The Algebra Project's High School Initiative: Impact on Student Achievement and Attitudes

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INTRODUCTION

The Algebra Project's new focus on high schools began when founder Bob Moses was teaching at Lanier High School, Jackson, MS. After working with a group of middle school students who passed Algebra in Grade 8, he followed them to Lanier where he taught Geometry and was also asked to be department chair. He observed the great need for an algebra course for the many Grade 9 students who were struggling with the existing approaches to Algebra I, and were required to pass Algebra I in order to graduate.

Moses spent ten years working with Lanier High School students, reaching out to university based mathematicians who would commit to the needs of these students. The result was two NSF grants for Instructional Materials Development, and a cohort model for high school math education for students who are performing in the lowest state or national quartile on standardized tests.

A team of six university based mathematicians and/or math educators has developed and piloted new materials for Grade 9 and 10, and will continue with materials for Grade 11 and 12, as well as resources for teachers and a professional development program. The materials are designed for daily instruction in long periods (70-90 minutes) in order to prepare students to graduate from high school ready for college mathematics courses. The materials are very well aligned with the Common Core Standards for College and Career Readiness. In fact, the project's approach to both content and "mathematical practices" was similar to these standards before they were articulated.

With a third NSF grant, as well as local funding, schools in several districts are now implementing the Cohort Model (attached): Baltimore, MD; Mansfield, OH; Ypsilanti, MI; Eldorado, in southern IL; and Los Angeles.

Current evaluations are tracking student outcomes on standardized tests, as well as their conceptual understanding, and the development of a peer culture and positive attitudes toward further education.

Two teachers carried out their own studies with district support: Marcus Hung of Thurgood Marshall High School, San Francisco; and Andrew Wynn, of Petersburg High School, Petersburg, VA.

STUDENT OUTCOMES

Materials were piloted in high schools that were low performing as a whole, or in the lowest track of schools were many students perform in the lowest quartile.

Lanier High School, Jackson MS

This school was historically the lowest performing of the eight high schools in Jackson. The evaluation tracked all of the students at Lanier who took Algebra I in 2002-03, and compared outcomes for the Algebra Project students (108 in Grade 9) and those who took Algebra I using traditional materials (86 in Grade 9). The Algebra Project group intentionally included *more* low performing students than the nonAP group, according to counselors, and teachers' observations.. (Unfortunately we did not have access to the Grade 8 records of the students.)

The Algebra Project students had improved outcomes in passing the state Algebra I test on first attempt, and on-time graduation rates. Fewer students dropped out of school, compared to the nonAlgebra Project students.

These effects strengthened after TWO years in the project. This is due to the project's strategy to enable students who failed the state test at the end of Grade 9 to continue with the project's Geometry course in Grade 10, with extra support to re-take the state test. After two years, the advantages of keeping students together was observed by project members. This practice contributed to the formation of a peer culture for persistence and achievement.

By 2006, results showed:

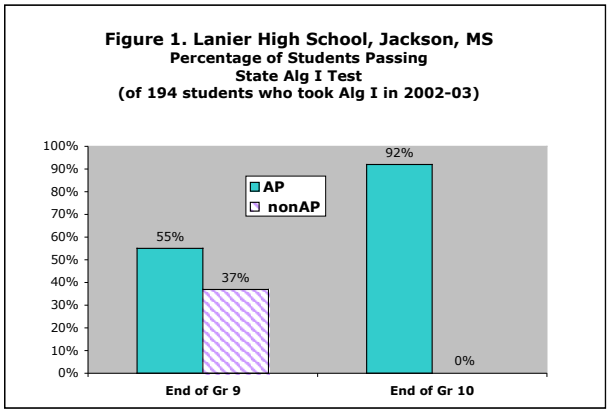
1. increase in the proportion of students who passed the state Algebra I test (required for graduation)

