Algebra Project DR K-12 Cohorts Demonstration Project

Summative Evaluation Report

January 2014

INVERNESS RESEARCH

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Executive Summary

The Algebra Project DR K-12, funded by the National Science Foundation as a Research and Development Project, addressed the challenge of offering significant STEM content for students to ensure public literacy and workforce readiness. The project's primary purpose was to test the feasibility and effectiveness of a model for establishing four-year cohorts of low performing 9th graders learning accelerated mathematics with the goal of being college-ready at the end of high school. Students would:

- Complete four years of accelerated high school math, pass high school graduation tests, and meet college entrance requirements
- Be accepted to college and place into non-remedial math courses as freshmen
- Develop more positive attitudes towards and be more confident in mathematics and begin to demand math literacy for themselves

Inverness Research's Study

Inverness Research (IR) conducted the summative evaluation for the Algebra Project DR K-12. The evaluation sought to understand the model and articulate its theory of action. It studied the work of the sites to learn about the cohorts, identifying the successes and challenges of the work, and what the essential components of the model are. The full report portrays the work at the individual sites and how the model played out across sites, identifying lessons learned about and the value of the cohort model and the feasibility of more widespread use.

To monitor the progress and developments of the demonstration sites and the work of the AP leadership team, the evaluators attended project-wide meetings, conducted periodic phone interviews with key stakeholders, and made annual site visits for two years. Data collection methods included observations of classrooms and project events; interviews with teachers, families, students, and administrators; and student surveys. Additionally, Inverness talked with representatives of Algebra Project leadership in a formative role and wrote annual updates for NSF.

The Project's Theory of Action

The conceptual model of a cohort specifies five core conditions and experiences:

- Daily 90-minute math periods for four years
- Reduced class size and common planning time for teachers
- Accelerated course content that draws on AP math materials and pedagogy
- Local summer institutes for students for academic and personal development
- Algebra Project professional development and support for teachers

The basic premises of the theory of action are that, in classes of 20 or fewer, low performing high school students will take intensive math courses every year with the same teacher studying non-traditional, accelerated materials taught with a specified pedagogy. In these classes, students have the time and support to develop an academic peer culture. Sites provide local summer institutes and other activities for student enrichment, especially around college and professional culture, and the Young People's Project (YPP) provides training and work experiences that pay students to be "knowledge workers," in contrast to menial jobs that they might otherwise take. A local university faculty member provides support for teachers and links the cohort to a university. A community organizing team forms to advocate for the cohort, creating a community-based movement for quality education and math literacy so that the cohort is not an isolated classroom program. These experiences and conditions will prepare the target students to be college-ready in four years.

Crosscutting Summary of Sites

Eight cohort classes in five schools at four sites began in Year 1. Three sites launched cohorts at one school each, and one site launched them in two schools with a total of 188 students. Some sites grasped the essential dimensions of the model quite independently, and others needed the Algebra Project to offer them more careful articulation of the model and support than they did to fully realize the cohort model. At the end of four years, one site had expanded the cohort model district-wide, continuing to offer one cohort section each year in high school and AP mathematics in their elementary and middle school programs. No cohort classes continued at the other three sites after the first cohort class graduated.

Crosscutting Summary of Students' Experiences

The cohort students, in classes of 20 or fewer, had more time with math and studied different course material taught with different pedagogy than traditional math classes. Some of the course content was accelerated, and some was traditional. Student behavior was often disruptive, particularly during their first two years. Adjusting to AP classes and "seeing" the math in the activities was challenging for students who brought with them histories of disruptive behavior, lack of focus, and sometimes defiance. For these students to engage in math, a subject they were not successful in, in daily double block periods was a tall order. However, during the first two years students matured and attrition weeded out those who were not serious, behavior improved and pedagogy shifted. The predominant lecture-style pedagogy gave way to more group-based, collaborative learning with students explaining their work and answering each other's questions. In the best cases, junior and senior cohort students learned to look to each other for help when they had questions before asking the teacher. In other classes, students continued to need one-on-one attention from their teacher to stay focused.

Cohort students engaged in extracurricular activities that supported their development, and they looked on these experiences positively. Three sites offered cohort students summer institutes annually, which addressed personal growth and enrichment in careers, arts, language arts and math. The Young People's Project (YPP) contributed to most of the cohort students' experiences, preparing students to work in after-school programs with middle and elementary school students. Cohort students had support for college preparation and applications during their junior and senior years. A notable 93% of the seniors said that the project prepared them for college.

The majority of students reported in student surveys that they were more confident in math since being in the math cohort, and that the cohort class had been good for them. They said they liked the way they learned in their math class, attributing their positive attitudes to small class size, working in groups, and helping each other, all of which reflect pieces of the project's theory of action about the kinds of experiences the cohort students need to succeed. A positive student culture developed in most of the cohort classes, which teachers and students often described as family-like. For most students, however, the culture did not center on academics and fell short of the goal of students demanding math literacy for themselves and their peers.

Student Survival Rate

The barebones story told by the numbers is that about a quarter of the Cohort 1 students were college-ready at the end of four years. Fifty-seven students out of the original 188 graduated[1] and fifty of these

[1] The students who graduated from the high school where the cohort was dissolved after Year 3 are not included in this count.

entered college the following fall. A few of these students were eligible for college level math courses as freshmen, but most were not or took courses of study that did not require math. These numbers only hint at the complexity of the diverse stories of different cohorts and different students. Some students left a cohort and came back, some left and were never heard of again, and new ones joined. Trials and tragedy filled the daily lives of students. One student had a baby, another was pregnant and died of a drug overdose, and a third was killed just a week before graduation in a car accident. One student dropped out of school a couple of months before graduation to start work so he could pay for food and housing. The approximately fifty students who enrolled in college in Fall 2013 succeeded in spite of hardships and the disadvantages they entered high school with. It is likely that only a small number of these students would have made it to college without the support of the cohort.

Cross-Site Summary of Teachers' Experiences

Teachers were the lynchpin on which the success of the cohort relied. Teaching the materials was demanding and often required teachers to take a leap of faith to trust that the lessons were important and right for the students even though they were so unfamiliar. Teachers spent extra hours outside of class understanding the materials and planning lessons. Student behavior presented a challenge. Teachers had to build their own personal relationships with the students, and create a student culture of responsibility around academics. They had to prepare students for standardized tests and prepare them for college. Teachers needed to relate to parents, community, and university faculty and sustain these relationships across years. And teachers had to teach full course loads in addition to the cohort classes. Seven teachers out of twelve left the cohorts causing classes to disband or combine. Four of the original nine teachers saw Cohort 1 through four years, and a fifth teacher lost his cohort class when the school dissolved the program. Two of the original nine teachers[2] continued at their schools as cohort math teachers after Cohort 1 graduated. Nevertheless, being an AP cohort teacher was a life changing experience for the ones who persisted, and all of them valued the experience.

Teachers reported that AP professional development was valuable and necessary for teaching the materials, but not sufficient. The support the AP provided for teachers addressed all four professional development goals[3] to some extent, but not all areas were addressed equally, some additional areas needed to be added, and not all teachers had the same level and type of support. Some teachers wanted

[2] The teacher who taught the cohort that was disbanded at the end of Year 3 remained in the classroom as a math teacher but the cohort model did not continue at that school.
[3] The goals for the project's professional development were: To strengthen content knowledge; to become familiar with the modules; to explore student collaboration, communication, and learning; and to assist teachers in building professional learning communities.

more time and different kinds of opportunities to explore the AP modules together. They all needed models for what a cohort class looks like, support for how to design and teach 90-minute periods, effective classroom management practices, and how to develop an academic student culture. They said that the single most important support they had was weekly in-class support with the local university mathematicians or AP professional developer.

Cross-Site Summary of Classrooms

The eight cohort classes started in Year 1 with daily 90-minute or longer math periods. By Year 4, two of the remaining four Cohort 1 classes had reverted back to regular length periods. The classroom climate and nature of the learning experiences in classes evolved. The first two years were most challenging when teachers were learning to teach new materials that were significantly different from traditional high school math while trying to manage students who did not excel in math in longer class periods. *Trip Line*, which is a 9th grade module, engages students in a local trip, which is then used to learn about positive and negative integers and movement along a number line using the 5-step pedagogy. Students did not accept this unusual math unit easily or without complaints, and disruptive behavior plagued classrooms. Ironically, they missed having a textbook and initially thought that the content was dumbed-down for them because the pedagogy was hands-on and unfamiliar. Most teachers responded by initially abandoning group work and resorted to lecture in an effort to control classes. But as students matured and teachers engaged in more professional development, all teachers were able to wed the content with the pedagogy with more regularity; not surprisingly, some teachers met with more success than others.

Quality of instruction and learning experiences

The choice of materials and curricula was a key one but was not uniform across teachers or fully supported. Most teachers used a combination of AP modules, other curricula that they adapted to fit their understanding of AP principles or for standardized test preparation; one class offered a college course in Year 4. The quality of the classroom experiences, therefore, varied widely within a class, module-to-module, year-to-year, and between classes. The common thread, however, was that the content of the modules and other class materials was on grade level or accelerated and not remedial. The AP materials included concepts not commonly found in standard high school math curriculum such as multiplication and addition of matrices in 9th grade, and slope as rate of change and vector representations in 10th. Different teachers achieved different levels of confidence and comfort with these materials. When teachers were able to operationalize the materials, the results were often satisfying and contrasted with traditional math where teachers give explanations of procedures followed by examples. On one end of the continuum a cohort teacher talked about how the materials on symmetry are "brilliant, engaging and very tactile" and led students to understanding and not memorizing that opposite sides are congruent, "because you can see it." On the other end were teachers who found the materials too enigmatic and difficult to create lessons from, and they stopped using them. Teachers also supplemented the modules and spent significant time preparing students for standardized tests during 10^{th} and 11^{th} grades.

