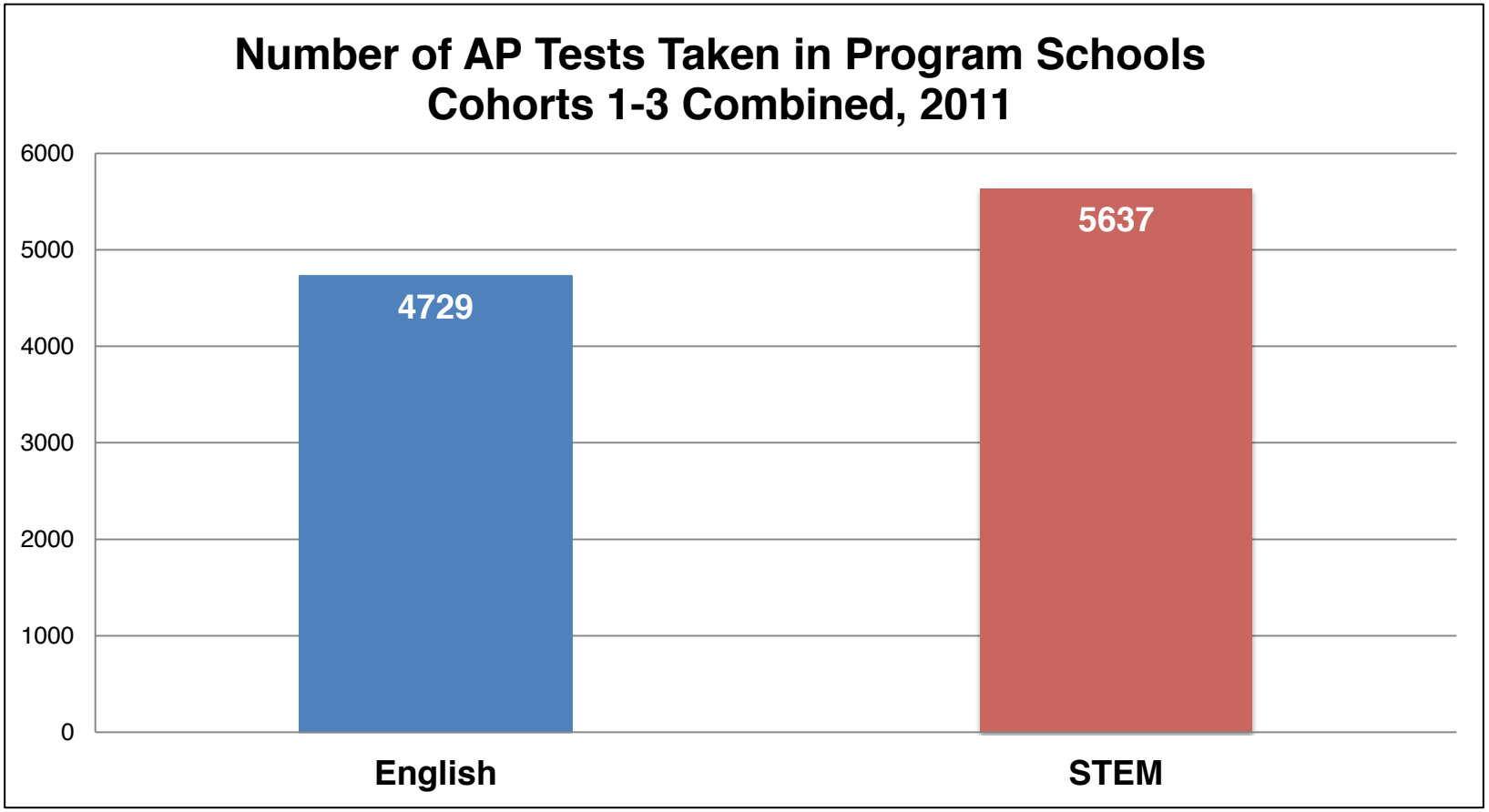