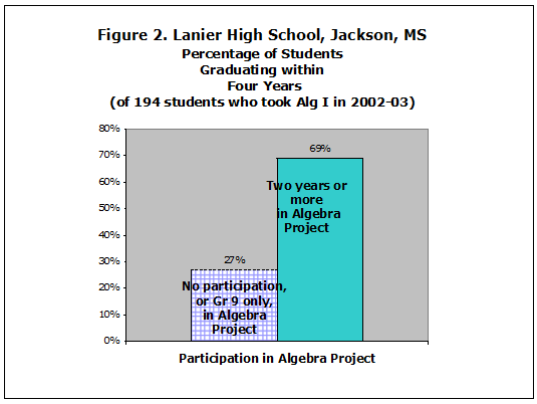
At the end of 2003, all Algebra I students took a state Algebra I test. 55% of Algebra Project students passed, compared to 37% of nonAlgebra Project students. After two years, 92% of Algebra Project students had passed (see Figure 1).

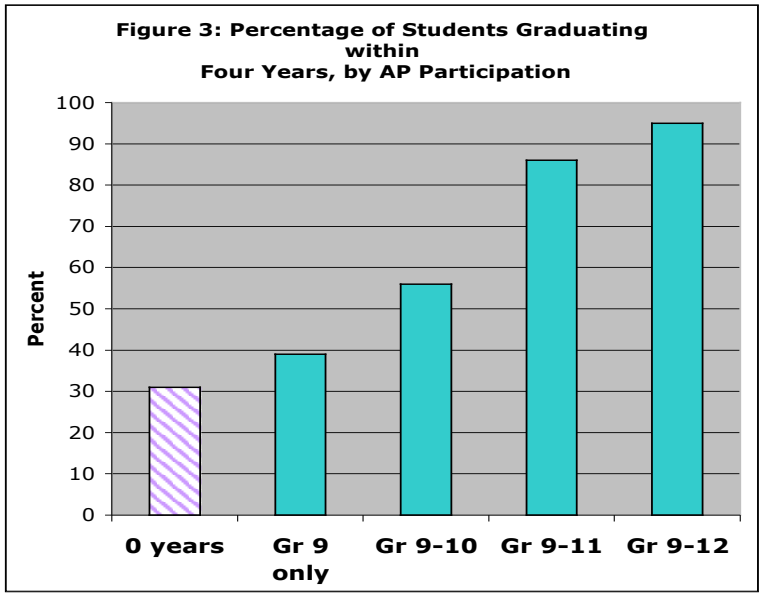
2. increase in the on-time graduation rate

Among students who participated for only one year (Grade 9), 53% graduated on time, compared with 31% of students never in the project; however, if students remained in the project for at least two years…

69% graduated on time, compared to 27% who were in for only one year, or not at all (see Figure 2).







3. decrease in the proportion of students who drop out of high school.

Only 17% of students who were in the project at least one year were known to have dropped out of high school, compared to 35% for those never in the project (based on state records).

Petersburg High School, Petersburg, VA

This school enrolls over 95% African American students, and most are eligible for free or reduced lunch. In the mid 2000s, this high school was one of the lowest performing in the state. After attending the Algebra Project teacher institute at Cornell in summer 2007, three teachers piloted the Grade 9 materials with randomly assigned classes of Algebra I students, in a three semester sequence. The amount of class time was equivalent to a two-semester course, but stretched over three semesters. Between semesters, some of the original students were lost, due to a few failures, reassignment of overage students to the GED track, and transfers out of the district. However, the remaining students, and others on the three semester program who did not

use project materials, were tested on the Virginia Standards of Learning end of course Algebra I test in January 2009.

The results were examined by both Mary West, as a part of internal evaluation, and by Andrew Wynn (one of the teachers), for thesis research for the Master's degree in Mathematics Education at Virginia State University, with the permission and cooperation of the school system.

In separate studies, West and Wynn compared the total scaled scores of the students using the project Algebra I materials, and those using a text. Although the datasets they received from the system were apparently slightly different (West, n=92; Wynn=86), the results are very similar:

Table 1
Means and Standard Deviations on End of Course
Algebra Test: Total Scaled Score in Two Studies
Comparing AP and nonAP Students Tested January 2009

	West Dataset			Wynn Dataset		
	n	Mean	SD	n	Mean	SD
Algebra Project	28	441.63	39.7	25	444.72	38.5
NonAlgebra Project	64	433.0	36.3	61	435.31	35.3
T-test *p*		.31			.28	

In both analyses, the Algebra Project students outscored the nonAlgebra Project students. However, the difference did not reach the convention for statistical significance.