The student learning experiences ranged from best cases incorporating collaborative groups, students working together to solve substantive problems, sharing solutions on the board and questioning each other, to more challenged teachers teaching students one-on-one while seated in groups, to traditional lecture. We mostly observed the latter two styles. The pace of classes was often slow, and students were not engaged in thinking about and doing mathematics throughout the full class time.

We saw success in about one-third of the classrooms we observed and partial success in another quarter. When the model is well done, fully supported, and led by an inspired and competent teacher, it can work for students who have a long history of failure in school and mathematics. However, there are many challenges along the way and many ways the effort can fail. Hence it is perhaps not surprising that we saw success in about a third of the classrooms and students.

Components of the Model and How They Played Out

The evaluation affirms that AP's core elements were necessary to the model but also adds that they are not sufficient and the conceptualization of some components needs revising. The one site that was able to most fully realize the model had the highest retention of Cohort 1 students and is the only site where the cohort model persists.

The evaluation findings suggest that teacher selection is foundational to the cohort model. The original cohort model did not specify criteria for teacher selection, so this is an area where the Algebra Project needs to elaborate the model. Central to the model are some of the key features identified by the Algebra Project at the outset. Two of these features are reduced class size with the same students and teachers together for four years because this structure allows for in-depth teaching, relieves pressure from grading, and allows students time to build new habits and community and to buy into the class. Other key features are teacher supports and professional development, student extracurricular enrichment activities, and non-remedial course content taught using a variety of non-traditional pedagogies. However, all three of these components call for refinements and deeper elaboration than the model offered. The teacher supports and professional development are essential for teachers to teach the AP modules and to learn the pedagogy, but the professional development needs to address a broader range of topics offered in a variety of different professional development designs. Accessible and committed university mathematicians are essential to the model as they provide necessary local support for teachers to use the AP materials successfully, but local teacher collaboration also needs to be included as an essential feature of the model. Student extracurricular activities need to be more carefully specified, including a menu of effective activities and suggestions for who is responsible for planning and offering these activities at a site. The conceptualization of math course content as fresh and non-remedial is essential to the cohort model but needs to be expanded to include other materials because even though the AP materials are valuable, they are not sufficient course content for four years. The AP materials also need revising to be more accessible to teachers and to provide them the support that standard high school curricular materials do. Ninety-minute math periods may be most important for the first two years and not necessary for all four years.

Community support, a key component of standard AP work, is essential to the cohort model as it changes the nature of a cohort endeavor from an isolated classroom program to a larger community concern and contributes to sustainability and expansion. More research is needed to understand the extent to and ways in which the Young People's Project (YPP) work contributes to student success.

And finally, the cohort model needs to acknowledge and provide for remuneration of teachers for the extraordinarily high workload required for creating a successful cohort.

Lessons Learned and Implications

The model makes a valuable, if costly, contribution to the field as a viable reconceptualization of teaching, learning, and support for the target students. It offers promise for stopping the downward spiral of failure by shifting the mindset about what works for these students away from the common practice of remediation. Lessons learned from the work are:

- The model holds some promise but also needs some refinements. It is flexible enough to implement in a large metropolitan area serving inner city students of color, as well as in a high poverty all white Appalachian mining community.
- The per-student investment in terms of the cost to schools is high and calls for recalibrating expectations around what reasonable costs are for an intervention program that starts with high school students with well-established histories of poor performance, negative attitudes towards math, and lack of confidence.

- The most essential single element of the model for student success is teacher selection. A cohort teacher is a practiced teacher who has strong knowledge of mathematics, is open to change and willing to learn non-traditional content and ways of teaching, and knows how to relate to and engage with the community of students. She is willing to devote more time to the cohort than to a typical class. For the right teacher, the experience can be a rewarding, life-changing professional experience. We also hypothesize that a stronger teacher community would help support these teachers as they face challenges on many fronts.
- Cultural and racial identities are important considerations in cohorts for students, teachers and community members and need to be addressed explicitly in teacher selection, professional development, and classrooms.
- Teachers need expanded professional development that includes regular opportunities to meet with other AP teachers to reflect on quality of teaching; classroom management; design for 90-minute classes; developing an academic student culture; the role of race, ethnicity, and community; and visual models of cohort classrooms.
- Community engagement and support sustains cohorts because without community advocacy, the program becomes isolated and loses visibility. The bulk of evidence suggests that one teacher teaching a cohort class in a school is insufficient to generate the advocacy needed to sustain and expand the cohort model within schools and districts: the cohort model persists at the only two demonstration sites that had organized community support. The Algebra Project notion of situating a cohort within a movement that demands math literacy relies on community engagement. However, to organize the community requires special skills, knowledge and connections that most sites needed outside support to learn how to do.

Another way to think about the investment is that 66 students who may not have graduated high school, and who most certainly would not have taken four years of non-remedial mathematics, succeeded in doing both. Perhaps we need to recalibrate our expectations around what reasonable costs are for an intervention program that starts with high school students who already have well-established histories of poor performance, negative attitudes towards math, and lack of confidence.

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I. Introduction

Background

The Algebra Project DR K-12 was funded by the National Science Foundation as a Research and Development Project. The project's primary goal was to test the feasibility and effectiveness of a model for a four-year math cohort, which the Algebra Project first developed at the lowest performing high school in Jackson, MS and piloted at two other locations in different contexts prior to this grant. Dr. Robert Moses' work in the Civil Rights Movement in Mississippi in the 1960's and the Algebra Project, which he started in 1985 in Cambridge, MA, informed the conceptualization of the model and the proposed work of the project. The target population for the model is high school students who score in the lower quartile on standardized tests in mathematics in 8^{th} grade. The primary goal of the model is, in four years of high school, to prepare participating students to enter college and to be prepared to take non-remedial mathematics college courses.

Evaluation and Purpose

Inverness Research (IR) conducted the summative evaluation. The evaluation aligned with the goals and intent of the project and provided an independent perspective on the project's work. The evaluation activities were aimed at learning about and portraying the theory of action of the project and documenting the cohort model as it played out at the four demonstration sites, identifying the successes and challenges of the work, and summarizing the lessons learned about the model. A second intent of the evaluation was to codify the Algebra Project's cohort model, assessing its value and feasibility for a national audience who is interested in supporting the same student population.

During the first two years of the project, Inverness Research monitored the progress and developments of the demonstration sites and the evolving work and thinking of the AP leadership team by attending annual meetings of the project and conducting phone interviews several times annually with demonstration site point people and classroom teachers. In the third and fourth years of the project, Inverness conducted annual site visits to the cohort demonstration sites to learn firsthand about the cohorts, observing classrooms, interviewing key players and students, and collecting student survey data. Additionally, Inverness periodically talked by phone with representatives from the project leadership team in a formative role and wrote annual updates for NSF.

The domains of the evaluation and questions that guided data collection and analysis are identified in the table below.

Evaluation Domains and Questions

Summative Evaluation Domains	**Summative Evaluation Questions**
Explicate the project's theory of action	What are the design features of the cohort model? What are the premises on which the core features are based? How does the project conceive its purpose and goals, and how it will achieve them?
Document and portray the cohort model as it was realized at the four demonstration sites	In what ways and to what extent were the sites able to realize the cohort model? What were the experiences of the sites, students, teachers and classrooms?
Analysis of what contributed to student success	In what ways and to what extent was the model successful in meeting the goals of the project? What are the lessons learned about the model and the work? What are the implications for the cohort model and our knowledge about successful

	strategies for addressing the needs of low performing students?
Assessment of the contributions, value and feasibility of the cohort model for supporting the success of the target population	What capacities remain at the schools at the end of the project? What is the cost/benefit ratio for the cohort model? What is the feasibility of widespread use of the model?

Methods and Data Sources

Inverness used interviews, participant observation of project activities, and observations of classes and other school- and project-related activities on site visits as data sources. We interviewed local university point people and stakeholders, school and district administrators, teachers, students, parents, and community members. A student survey captured the participants' attitudes and dispositions as math learners in the last two years of the project. The student sample was focused on the first cohort but included students from subsequent cohorts at some sites.

This report primarily draws on the data from the Cohort 1 students. Inverness' evaluation work did not include assessment of student achievement. The internal evaluators took responsibility for that aspect of the work, but the teachers and university liaisons at three sites shared these data with Inverness Research.

This Report

The intended audience for this report is the Algebra Project, the National Science Foundation, and educators interested in improving educational opportunities for low performing students.

Six sections follow. Section II explicates the theory of action of a cohort and the basic premises behind the model. Section III offers a cross-site summary of how the cohorts played out at the site level, for students, in classrooms, for teachers, and community involvement. Section IV discusses the cross-site outcomes of the cohorts, and Section V assesses the essential elements of the model, and its value and feasibility. Section VI offers lessons learned and implications for future work, and the last section offers concluding thoughts. Appendix 1 is a numeric depiction of the project by year and site across a variety of dimensions such as number of cohort schools, students, classes, teachers, students who participated in the summer programs, and math content and materials used. Appendix 2 includes profiles of the four demonstration sites.