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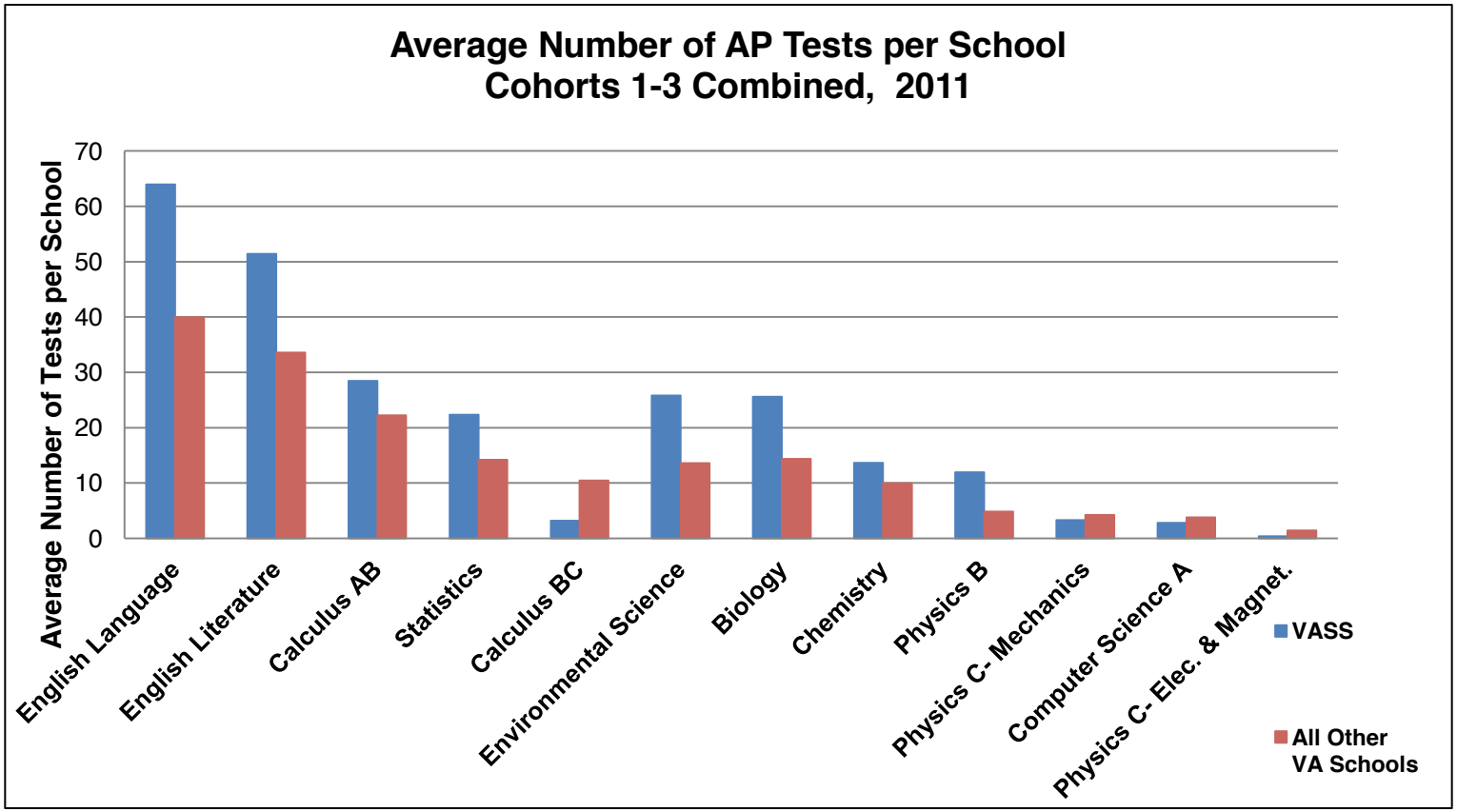
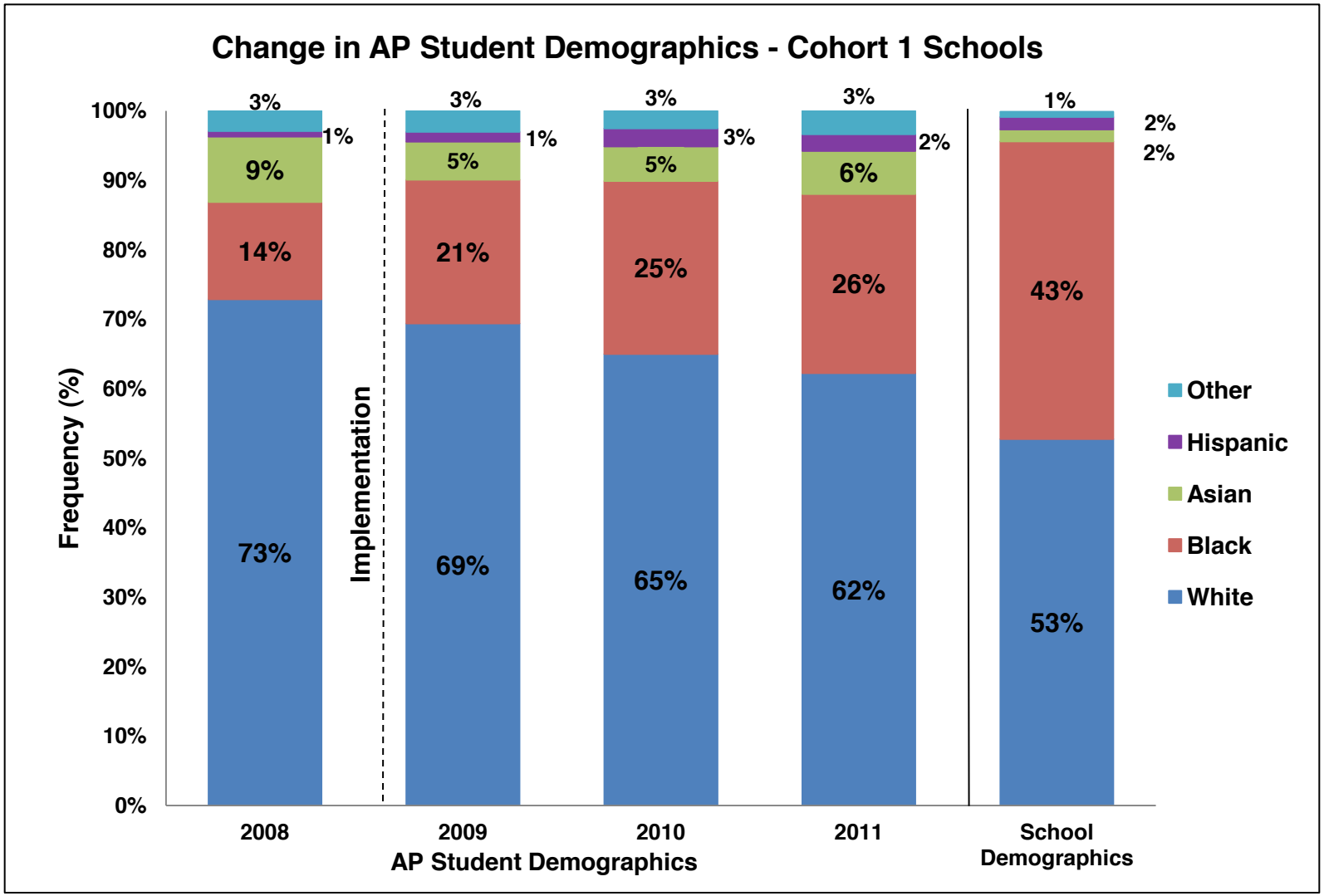