Wynn went on to compare the total scaled scores of the Algebra Project students with the group tested in Spring 2007. This analysis showed differences that were nearly significant, p=.101. This is a more meaningful comparison because no teachers were trained until Summer 2007. The classes tested in January 2009 were taught by project teachers, but using different materials.

Next, Wynn compared students' scores on the Relations and Functions strand only, and found significant differences favoring the Algebra Project students.

Table 2
Means and Standard Deviations on
Relations and Functions Strand
Comparing AP with nonAP students Tested in Jan 2009 and Spring 2007

	n	Mean	SD	*p*
(1) Algebra Project Tested Jan 2009	25	39.00	5.26	(1) vs (2) $p = .002$
(2) NonAlgebra Project Tested Jan 2009	61	34.52	6.32	
(3) NonAlgebra Project Tested May 2007	66	34.20	7.25	(1) vs (3) $p = .003$

Finally, Wynn examined the correlation between students' scores on the Relations and Functions strand, and their total scaled score, and found strong Pearson correlations in four groups: (1) and (2) combined; (1) only; (2) only; and (3) only. The correlation coefficients ranged from .647 to .800, all significant at $p < .05$ level or lower.

Thurgood Marshall Academic High School, San Francisco

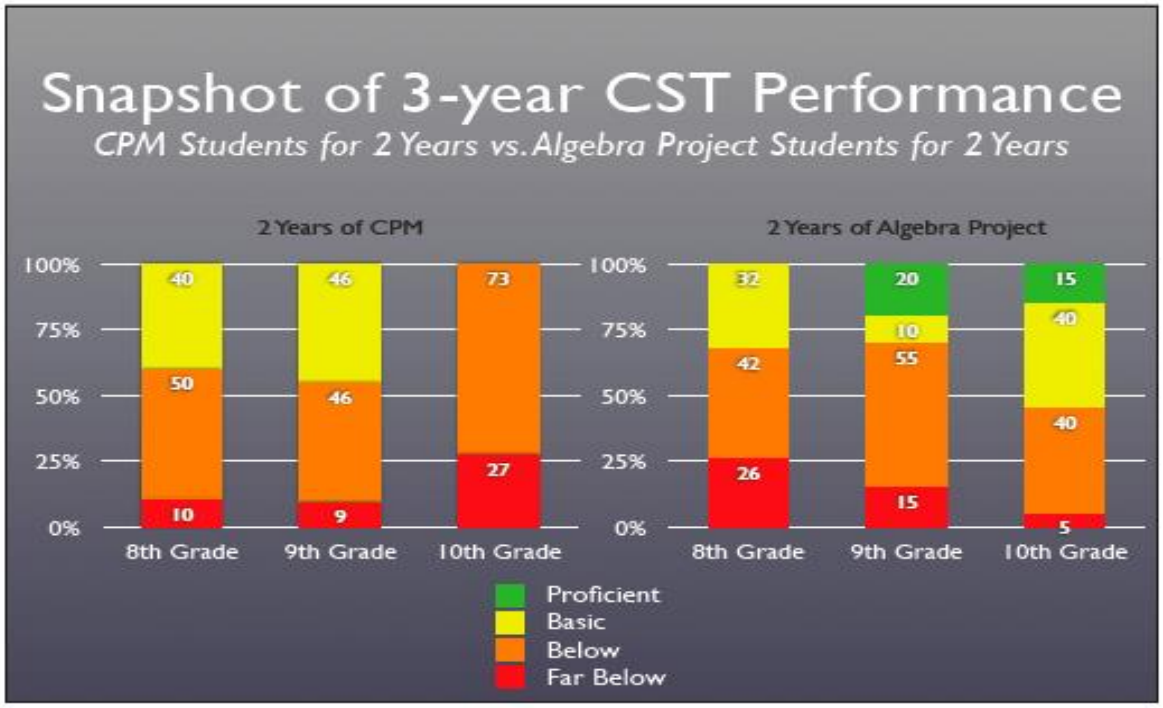
Two math teachers attended the Algebra Project summer institute in 2008. One of them, Marcus Hung, used the district's data reporting system to study his students' success on both the California Standards Test (given at the end of each year) and the California High School Exit Exam. The system allows teachers to follow their own students from year to year. TMAHS has a very diverse enrollment including African American, Latino/a, Pacific Islander/Philipino and Asian students. About 63% of students receive free or reduced-price lunch, and 37%% are English learners.