II. The Theory of Action

The conceptual model of a cohort relies on five features, which the Algebra Project called Cohort Characteristics. The project hypothesized that these features were essential to prepare low-performing entering high school freshmen to do college level work in four years of high school mathematics. The five features of the model are as follows:

- Reduced class size, 90-minute math periods daily, and a common planning period for Algebra Project teachers when there are multiple teachers
- Four years of math for students
- Math content that is experientially-based and taught using AP pedagogy
- Summer institutes that are locally designed to enhance cohort students' academic learning and personal development
- Annual professional development institutes and follow-up local support for teachers using the math materials

The project recommended, but did not require, additional features to be incorporated at the discretion of the sites. They included developing a community movement to advocate for quality education and the cohort intervention; offering support to students in English language arts; support from counselors for individual students and small groups; enrichment activities for overcoming isolation; and support for college entry and introduction to "knowledge based" jobs and careers.

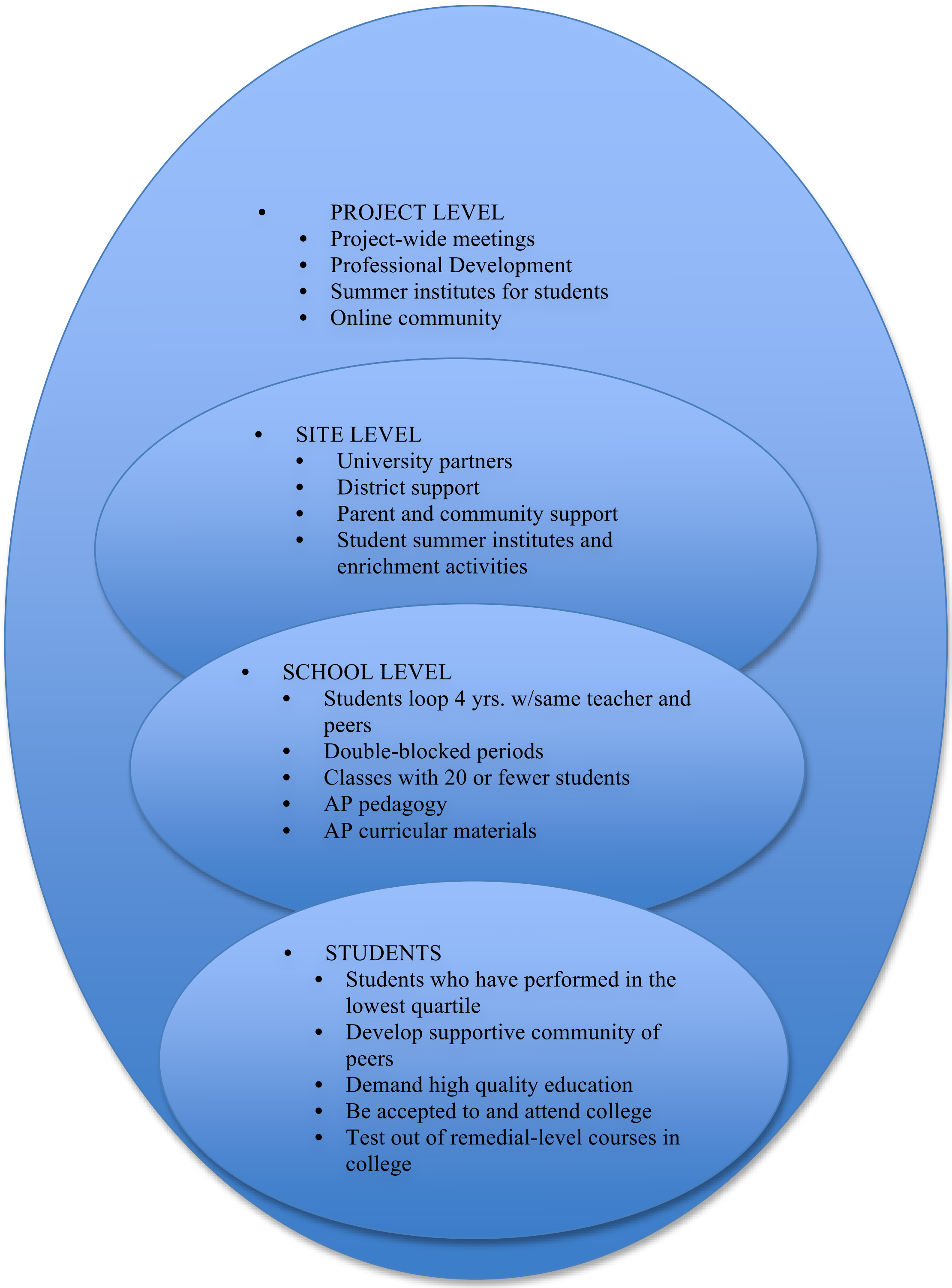


Figure 1. The Cohort Theory of Action

The basic premises of the theory of action for the AP Cohort model are that, in classes of 20 or fewer, low-performing high school students take intensive math courses every year with the same teacher, studying non-traditional, accelerated materials taught with a specified pedagogy. In this structure, students have time to cover the math concepts in depth and to catch up on their math skills in a supportive climate, in order to develop a peer culture focused on academic success. Sites provide local summer institutes and other activities for student enrichment, especially around college and professional culture, and the Young People's Project (YPP) provides training and work experiences that pay students to be "knowledge workers," in contrast to menial jobs they might otherwise take. A local university faculty member provides support for teachers and links the cohort to a university. A community organizing team forms to advocate for the cohort, creating a community-based movement for quality education and math literacy so that the cohort is not an isolated classroom program. A set of assumptions underlay these experiences and conditions:

- The AP has the capacity to effectively communicate the model to the sites so sites can create their own version of cohorts.
- The AP has the capacity to provide effective professional development to prepare teachers to fully realize the cohort model in their classes.
- The local university point person has the knowledge, expertise, support, and commitment needed to form the site and support the cohort class(es), including the cohort math teachers, district and school administrators, and parents and community.
- A student culture will develop in the cohort that promotes students taking responsibility for their own and their cohort peers' learning. This culture will create positive peer pressure to motivate this population of students to persist in studying accelerated math.
- Local sites have the expertise and capacity to design and offer extracurricular enrichment activities to broaden students' interaction with the world such as local student summer institutes, fieldtrips to colleges and other college preparation, and connecting with the local Young People's Project to offer opportunities for paid work as Math Literacy Workers (MLW).
- Teachers can simultaneously learn about the AP modules (Algebra 1, Algebra 2, geometry, polynomials and modular arithmetic, statistics, trigonometry, discrete mathematics

and classical functions) and effectively teach them using Moses' five-step process,[4] as well as other practices such as students working in groups, presenting to their work to classmates and participating in whole-class discussions.

The primary anticipated outcomes were that cohort students would:

- engage with their courses and successfully complete four years of accelerated high school math;
- be college-ready in mathematics at the end of four years of AP cohort mathematics classes, having passed high school graduation tests, scored well enough on SAT or ACT to meet college entrance requirements, and met coursework requirements for college entrance;
- be accepted to and attend college, placing into credit bearing, non-remedial math courses their first year of college;
- develop more positive attitudes towards and improved confidence in mathematics; and
- develop a peer culture in each classroom that motivates and sustains students through four years of accelerated high school math, and that encourages students to demand math literacy for themselves.

III. How the Cohorts Played Out

The Sites

Four demonstration sites formed and started nine Cohort 1 classes in five schools. A strength of the design of the cohort experiment was that the five schools were in different geographic and cultural pockets of the country – two high schools in a large urban district, one in Southeast Michigan, one in Ohio, and one in Southern Illinois. This geographic diversity allowed for learning about the model's adaptability and feasibility with different populations of students and in different communities. The two large urban schools served primarily African American and Latino students. The Southeast Michigan and Ohio high schools were both in moderate size urban contexts and served primarily African American students. The Southern Illinois high school was in coalmining country adjacent to Appalachia and served all white students from

[4] 1) Mathematically-rich physical experiences; 2) Pictorial representations/modeling of events; 3) "People Talk" or intuitive language; 4) "Feature Talk" which is structured language about events; and 5) Symbolic representation of events (Moses and Cobb, 2001)

primarily working class, coalmining families. All sites found that the cohort work was demanding of time, energy and commitment. Annual numeric profiles for the four sites are in Appendix I and narrative profiles detailing the structure and work of each of the demonstration sites can be found in Appendix II.

The sites faced many similar challenges as they worked to adapt and realize the model, but they also had site-specific challenges and developed unique characteristics. Some sites grasped the essential dimensions of the model quite independently, and others needed the Algebra Project to offer them more support and careful articulation of the model than they did, in order to fully realizing the cohort model. For instance, some sites readily understood the central role of the teacher and established careful selection criteria, while others did not. Two sites offered broader academic support for cohort students including English language arts as well as in math, but the others did not. Some sites had university STEM faculty as the liaison with the schools and others did not. Some sites were able to establish community support and other sites never achieved this dimension of the model. The Algebra Project expected all sites to conduct their own research on the cohort experiment, but the communication of the guidelines and expectations for the research were unclear. As a key player at one site said in reference to the lack of guidance from the Algebra Project, "We know that they know more than they articulate that they know, but they sometimes don't know how to convey what it is that they know and they don't even understand that they need to convey it. There is lots of passion, but basically you had to invent it on your own and there was nothing in writing." The communication about the model and support to the sites from the Algebra Project occurred in large annual meetings, in personal site visits periodically, and by phone.

As the model played out, district and school administrators in the four districts gave their support to the program at the outset, but over the four years, this support also varied by site. It remained strong at some sites and flagged at others. All sites launched new cohorts after the first one, and one site continued the cohort model after the four years of Cohort 1. The Cohort 1 class at this one site had the highest retention of students across the four years of any cohort class – 14 of the original 19 students (74%), graduated in 2013.