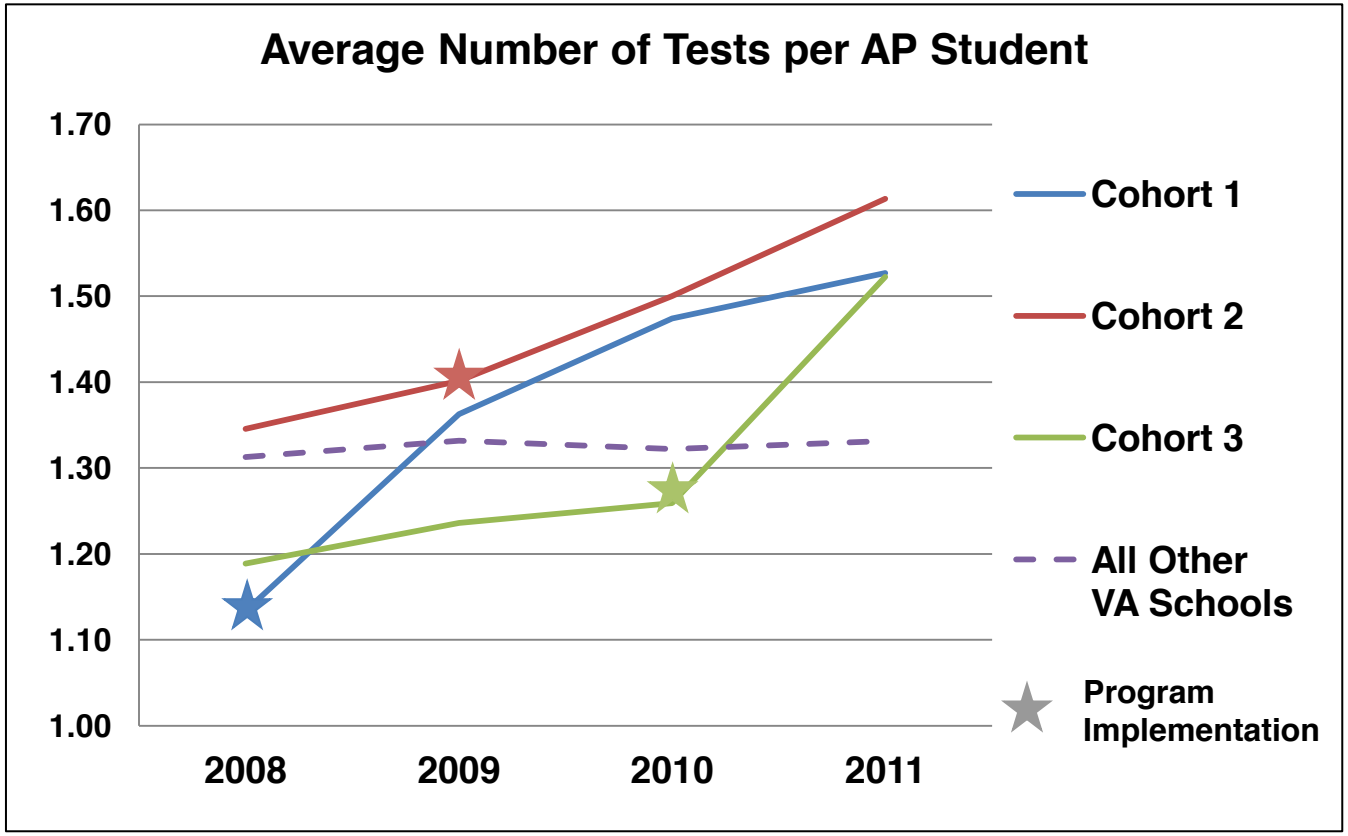