Before implementing the Algebra Project materials, Mr. Hung was using the College Preparatory Mathematics (CPM) text. He compared his students who used the CPM materials with his students who used the Algebra Project's materials for Grade 9 (Algebra I) and compared their Geometry performance in Grade 10. He also compared students he taught for one year versus two years on each curriculum.

On the high school exit exam taken for the first time in Grade 10, the Algebra Project students fared better than the CPM students, especially after two years in Mr. Hung's class. Those who had been in the Algebra Project for only one year, 47% passed, compared to 35%. Of those who had been in the Algebra Project group for two years, 90% passed, compared to 46%.

Similar differences were found on the California Standards test in mathematics (see Figure 3).

Figure 3: Proficiency Levels of Hung's Students Using the Algebra Project or College Preparatory Mathematics (CPM) After Two Year (% of Students)



Among students in each curriculum for two years, the Algebra Project students achieved higher levels of proficiency. About 15-20% of students scored at the Proficient level, while none did with CPM. The percentage of students scoring at the lowest level (Far Below Basic) decreased over time to 5%, but actually increased to 27% for CPM.

Grade Level Results

West compared the changes in math proficiency of AP with nonAP students at the end of Grade 9, as measured by the state tests (CST), using the district reporting system that tracks students from year to year. These data included the students of both teachers (Hung and Lyon). The reports indicates each students' level of proficiency the previous year, and their proficiency one year later.

At the end of Grade 8, 80% of the AP students had scored "below basic" or "far below basic" compared with 81% of nonAP students. The remaining students in both groups scored "basic" except for one AP student at "advanced" level.

Table 3
Change in Proficiency Level on CST, Grade 8 to 9 (2008, 2009)

	Algebra Project		nonAlgebra Project	
	n	%	n	%
Went up or stayed at same level	41	73%	32	57%
Went down	15	27%	24	43%

The X^2 statistic for this table is 3.19, which is between the $p<.05$ level of significance (3.84) and $p <= .10$ level (2.71). Somewhat more Algebra Project students stayed the same or increased level of proficiency. These results meet the typical standard for reform math curricula of students performing "as well or better" on standardized tests.

Discussion

These first results in Petersburg and San Francisco, added to the earlier success of the first Algebra Project cohort who graduated in 2006 from Lanier High School in Jackson, MS, are building a body of evidence on the potential of the Algebra Project's high school students to meet the goal of passing tests needed for college access. While the comparisons of students in Petersburg and San Francisco necessarily involve only small numbers of students, the results in both sites are promising.

On the goal of advancing into the college prep sequence, the comparison of the Lanier experience and these pilot schools shows that it is essential to gain better control over school and district practices in the design of the college track and in how students are promoted from one course to another. At Lanier, the project was permitted by the school to change that practice for their own students, and to advance students into Geometry even if they had not passed the state test. Under the NSF grant for piloting materials in Petersburg and San Francisco, the project did not attempt to influence those practices. Further research is taking place under a grant from the NSF (DRK0822175) to study a "cohort model" in which students stay together for all four years, and schools and districts become more engaged in issues of student advancement from the beginning.