At a second site, a nationally affiliated community organizing group helped maintain superintendent support and building administrator support for the four years of Cohort 1, but the cohort model did not continue at the two cohort demonstration schools after the completion of Cohort 1. A third school in this large urban district embraced the AP cohort model in all of its math classes, and the Algebra Project team's energies shifted to this one school, which was not a cohort demonstration school.

At another site, administrator support met the original agreement to offer the program for four years, but after the first year, the program slipped out of the public's eye, and there was no coordinated effort to generate interest for sustaining cohorts. At the fourth site, the district and school terminated the cohort program at the end of Year 3 without consulting the university partner, because administrators did not think it was meeting the needs of the target population based on test score data, and the program was costly. At this point, the principal at the high school had changed three times and the school was going through restructuring.

All four demonstration sites made an enormous investment in the cohort students regardless of their final status. This story is told in some detail below.

Student Experiences in Cohorts

The barebones story of how the Cohort 1 students fared is that about a quarter of them were successful. The numbers only hint at the complexity of their stories, however. Classes formed, disbanded, combined. Some students left a cohort and came back, and some left and were never heard of again. The daily lives of students were filled with trials and tragedy. A couple of students had babies, and one of these young mothers died of a drug overdose. Another student was killed just a week before graduation in a car accident. One student dropped out of school a couple of months before graduation to start work so he could pay for food and housing. His cohort teacher led an effort to get him back to school in time to graduate. Approximately fifty of the original 185 students enrolled in college in Fall 2013. These students succeeded in spite of the hardships in their daily lives and the disadvantages they entered high school with.

- Math class experiences

The cohort students had more time with math and studied different course material taught with different pedagogy than in traditional math classes, but the learning experiences they encountered in their cohort math classes varied widely. The content of the AP modules that students learned was often accelerated and different from regular high school math courses, but most teachers also supplemented the curriculum with lessons they created from standard textbooks and test preparation materials. Most teachers spent significant time preparing students for state standardized tests and SATs or ACTs during sophomore and/or junior years.

Inverness' student focus group interviews and two years of student survey data suggest that the Cohort 1 students looked on their cohort experiences positively. Ninety-one percent of the senior Cohort 1 students agreed that the Algebra Project cohort class had been good for them and 79% would choose to do it again if given the opportunity. Ninety-three percent of the students said they liked the way they learned in their math class, and highlighted specific aspects that they liked such as small classes, working in groups, and helping each other, all of which reflect pieces of the project's premises about the kinds of experiences the cohort students needed to succeed. Students said:

> "Learning is easier. Plus more hands-on interacting. Fewer students = better."
> "The small classes. I like how I work with the same students so I know them well."
> "We're able to be in groups and there is less people in class so that gives the teacher the chance to help everybody individually."
> "It's a small class and there are students I can ask for help if I need it."
> "I get the help and attention I really need and it seems easier."

Students often found the pace of classes slow and repetitive, but some students justified it as necessary for learning the concepts well. The following three student quotes are representative:

> "I think we work on the same subject for a long period of time and I don't think that is necessary."
>
> "We talked about lines for a month and a half."

> "Our pace is slower, but it is because we are working completely through until we completely understand it."

The slower pace may have well served the 66% of the senior cohort students who said that they understood math better from being in the cohort. The same percentage found math easy most or all of the time. A senior Cohort 1 student said that she understood and liked math better since being in the cohort:

> "I used to hate math and now it is like I am okay with it. Like if you explain it to me, then I get it."

Sixty-eight percent of the senior cohort students who took the survey said that they were more confident in math since being in the cohort. All teachers noted that students' confidence in math and in themselves improved over the four years. A cohort teacher said,

> "The number one thing [students have benefited from] is confidence. Confidence in their academic ability and then the next thing is I think it enhanced their critical thinking skills because in the four years, I don't have to question so much any more. 'Why? How did you know? Well does that make sense to you?' They question themselves, which is critical."
>
> --Cohort teacher, Year 4

Some students, but not all, benefited from their cohort experience by learning how to make mathematical arguments, which is a real world skill that students can apply to many life situations. A teacher during Year 3 explained:

> "They have an opportunity to think, and…they may have just a different picture of what it is to think mathematically than other students. I think they have an opportunity to see what it feels like to really have a chance to learn something, rather than, 'we are going to spend a week on Chapter 1 and then we are going to spend a week on Chapter 2 because we have to get through all of this content.' I think these students have a chance to sort of dwell on something until they get it, and then we move on to the next thing. They have a chance to see what it is like to engage in a mathematical argument. These are all of the things that… I think

> those opportunities are out there in this class, which is different than saying, 'these are the things that are happening in this class.' I think some students do take advantage of those opportunities, but not everybody does." --Cohort teacher, Year 3

Similarly another teacher said that he noted gains in students' ability to argue the logic behind a problem more than in their procedural fluency:

> "They are not that strong in procedural fluency, [such as] knowing 'when do I make a common denominator with fractions and how do I do that with rational expressions...' They are not going to be strong in that stuff and it is not something that interests them. But developing an argument and understanding the logic behind it, reasoning and being able to tell someone else that their argument really doesn't make sense, they are stronger at that than procedures, which is definitely a more important skill in terms of the real world." --Cohort teacher, Year 4

The discrepancy between the potential benefits of the cohort versus what students were actually taking advantage of—referred to in the first teacher's quote above—persisted for the first two to three years because of behavioral problems and students' lack of focus. By senior year many of the disruptive students had either dropped out of the class or matured enough to participate, and the students who remained said that the climate of the classes was more conducive to learning. Almost half of the students said that there was nothing they could think of that they didn't like about the class. Individual students' complaints touched on key characteristics of the program such as scheduling difficulties, e.g., not getting to study Spanish because of scheduling conflicts with the AP cohort due to the double period and the length of class, and that the cohort was unique, not at other schools, and had no textbooks.

- Cohort peer culture

Development of a positive peer culture, which motivates students to learn accelerated mathematics and demand math literacy for themselves and their peers, was postulated as an essential feature of the student experience. By senior year some of the Cohort 1 students had learned to help each other and take responsibility for each other's learning. On the student survey, 70% of the senior Cohort 1 said that they felt responsible for helping their classmates. To the students, this meant explaining work to each other when someone needed help. Four students from different sites said:

> "I explain to them if they don't get something and I do."
> "If I understand, they should too. It's only fair."
> "Mentor, tutor, brotherhood"
> "Reword everything"

A teacher elaborated on the difference between the cohort student culture and that of her regular students:

> "Anytime they saw each other getting off task, like 'this is hard' and putting their head down, someone at the table would have encouraged them, 'No we got to get this done, we only have such and such minutes.' That is what the project has taught them or allowed them to grow into, where [for] traditional students, if it looks hard for a couple of seconds, they are like, 'Ah, I am going to skip that one.' And so, they [the cohort students] have grown confident enough to know that, 'no, we can solve it. She wouldn't give it to us, if we couldn't.' The level of trust [is there]."

However, the student culture was not focused on academics in all of the senior classes, and it fell short of students' learning to demand math literacy for themselves and their peers. Some teachers continued to struggle with how to move the Cohort 1 peer culture from a social to an academic orientation in Year 4. Students continued to be more driven by meeting requirements than by an understanding of the personal power and larger societal implications of demanding math literacy for themselves.

- Students' extracurricular experiences

The Cohort 1 students experienced a wide variety of extracurricular activities such as local student summer institutes, or "math camps," working with the Young People's Project (YPP), special events with Dr. Moses, family nights with parents, college preparation, and visits to college campuses. The YPP contributed to the student experience in three of the five Cohort 1 classes,[5] preparing students to work in after-school programs with middle school and elementary students as paid tutors in mathematics and providing in-class activities to promote self-esteem and the growth of self-perceptions as college bound students. However, Cohort 1 students participated most consistently as Math Literacy Workers (MLW) at only one site.

At three sites, students attended summer institutes which addressed personal growth and enrichment, careers, arts, language arts and math for three summers, and for two of these sites the summer institute was offered jointly for five years from Summer 2009 through 2013 after Cohort 1's senior year. Some of the summer institutes offered opportunities for students to live on the college campuses for several weeks and interact with university faculty in activities such as shadowing a person in a career of their choice. A senior Cohort 1 student said that the student summer institutes held on college campuses influenced his thinking about college:

> "When we went to math camp it was fun and it made me want to go to college, when we went to stay at a college."

All sites offered cohort students support for college preparation and applications during their junior and senior years. At some sites these activities included visits to colleges and regular family nights where students presented mathematics and worked on college applications. At one school YPP helped students with writing personal statements and completing applications and FAFSA forms. The extracurricular activities, which focused on preparing students for college, were quite successful. A notable 93% of the seniors said that the project prepared them for college.

<u>The Cohort's Benefits to Students</u>

Students who stayed with the cohort for four years benefited in multiple ways. Their confidence and belief in themselves as successful students increased. Teachers noted that students began to voice their opinions, exercise critical thinking and participate in classroom decisions. They

[5] YPP worked with a few cohort students at one of the two schools at the fourth site but never developed a strong presence. They worked more intensively with students at other schools in this area but not the cohort schools.

learned how to be successful learners. One teacher explained the primary student benefit in terms of increased confidence as successful learners:

> "For me it is a community of learners. We have taught them how to be successful learners… What we have taught them is they need support people, they need people like me, and they need people like [the university mathematician] that they can go to …but then they also need their friends. They need to know how to study in groups because that is huge in college and …so we have created that atmosphere. They now know that they can do well in group studies. They have also the idea that… math can be something that they can achieve and so that is huge... So I think the idea of creating…how to be successful learners in lots of different ways and talking about it. Now they can talk about mathematics because they can support their work." --Cohort teacher, Year 4

Students learned about colleges and financial aid, took the necessary tests for college entrance and applied to colleges. They began to see themselves as students who were college bound. Students who had histories of disliking and performing poorly in math began to like it and understand it. Some students completed four years of high school math successfully, graduated from high school and entered college the following fall.