Question 4: Have the demographics of students taking AP changed since implementation?

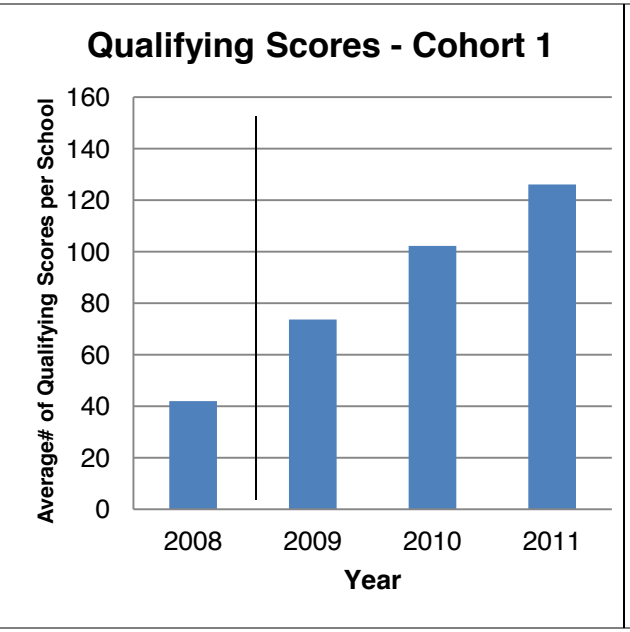


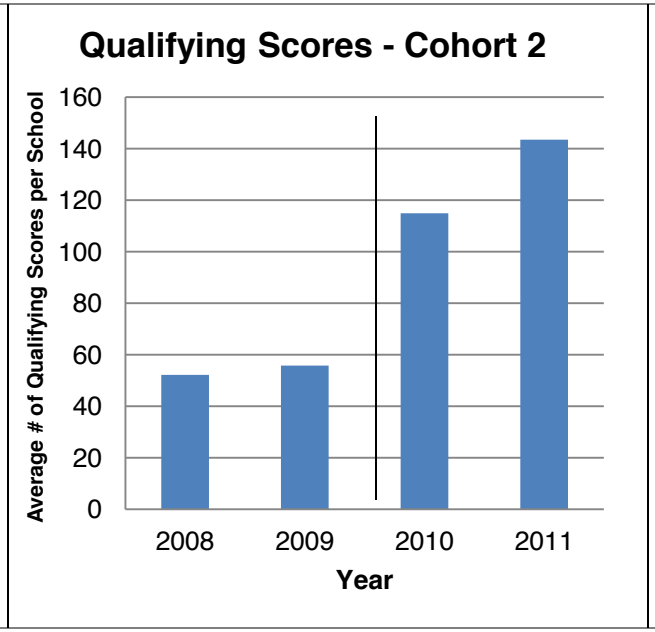
Question 5: Are more students taking multiple AP exams in program schools?