STUDENT UNDERSTANDING OF THE CONCEPT OF FUNCTION

NSF funded the Algebra Project and mathematician/math educator Ed Dubinsky for basic research on students' understanding of the concept of function. Dubinsky is a leading researcher on this topic. A study of 25 AP students in two pilot sites (Petersburg, VA and Summerton, SC) and 15 at Edison High School in "little Haiti" Miami, indicates that, after working with material on functions, students developed understandings and problem-solving abilities related to basic function concepts -- such as composition,

domain, range, one-to-one and onto -- on a level that compares favorably with understandings of incoming college students, as reported in many studies such as Breidenbach, Dubinsky, Hawks, and Nichols, D. (1992). Their knowledge of functions is even on a par with that of pre-service secondary teachers as reported in studies such as Even (1993).

The results were similar in the Petersburg/Summerton group and Edison group: 36% of Petersburg/Summerton students were able to recognize a function in each representation except for two, compared with 45% of the Edison students.

The results for total score are shown below:

Table 4
Total Score
% of students at each level

Score	Petersburg & Summerton	Edison
>20	36%	45%
10-20	36%	27%
<10	28%	27%

The results on APOS level were also similar, with the majority in both groups between an Action and Process conception. Two Edison students showed evidence of Process level, and more Edison students appear to be at an emerging Process level than in the Petersburg/Summerton group. A fairly large percentage of the students avoided difficulties and errors reported in the literature called conditions UDC, FDC and DEF.

While the results are encouraging, especially given the nature of these schools and the students' low proficiency levels entering the Algebra Project, their understanding must be improved for a full program of college work. The project believes that this can be done in future work with the materials in development for Grades 10-11.

CLASSROOM OBSERVATIONS

The following conclusions were drawn from classroom observations in pilot sites, conducted by the evaluation team under the Program Evaluation & Research Group, Lesley University – a group experienced in evaluation of NSF projects in STEM education.

(a) Students developed positive relationships with each other and comfortable relationships with teachers. The students who had three semesters of the Algebra Project formed positive relationships and with each other and comfortable working relationships with their teachers. This is evidenced in classroom observations, as well as in students' comments in whole group discussions. As one student said during Year 2, "We be family." This was strongest where the students stayed with the same teacher for all three semesters. (Due to scheduling problems, this was not always possible.) During Year 3, when asked their opinions about why students in high school might be disruptive, they offered: Male student: Students might be trying to show off.

But we are all together in this class, no one is out of line. Female student: We are like family in this class, like brothers and sisters. There ain't no point of showing off in this class!"

(b) Students developed more persistence in solving problems and increased in overall productivity: The "classroom culture" differed across sites and some times within sites. Two of the two-semester classes included large numbers of students who were far below grade level, or over-age. These were the most challenging classes for the teachers; but by the end of the year students were spending more time on task.

(c) Nearly all students prefer to continue with Algebra Project materials, rather than enroll regular classes. After one semester, student stopped asking "where's the math" and worrying that they are not really learning math – the reaction of about one third of students in the first months of implementation. In San Francisco, students said that their peers in regular math classes were "jealous" of them. Another said: " It works well even on our people skills. Last year we had to present with (our teacher), to others who wanted to learn about the Algebra Project. It helps build our character, not only math."

(d*) Impact on schoolwork-"resistant" students.* We often find school-resistant students in our classes – students who fell behind academically years ago. Many of them are socially adept, even leaders among their peers. We, as well as teachers and some administrators, have observed students like this who do become engaged in the classroom, and may influence their peers to become more engaged. Administrators often comment on students' engagement and excitement in explaining their work to others.

We believe that the positive impact on students' classroom culture is attributable to the students' ability to access content through the experiential activities, and the classroom participation structure, in which students often work in teams and present out their work, followed by discussion. This method enables students to take more ownership and even compete with each other on math ideas. Also the classroom activities begin like "games", and appeal to students, the activities are designed to lead students from physical experiences to conceptual understanding. They are enjoyable, and often "culturally responsive." However, they are adapted to more than just the students' "culture". They are physical experiences undertaken by the WHOLE class together, first worked through with students' intuitive representations, so that students' "own" them. They are processed through students' own senses (observations, movements). This lays the foundation that allows the hard mathematical work that follows to be meaningful, interesting, and challenging.