Cohort Classrooms and Curricula

All cohorts started in Year 1 with at least 90-minute math periods, and some even longer because the school's master schedule dictated two full periods for math. One of the original eight Cohort 1 classes stayed with the same teacher for all four years, and as mentioned above, this class had the highest student retention of any of the original classes. In three other Cohort 1 classes, a subset of students were with the same teacher for four years, but other students joined after the first or second year when students dropped or their cohorts disbanded. Combining classes was a difficult process that required time and the teacher's attention because students had bonded with their original cohort classmates and the class culture in each cohort was different. Scheduling 90-minute classes was a challenge for all schools. At three sites this configuration meant that cohort students could not take electives such as foreign languages or special programs and stay in the cohort with 90-minute periods, so some students opted out of the cohort. By senior year, only two of the remaining four classes still had 90-minute classes.

The Algebra Project modules provided much of the math content for the first two years for all except one class,[6] and the modules were on grade level or accelerated. In Year 1, all cohort students learned Algebra 1 concepts from Algebra Project's Trip Line, and functions and introduction to matrices from Road Coloring. Studying matrices to the extent the AP cohort students did in Year 1 is not usually covered in regular high school math courses, as a cohort teacher pointed out:

> "You don't teach matrices in 9th grade, matrix addition, matrix multiplication, composite functions, but it comes up in Road Coloring. Now they are exposed to it, not on the level that they will be when they get it later on, but the fact that they are exposed to it, and they can do it—that is pretty cool." --Cohort teacher, Year 2

In Year 2, students at three of the four cohort sites learned geometry from the AP geometry materials and linear equations, slope as rate of change and vector representations from Racing Against Time. Cohort students at the fourth site learned from materials the teacher and AP professional development specialist created using the textbook *Discovering Geometry,* as a primary resource. Starting in Year 3, the junior cohort students learned from a variety of materials, some of which were AP: polynomials, trigonometry, and pre-calculus. Teachers at one site used the AP modules almost exclusively in Year 3: AP quadratics, trigonometry, and Flagway.[7] At another site, the teacher used a Holt Algebra 2 textbook for content and created real-world contexts for teaching and making sense of the concepts. At a third site, the teacher continued to create materials from textbooks using metaphors to frame the lessons and a combination of AP pedagogy, one-on-one, and traditional lecture.

In Year 4, different cohorts studied different math topics from a variety of materials, some created by AP and others not. They included AP modules on discrete math and polynomial

[6] The teacher in this class found the modules difficult to translate into teaching and thought that the students were better served by materials adapted from textbooks and online sources.
[7] Flagway is a game created by Dr. Moses in which students navigate a Flagway, or course of "radical" paths based on the rules of the game, which are derived from the "Mobius" function.

calculus, and statistics from textbooks and adapted university materials; one cohort took a course for non-math majors from a local university taught by the university liaison.

Most of the AP materials still need to be revised to provide teachers the support that standard high school curricular materials provide such as suggestions for homework, answers to problems, and assessments. The Algebra Project's Teacher Resource Materials (TRM) team began to collect teacher-created materials of this nature online, but they are not available for all lessons in all modules, they are not uniform in presentation, and they are not integrated into the course materials. To make the job of a cohort teacher more manageable and to better serve students, the Algebra Project needs to continue to improve the modules along these lines.

- Test preparation and performance

In addition to accelerated math content, longer math classes, staying with a cohort for four years and developing a supportive peer culture, the project posited that cohort students would need preparation to pass state tests necessary for graduation from high school. The project proposed a two-phase approach that was grounded in teaching the content of the AP modules supplemented by learning procedural methods, problem solving, and test-taking strategies. Test preparation played out differently from this vision. Teachers found that in addition to learning procedural methods and test-taking strategies, students needed to compare the math content they were learning in the AP modules with traditional textbook materials to become familiar with standard presentation of concepts to be ready for tests. A junior Cohort 1 student explained how his teacher modified the material from the text, but also referred students to it to compare with the teacher's presentation:

> "We are learning how to do stuff in the book and she will teach us her way and then she will go back and say, 'but if you are in a book, it looks like this.'"

Test preparation during sophomore and junior years took significant time in class, and sometimes on Saturdays. One site created and used test preparation packets by topics such as "Slope and Lines" and "Absolute Value and Quadratics." At another site we observed two teachers using released state test items to prepare students for testing, and one teacher combined the released test items with some resources from Kagan online.

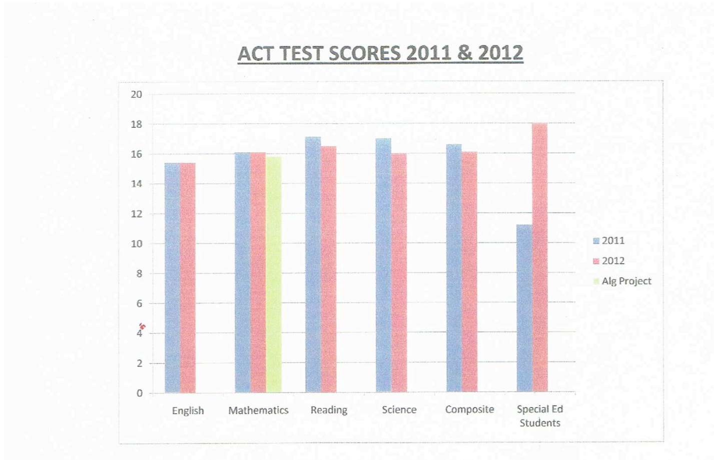
The external evaluation did not use test scores as a way to measure the success of the cohorts because others in the project are collecting these data. However, we reference students' performance on standardized tests as an indicator of student growth and performance over the years of the project. We were interested to see whether students had moved out of the lower quartile in their scores or not.

The superintendent in one district said that the senior Cohort 1 students were competitive in the overall student population: "Achievement-wise they can compete with anyone and so from my standpoint, as a student benefit, it has just been tremendous."

At another site in Year 2, the sophomore cohort students took the state graduation test, and four of them earned a score of "accelerated." A cohort teacher pointed out that his students outperformed the school on the state test, but he cautioned not to misinterpret their improvement because that they still had a ways to go:

> "We took kids from far below basic up to basic. They went up two levels [on the state test], and I had a couple of kids testing proficient. These were far below basic kids to begin with, low basic kids, and so out of the 18 that remained in the cohort at the end, I had I think 9 of them who had moved up at least a band and only one went down. We had a couple that moved two bands." --Cohort teacher, Year 2

At a third site the senior cohort students' mean score on the state test, which is the ACT, was just about equal to the mean for the school for the previous two years. On the graph below the green column represents the AP cohort students' mean score in mathematics in 2013 and is very close to the school means for 2011 and 2012. For students who started the cohort performing in the lower quartile on standardized tests, this represents a notable achievement.



By Cohort 1's senior year all students except those with IEPs had passed the state high school graduation tests at the four remaining schools. Improved test scores are a positive outcome, but we want to reiterate that the standardized tests do not measure the major benefits to students that the cohort offered.

- Learning experiences in cohort classes for students

The cohort student learning experiences varied by teacher, and some teachers were able to realize AP pedagogy better than others. The following two descriptions of lessons provide a flavor of two classes in which the teachers were more accomplished in realizing AP pedagogy than other teachers.

> The thirteen students talked in groups and solved substantive problems together during the one-hour class.[8] Each student did one of the problems at the board, explained his/her work, and answered questions from the group. Students readily looked to each other for help when they had questions before asking the teacher. When they did ask the teacher for help, she usually asked a question in response and waited for another student to respond rather than immediately answering the students' questions. Students appeared to be comfortable working together, helping each other out, explaining work in front of the class and discussing, which created a sense of group identity in the class.

[8] Due to a schedule change, the class observed was one period instead of the usual two.

In another cohort classroom, the fourteen students always sat in groups with the teacher or YPP facilitators rotating among the groups. The learning experience was much more of an active community experience than a traditional math class. The students actively participated in the lesson activities, using the AP curriculum as a guide and not simply completing problem after problem (as is so common in math classes guided by textbooks). The teacher and facilitators asked questions along the way to both guide and contribute to the discussion.

> After the students had participated in one group math problem, disguised as a game, the teacher asked: "If there are only two people playing, who is guaranteed to win? Everyone think about it. Does it matter who I pick to go first? Can it be random?" A student spoke out: "No, it doesn't matter." The teacher asked the other students: "Do you all agree with that? Put your own hypothesis on the board." After all students had written their hypotheses on the board, the students reasoned through each hypothesis as a whole group, and energetically questioned and challenged each other. During this time, the teacher and facilitators did not reveal their own personal opinions or steer the conversation in a pre-determined direction. After the students had reviewed each hypothesis, they came up with a conclusion regarding a sensible strategy for winning this particular 'game.'

In contrast, two other teachers, whom we observed multiple times, tended to teach one-on-one with students sitting in groups. At times in these classes some students worked independently while the teachers worked closely with one student, but other students wandered around the room talking socially with friends, listening to iPods or talking on phones, or sitting unengaged until it was their turn to work with the teacher. These students tended not to collaborate with each other on math. Students in one of these classes remained resistant to sharing their work and in the other class, we did not observe a lesson that was designed for students to present their work. A third teacher taught using traditional lecture with little student participation.