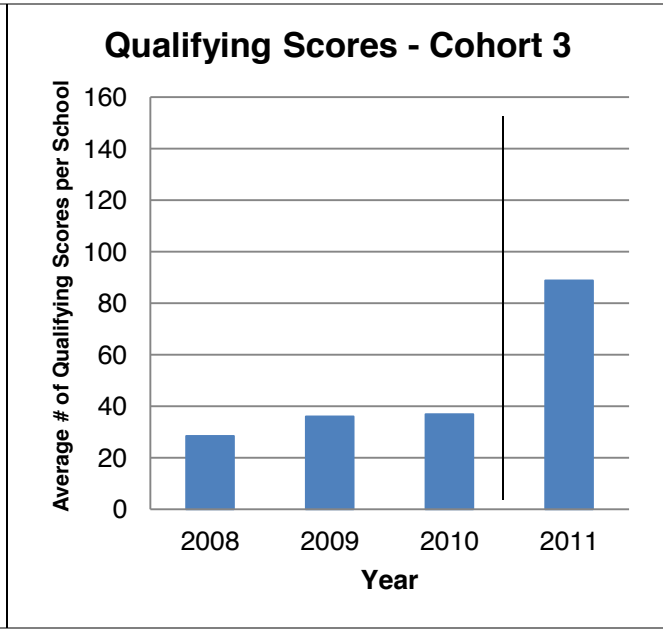


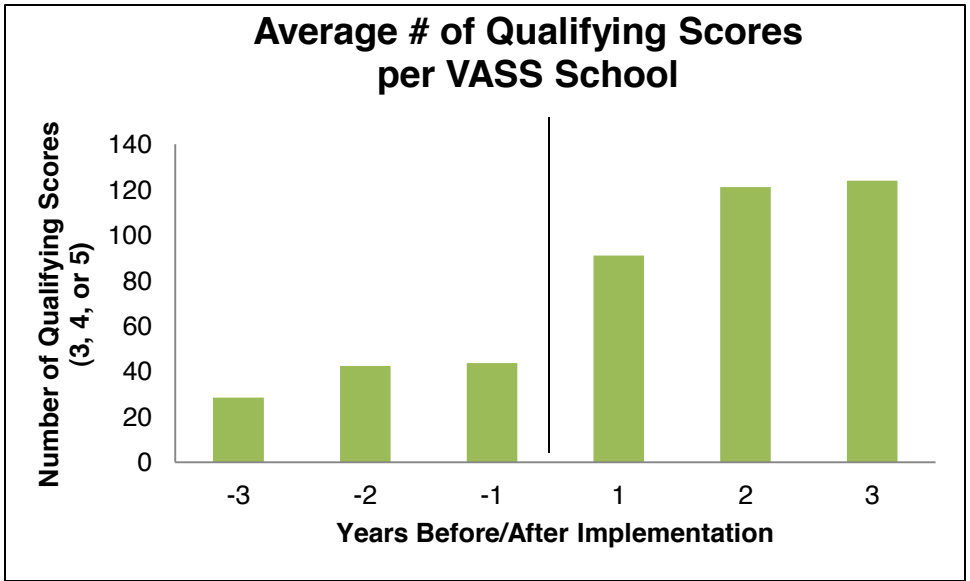
Program Goal: Increase the Number of Qualifying Scores

Question 6: Have the number of students earning qualifying scores increased since implementation?









Question 7: What affects the likelihood of students earning a Qualifying Score?

- Being in Cohort 1 has a negative effect on the chance of earning a QS.
- Gender and race have significant effects on probability of earning a QS.
- Students taking science and math have a lower chance of earning a QS than students who take English.
- Sophomores and juniors have a higher probability of earning a QS than seniors.

Marginal Effects on the Probability of Earning a Qualifying Score, 2009-2010	
	Probability of Earning a QS
Cohort 1 School	-0.223**
Gender: Male=1	0.186***
Race: Asian	-0.157***
Race: Black	-0.745***
Race: Hispanic	-0.354***
Race: Other	-0.242***
AP Subject: Science	-0.484***
AP Subject: Math	-0.240***
Grade: Sophomore	0.755***
Grade: Junior	0.207***
Observations	44,534

*** p<0.01, ** p<0.05, * p<0.1

Program Goal:
Improve Student Performance After High School

Question 8: What are the long-term program effects on students after high school?

- **AP students**:
  - Have higher freshman year GPAs than their counterparts
  - Successfully enroll in and complete advanced university coursework
- **Earning a qualifying score on AP exams**:
  - Is the largest predictor of enrollment in and completion of four-year college
  - Matters most for ensuring minority students' success in college

Recommendations for Program Improvement

- Focus resources on increasing qualifying scores
- Incorporate focus on technology/21st Century Skills
- Require administrator training to encourage buy-in
- Ensure long-term program fidelity

Suggestions for Future Evaluation

- Isolate 3 components of program
  - Teacher Training
  - Incentives
  - Classroom Resources
- Long-term Effects / Higher Education
  - Link high school student data with universities
- Analyze student outcomes after initial grant expires

Comments/Questions

Virginia Advanced Study Strategies:
http://www.virginiaadvancedstudystrategies.org/

Thomas Jefferson Program in Public Policy:
http://www.wm.edu/as/publicpolicy/index.php

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