The implementation and success of the AP pedagogy in the cohort classes was mixed. Teachers' comfort level, confidence, and ability to use the AP materials and pedagogy varied widely between teachers, from module to module, and year to year. For at least the first two years—because of disruptive student behavior, as well as lack of teacher experience with the students, materials, and pedagogy for teaching double block periods—teachers tended to prefer lecturing over group work so they could control the class. But as students matured, all teachers were able to wed the content with the pedagogy more often. However, teachers achieved different levels of understanding, confidence and comfort with the materials and pedagogy, and the student learning experiences varied accordingly. We observed two classes at two different sites multiple times where the university liaison or AP professional developer taught and primarily facilitated classes rather than the classroom teacher.

Cohort Teachers

The cohort teacher was the linchpin on which the success of the program depended. The project placed numerous demands on the teacher beyond teaching math, with each demand being consequential in itself. Teachers had to learn about and teach the Algebra Project materials and pedagogy simultaneously. Teachers needed to manage the behavior of whole classes of students, who brought with them histories of disruptive behavior, lack of focus, and sometimes defiance. They had to know how to teach *these students* math, which was a subject the students were not successful in, in daily double block periods. They had to know how to build personal relationships with the students and how to create a student culture of responsibility around academics. They had to prepare students to perform well on standardized tests. They also had to prepare cohort students for college, not just academically, but the students also needed to learn about colleges and get help with the application process and financial aid applications. Teachers needed to relate to parents, community, and university faculty, and build and sustain these relationships across years. And they had to teach a full course load in addition to the cohort classes.

- Teachers' classroom experiences

<u>Teaching AP materials and using AP pedagogy</u>

The AP provided the teachers with modules for course content and professional development to learn about them each year. We asked teachers to rate their experiences with three aspects of the Algebra Project materials—the quality, the usability (or teacher friendliness), and the content—

using scales of 1 to 5. For quality, *1* was inappropriate for these students and *5* fully supporting their learning; for usability *1* was close to impossible to use effectively with the level of support they have, and *5* was very teacher friendly and usable; and for content *1* was inappropriate content and *5* being exactly what students need to succeed in high school math. The teachers' mean ratings were the following:

Quality of materials	4.3
Usability of materials	3.8
Content	4.3

Teachers valued some aspects of the materials and their perceptions were that the quality and content of the materials supported student learning. However, they found some of the materials more challenging to teach than others and found them lacking teaching materials that standard curricula provide.

In interviews teachers explained both advantages and challenges of the materials. For all of the teachers, Cohort 1 was their first time using the AP modules. The first time a teacher uses new materials is always the hardest because she does not know where the materials are going, what questions to ask, what to emphasize and what to leave for later. With the AP modules, teachers encountered all of these challenges, plus the materials were not always complete at the time teachers started using them, and they did not include homework assignments, assessments, and other teacher materials including solutions to the problems. A teacher expressed uncertainty with the modules:

> "So knowing what kinds of questions may come up is very, very helpful, but also to know where this curriculum is taking me. I didn't have the whole package of a module soon enough to be able to say, I know where I am going with this and can I let the kids get off on this and we are going to come back around. I needed more complete materials before I got them." --Cohort teacher, Year 2

A teacher during the second year pointed out that he could see the value of the materials but that a gap existed between what the materials offered and what a classroom teacher needed to actually teach them:

> "I supplement the project materials with other material, especially in the geometry. And again, the materials that we get are really good, but they lack a little bit, because they have been developed by mathematicians and by people who haven't been in the classroom, so there is a lot of work that needs to be done and getting the classroom ready."
>
> --Cohort teacher, Year 2

In Year 4 a teacher expressed the same perspective:

> "It is a massive undertaking because to be honest, the materials are works in progress and I have to come up with a lot of my own homework and I have to come up with my own assessments and so it is not like you walk in with a textbook and it is all laid out there for you."
>
> --Cohort teacher, Year 4

The materials differed enough from traditional high school math materials that teachers had to take a leap of faith to trust that they were important and right for the cohort students, which was hard. But for some teachers who were able to operationalize them, the results were satisfying, and quite different from traditional math where teachers give explanations of procedures and then examples, as this cohort teacher describes:

> "You can't teach this if you don't believe in it. You can't teach this if you don't make the connections yourself and feel that it is important. You have to see what is happening. The opening of the geometry sections, the stuff that [the author] does and that we do with the kids on symmetry is brilliant and the kids get it because it is very, very… engaging and it is very tactile and they see it and they understand it and so, it is funny because you do symmetry first and… you look at a figure and see if it has reflection symmetry and if it has half turn symmetry. And so we finished half turn symmetry and then I drew 2 intersecting lines on the board and I said 'okay, what kind of symmetry is here?' And they said, 'it is about half turn symmetry.' I said 'what does that tell you about these 2 lines?' Without saying the words,

> they said, 'well the top angle and the bottom angle are exactly the same and the two side angles are the same.' It is pretty cool. We call those angles vertical angles. Okay, so I show you a rectangle, and you see the rectangle has half turn symmetry, or it has two reflection symmetries, and so you know from the reflection, from the half turn symmetry, that a parallelogram has half turn symmetry and so you know the opposite angles are congruent. You don't have to memorize that the opposite sides are congruent, because you can see it. And no curriculum that I have ever seen starts with symmetry like that and takes it to that extent." --Cohort teacher, Year 3

Using the AP's five-step pedagogy, group work, tactile engagement, and student presentation was also challenging for teachers. Most teachers found that students' disruptive behavior limited the extent to which they would engage in lessons using these pedagogical strategies to the point that using traditional lecture or one-on-one instruction was sometimes the only way they could control the class. Particularly in the first two years, only two teachers were able to realize the group work and student presentation. Most teachers rarely designed lessons to require collaboration or facilitated group interactions. Two teachers explained that engaging students in thinking about mathematics at all was progress given students' resistance to math and behavioral problems. A mix of organic and intentional process winnowed down the cohorts during the first two years so that by junior year most of the extremely disruptive students had left, and the ones who remained were more accustomed to the pedagogy. During these last two years, teachers were better able to use some aspects of the five-step method, group work, and presentation and they found that students engaged better.

Double period classes presented pedagogical challenges for teachers. The pacing of classes was often slow and repetitive as students' comments above indicated. Students were generally not engaged in thinking about and doing mathematics for the full period. Finding the right pace and balance of depth versus breadth of coverage to meet the needs of the range of students in the cohorts remained a challenge for most teachers.

Teachers' understandings of AP pedagogy varied. Even at the end of the four years, they did not share a common language around the pedagogy even though they held some common conceptions. We heard different teachers synopsize the pedagogy in different ways: It relates mathematics to contexts that are known to students; it makes students think mathematically and engage in mathematical argument; it engages students in in-depth learning over time, frequently revisiting concepts studied in the past. One teacher explained that "using metaphors to extract mathematics is a much deeper sort of pedagogy than to just overlay a scenario on top of a procedural problem." Another teacher said, "I think the biggest difference [from traditional classes] is in [cohort classes], we never tell them whether they are right or wrong and we let them figure that out on their own and in all of my other classes, you kind of do." A third teacher said that the teacher's role in an AP class is to facilitate students finding their own knowledge:

> "Just allowing students to explore and think on their own and share. When they showed us a desired answer, or a desired response for a question, it wasn't based on right or wrong, it was based on student rationale and student thinking and I think that is what the project promotes… Algebra Project pedagogy is less of you and more of them…I think the AP pedagogy is that eventually students take on the role of being the primary source of their knowledge …but [also] recognizing the other students in the classroom as part of their cohort and as sources of their knowledge and the teacher simply being a facilitator that helps channel that direction of knowledge." –Cohort teacher, Year 4

The demanding nature of the materials and pedagogy challenged all teachers, but the teachers who were most experienced and connected to the community of their students fared better than others. This lesson strongly suggests that teacher selection is a key factor in implementing a successful cohort. How readily teachers became practiced in the pedagogy and content of the project appears to depend on multiple factors such as how confident and competent they were as math teachers at the beginning of the project, their orientation to innovation, their communities of reference, personal beliefs about teaching, knowledge of mathematics, understanding of the role and place of authority in student-focused learning, classroom management skills, as well as the quantity, quality and nature of in-class support they received. How well teachers connected their students to learning mathematics was influenced by the teacher's understanding and connection with students, and their communities and cultural values. A superintendent emphasized how important classroom management was to realizing the pedagogy:

> "I think for this program to be successful, where you are going to have students in groups all around, you really need a strong, stronger than average, stronger than good even, disciplinarian." --Administrator, Year 3

We would reframe his point, saying that a cohort teacher needs to have stature in the students' community and match students' expectations of authority figures.

Teachers' experience developing cohort peer culture

Teachers mostly learned from their own experiences how to create the peer culture of a cohort because neither the AP professional development nor the more informal teacher communication focused on this aspect of the work. Two teachers learned that it was important to know what was going on in the cohort students' lives socially *and* academically. One explained that even knowing what was going on with students in other classes was important to the cohort work:

> "There has to be a social element …where we reach out and hold family meetings and parent meetings…I mean with the kids you have to know what is happening in their life for the four years that they are going to be with you, even if it is just what is happening at school, and 'why are you failing chemistry?' That is an important question, because if you fail chemistry, you have to take that next year, which means you can't have me for two periods next year. That is important." --Cohort teacher, Year 4

Most teachers' interpretation of cohort peer culture was that it should go beyond a positive social culture. One teacher found that creating the desired cohort culture required her to build relationships with students and their families, which meant that she had to establish personal connections that were counter to what she had learned in teacher preparation programs:

> "The lessons that I have learned are [that] everything that I learned in the teacher education program is not what I use here—not getting close to your students, not having personal relationships with them and their families. The [teacher preparation program] is like 'no, you can't…' but I have been so involved and I think it is a philosophy that falls back on what my

> coach…in high school said. He made us be friends…He said, 'if you know each other off the court, you play better on the court;' that is what this project does. It helps me knowing these students out of this classroom and knowing their families and knowing what they are going through and what they are talking about... They choose to learn from me every time they come in and they choose to because they know I care about them. I care about their family and I care about their brothers, their sisters and their mommas and daddies and I care about…everything that affects their life. For that, they choose to learn from this class and that is a lesson that I learned." --Cohort teacher, Year 4

This degree of academic and social connection with students and their families required a lot of teachers and of families, and not all cohort teachers were of the community of their students. Even though the majority of students said that they thought they had learned to take responsibility for helping other students in their cohort class, some teachers said that they were unable to establish a cohort culture of academic support. A couple of teachers were not confident that they had ever been able to achieve it as this teacher says:

> "Another challenge is building a culture among the students that really gets them to support each other in the academics and feel like 'yeah, we can do this and if we can do it together, we have a better shot of doing it.'…Developing that culture and how do I know I am on the right [track] and again how do you get there… So how do you make that happen and we haven't been able to do it." --Cohort teacher, Year 4

When teachers were from outside the local community, or they were from different racial groups than their students, they sometimes had difficulty building these kinds of close relationships. Creating an intimate connection of this nature largely relies on teacher selection, but professional development could also build teachers' capacity to bridge across cultures and races by understanding their own cultural norms and values and those of their students, and the role of racial/ethnic and socioeconomic factors in implementing a successful cohort.

- Benefits to teachers

Being an AP cohort teacher was a life-changing experience for all teachers. All teachers participated in professional development and grappled with course content and pedagogy. They all struggled with student behavior, and they all devoted an abundance of time to preparing for their classes and supporting the students in and out of class. One teacher completely changed his views on teaching and the place of math content versus active engagement in learning and thinking. He came to believe that the content was secondary to what students were learning about how to approach problems and argue their point:

> "It changed my values in terms of what…I believe education is for…'Why do we do it?' So, just having that perspective changed my whole life…To learn how to approach problems is so much more powerful when the students start to get into it and…the content itself is really pointless or meaningless if they are not getting something more substantial out of it. If the experience is only getting you to understand that the area of a triangle is ½ base times height, that was a pretty crappy experience...But if the experience got you to learn how to do research on your own, consult your teammates and come up with an answer that you all agree on and argue your point, it doesn't matter what you are talking about, the content could be anything." --Cohort teacher, Year 4

Another teacher said that she had changed her teaching not just in her cohort classes but also in all of her classes, and she learned to learn differently herself. She changed from being an isolated high school teacher to being more open and collaborative:

> "I have just grown so much professionally from it, and not only with this group of kids, but the way I teach has changed and even my traditional classes have changed… And the way I learn has changed, which is really huge for me because now I have all of these support people. Before, especially in high school, we don't work together very well and we are kind of an isolated bunch and so, for me, I have realized, hey, we can really learn a lot from each other and why be afraid to jump into that and so [a project researcher] and I are going to do a calculus study this summer and just something that you wouldn't do, or wouldn't have done before." --Cohort teacher, Year 4

A university liaison for the project said that another teacher often referred to how the cohort experience had changed her professionally:

> "She has said on many occasions that AP has changed her professional life—that she didn't realize how bad she was before. She didn't know that students are supposed to be the leaders, and that she is there to facilitate." -- University liaison, Year 2

The cohort experience required that all of the teachers be open to change and new ways of thinking, to learn and teach new and different materials and pedagogy, learn to question the status quo in mathematics and education, and to develop new beliefs about teaching and learning, and their roles as teachers. With the exception of one school where two teachers taught cohort classes, the teachers ended up being the only cohort teacher in their school, which meant that collaboration with other teachers occurred rarely, if at all. Teachers did not have the support and benefit of daily interactions with other teachers who were having similar experiences.

Seven out of twelve teachers left the cohorts over the four years, but one of these teachers had no choice because his school disbanded the program. By the end of the four years, two of the five cohort teachers[9] continued at their schools as cohort math teachers, and two had decided to leave high school teaching. The fifth teacher moved into an administrative position.

Professional Development and Teacher Support

The project was aware from the outset that teachers would need support, and the level of professional development support offered was significant. The Algebra Project had four goals for teacher support:

- to foster collaboration among mathematicians, math educators and high school teachers to strengthen content knowledge for teaching;
- to provide opportunities for teachers to explore and become familiar with the modules;

[9] The teacher who taught the cohort that was disbanded at the end of Year 3 remained in the classroom as a math teacher but the cohort model did not continue at that school.

- to support teachers' work with students by exploring how they collaborate, communicate, and learn math; and
- to assist teachers in building their own professional learning communities.

The support for teachers addressed all four of the goals the project proposed, but not all were addressed equally and not all teachers had the same level and types of support.

The Algebra Project offered a summer professional development institute annually for teachers to experience and become familiar with the modules. Most of the Cohort 1 teachers attended the summer institutes annually but one teacher attended only the first and fourth year. This teacher attended the University of Michigan's pilot institutes for the Secondary Math Lab for the other two years.

For the first three years, the summer professional development institutes focused primarily on familiarizing teachers with the content, format and progression of the AP modules for the upcoming year. Other work such as sharing teacher-made materials and aligning the modules with state standards also occurred during the two- or three-week institutes. The fourth year the AP offered the University of Michigan Secondary Math Lab to all cohort teachers as the cohort teachers' summer professional development institute. This institute took a different approach than previous ones. Teachers observed Dr. Moses teaching a lab class of rising high school freshmen for the first week, discussing and analyzing what they saw in relation to their own teaching. A teacher said that, in contrast to the earlier professional development institutes, her focus during the first week of this two-week institute was more on relationships between the teacher and students than on the curriculum:

> "I can't really even remember what math they were doing. But I probably wasn't that focused on the math that they were doing. I was very interested in the interaction that was going on."
>
> --Cohort teacher, Year 4

The second week of this institute more closely resembled past institutes in that teachers met together with support from the mathematician module developers and AP professional developers to familiarize themselves with the materials and math concepts for the coming year and to think about how to translate what they were learning into their teaching.

Collaboration with the local university math professors also supported teachers, but not all teachers had the benefit of this support. University mathematicians visited teachers' classrooms weekly at three of the four demonstration sites, providing support for planning lessons, understanding the materials, and teaching during the academic year. They also helped the cohort teachers at three of the demonstration schools with planning and conducting family nights, arranging for college preparation support for students, and planning and delivering student summer institutes. However, both the in-class and out-of-class support from the university liaisons varied across the years. Algebra Project professional developers and mathematician materials developers also visited the sites periodically for a week or two at a time, sitting in on classes and meeting with teachers to explore modules and math content. Again, not all teachers had visits from the Algebra Project professional developers.

The support provided by the university mathematician was essential. The sites that did not have this support had to figure out how to make up for this deficit and to provide sufficient hands-on support to the cohort teacher. An AP professional developer began to visit for two weeks each month to provide in-class and planning support in Years 2 and 3. At one site, this support was funded by a separate grant. University faculty and YPP supported the teacher in conducting family nights, college preparation support for students, and planning and delivering student summer institutes.

Overall, exploring how students collaborate, communicate, learn math, and develop a peer culture around a demand for math literacy received less attention in the professional development than did building teachers' understanding of the modules, the math content and planning lessons. A professional learning community of teachers did not develop although one university liaison made an effort to host periodic phone calls for this purpose, and the Algebra Project established an online platform for sharing teacher resource materials. Teachers used both of these supports infrequently, if at all. When teachers did talk by phone or share materials online, the focus of their communications was primarily on lesson logistics, the course materials and supplemental materials, and not on other aspects of the cohort such as reflection on their teaching and student work, classroom management, how to establish an academic peer culture in the classroom, and outreach to parents and community.

Teachers' perceptions of professional development and support

Teachers said that above all the most valuable support the project provided was the local university mathematics professor or the AP professional developer (when there was no university mathematician) who came to teachers' classes sometimes on a weekly basis. This type of one-on-one support persisted all four years at three sites. Teachers had some of the most intensive support the last semester of Cohort 1's senior year because the course material for senior year was less specified than in previous years. A teacher explained that it was powerful for the students and teacher alike to have the support of a mathematician in class:

> "The biggest strength is the support of the local college…Four or five professors in the class working with the students…I think that support is really important. It's really powerful. It's powerful too for teachers to work with professors to get their perspective on the math and what's needed." --Cohort teacher, Year 4

In interviews teachers rated the amount and the type of professional development support they received during their tenure with the project. They rated the *amount* of support on a scale of *1* to *5*, with *1* being insufficient to successfully implement the program; *3* being necessary but not sufficient; *5* being well matched with the level of need. Teachers also rated *type* of support on a 5-point scale: *1* was the teacher needed different types of professional development for implementing the cohort model; *3* was the kind of support worked well for some aspects of preparing the teacher but not for others; and *5* was the kind of support that prepared the teacher well. Their mean ratings were the following:

Amount of support	4.04
Type of PD Support	3.62

Both of these mean ratings are quite positive, but they also suggest that teachers could have used more and different types of support given the number of demands they faced, the new, in-process materials, and the combination of difficult classroom management and complex pedagogy. Our interviews with teachers help with interpreting the ratings.

Teachers reported that the professional development from the project was valuable and necessary for teaching the materials and the students, but not always sufficient. One teacher commented on the two different approaches in the Algebra Project professional development institute and the Secondary Math Lab. She said that she would have benefited from more exploration of the materials than the Algebra Project institutes offered before teaching them herself, but that seeing what a cohort classroom looked like in the Secondary Math Lab would have helped her even more earlier in the project:

> "Both [of the designs for summer institutes] were very valuable. I could not say that we didn't need to go through the materials first because as a new Algebra Project teacher, I really could have gone through the material even more, I think. But it also would have been very beneficial to actually see at that time what that classroom was supposed to look like."
>
> --Cohort teacher, Year 4

In general, teachers experienced a variety of types and formats of professional development and support, but the focus did not sufficiently encompass all of the dimensions of a cohort for which the teacher was responsible, including how to design for double-period classes, how to realize non-traditional pedagogy with low performing students, how to translate the modules into their teaching and classrooms, how to create the desired cohort peer culture and move students to advocate for themselves by demanding math literacy, and classroom management strategies for the type of students in the program.

Community Support

The model suggests a community support component to provide a larger, caring context for the cohorts and maintains momentum and sustains the cohort model beyond the four years of Cohort 1. The vision was that the community would organize itself around not just the cohort, but a larger demand for rigorous, quality education focused on math literacy. The cohort model, however, did not specify how each site would realize this component, so it was unclear who would take responsibility for it or what the work might look like. Although the project did not state that sustaining the cohorts beyond four years was one of its goals, in this report it is considered one measure of the extent to which the sites valued the cohort.

Two sites successfully seeded a community movement. At one site, an independent community-organizing group with national affiliation did the work. This group managed logistics and politics related to the project, did neighborhood walks to recruit students into the cohorts, scheduled AP community meetings and even helped with negotiations when students threatened to drop out of the program. This support contributed to the birth of a cluster of new charter schools that embrace the cohort model in all math classes. However, at the same time the two original cohort demonstration schools at this site stopped offering Algebra Project cohorts with the graduation of Cohort 1 classes.

At the other site, the university liaisons, a group of community leaders that pre-existed the AP cohort experiment, and district administrators collaborated from the outset and developed a unified vision of how the cohort model could meet the district's need for a distinctive approach to teaching and learning to attract students to the public schools. The district superintendent and high school principal at this site viewed the Algebra Project as a relationship-based program, which the district could embrace as their "brand" to counter the trend towards charters and home schooling in the area. The superintendent expressed his enthusiastic support of the personal connections the cohort builds:

> "The cohort is a tremendous concept. A lot of our kids are pretty mobile and I know for example that [cohort] kids have [their teacher's] cell phone number and when they have a problem, the relationship that she has built with the kids is pretty phenomenal… That is really the model that we want for our entire system: that kids can feel that they are not just going to come to a school and sit in front of a computer and do worksheets on a screen, but they are going to establish meaningful connections with a teacher…I think that will separate us from a lot of approaches out there. We are pretty competitive. [Our state] has one of the most liberal home schooling laws where we are really into charters now here and politically

> it is an environment that is really anti-public ed. So we really are countering that through programs like the Algebra Project…So that is our marketing strategy." --Superintendent

Where parents and community members connected with the project, they saw benefits to the students and helped recruit new students. A Cohort 1 teacher said that the parents came to bat for the program when the high school was trying to launch a new 9th grade cohort in 2013:

> "Parents have been wonderful and they have stuck with us. They believe in the program and they came the night that we tried to get the freshmen set up. We had a couple of parents talk and say, 'you really need to get your kids in this program.'" –Cohort Teacher

Parents and community members at another site came together as a group at the beginning of Year 2 at Dr. Moses' suggestion to address the student behavior that was paralyzing the cohort class. They were surprised and disturbed by the behavior, and they helped create a plan to correct it.

The two other sites lacked support for making community and parent connections. These sites did not have teachers or university liaisons with connections to the community, and they did not know how to create these connections. A counselor at one of these schools realized that the cohort teacher needed to be a person "of the community" to promote the program:

> "Get somebody in that building that has been there a thousand years who the parents know and will listen to and trust when you say, 'this is what we want to do.' And then the parents say, 'well, you know, if you think that is what we ought to do, maybe that is what we ought to do.'" --High School Counselor

Fully realizing the cohort model and sustaining it relies on a community-based group to continually advocate for the program and to motivate and organize around a demand for math literacy. The same counselor as above said that the program needed to have a high public profile in order to last. She acknowledged that the cohort program initially had some visibility in the community with the project having the imprimatur of the National Science Foundation, but by

Year 2 it had ebbed: "If you want to keep this program going, it has got to be out there. It has to be visible. Ours has just become invisible."

The work of the demonstration sites made it apparent that when the parent and community support component was intentionally nurtured and structures were established for fostering these connections, they sustained the model beyond the four years of the project. However, none of the sites actually succeeded in creating a movement for math literacy.

IV. Outcomes of the Cohorts

The cohorts served some, but not all, of the students well. The ones who succeeded realized the following outcomes.

- Students who entered high school in the lower quartile on standardized test scores took four years of non-remedial high school math.

A total of 66 students were in the four remaining cohort classes by senior year.[10] Most of these students were part of the original 185 who began their freshman year, and the others joined a cohort after the first year. Students, who would not have otherwise completed four years of high school math did so, and attributed their persistence to the cohort. The student survey data show that 62% of the Cohort 1 seniors who completed an Inverness Research survey said that they would not have taken four years of high school math if they had not been in the Algebra Project cohort. All these students learned on grade level or accelerated non-remedial mathematics.

- Cohort students were accepted to and began attending college.

Fifty of the 73[11] Cohort 1 graduates enrolled in colleges and universities, and a few additional students enrolled in vocational programs or online courses in the fall following their graduation

[10] The numeric profile in Appendix 1 indicates that 66 students were enrolled in cohort classes and 73 graduated. This discrepancy is due to the fact that one site disbanded the cohort class in Year 4 but some students from that class graduated at the end of their senior year.
[11] Ibid

from high school. The vast majority attended community colleges. A few students were eligible for college-level math courses as college freshmen, but most were not or took courses of study that did not require math. At one site, 17 cohort students graduated, and ten of these students enrolled in community college in Fall 2013. Three of these students took non-remedial math in college, and the other seven either did not take math their first semester, or at all, because they entered vocational programs that do not carry a math requirement. At another site, five students enrolled at the local university where they all had to take remedial math courses (though one student missed testing out of remedial math by one point on the placement exam). Two more students enrolled in college too late to be placed in a math course. Other students from this site enrolled in the military, culinary school, or community colleges, where we do not have information on whether they placed out of remedial math. Others took on jobs as house painters or nursing home attendants. More students were successful in attending college their freshmen year than were committed to continuing to learn mathematics and demand math literacy for themselves. Most students did not realize the outcome of pursuing higher levels of math literacy.

- Cohort students' attitudes towards and confidence in mathematics improved over the course of the project.

Sixty-eight percent of the Cohort 1 senior students said that they were more confident in math since being in the project, and 66% said that they felt like they understood math better since being in the cohort project. Teachers corroborated the student reports, saying that students gained confidence in general, and in math specifically, and that these changes were likely the most significant student benefits of the cohorts. Parents agreed with student and teacher assessments. Inverness researchers' perceptions corroborated all of these sources. We interviewed and on site visits we observed students with positive attitudes engaging in the study of polynomials, functions, and geometry.

The project was less successful in realizing other desired outcomes.

- Students were not advocating for math literacy in their lives.

Most students did not achieve the outcome of learning to demand math literacy for themselves. The developmental process that most students followed was movement from disliking and resisting math to liking their cohort class and teacher, and even feeling successful in mathematics. However, their experiences did not engender a deep understanding of the larger implications of demanding math literacy for themselves at ever-higher levels of competency. This fact is born out by reports that only a small number of college attendees actually enrolled in math courses, and even fewer qualified for college-level math classes. Additionally, students did not have a math requirement to fulfill their senior year, and some did not perform well in their cohort math class without the pressure of a requirement. Even when dual credit for high school and college was offered as an incentive at one site, cohort students were not motivated to pass the course at the level required for college credit. This suggests that the cohort helped students meet requirements, but that students did not embrace the inherent value that math literacy can have for their lives. Had the project provided teachers themselves with experiences and perspectives to develop a deeper understanding of what it means personally and in the society at large for these students to begin to demand math literacy, as well as the skills for teaching this profound notion, teachers may have been able to support students better in developing awareness and self-advocacy around math literacy.

- Sustaining the cohorts beyond the first four years

One of the five demonstration schools is continuing to offer cohort math classes. This school had two cohort teachers and well-organized and coordinated community and university support. In fact, the entire district embraced the Algebra Project approach and applied for funding to expand the AP approach to the elementary and middle school math classes. The district intends to continue offering minimally one cohort class every year at the high school. There are no cohort classes continuing at the other demonstration schools. The bulk of the evidence suggests that both community support and more than one teacher teaching a cohort class in a school are important factors in sustaining the cohort model. Changes in accountability away from the state standardized tests of the last decade and a half may create a more cohort-friendly climate where administrators make decisions about the success of programs based on different criteria than was the case when this cohort experiment occurred.

In summary, the work was hard and the casualties were high, but the students who stayed the course were well served by the cohort model. The students who succeeded increased their confidence in math, graduated from high school, and enrolled in college the following fall. However, students did not learn the value of or skills for advocating for their own math literacy, and an academic student culture did not develop in most classes. Only one site valued the model enough to continue after the first cohort graduated.

V. Assessment of the Cohort Model

In this section we move out from the work of the demonstration sites to consider what was learned about the essential components of the model, its value, and the feasibility of more widespread use.

Essential Elements of the Cohort Model

The cohort demonstration sites' on-the-ground work, sustainability and capacity to continue offering cohorts, as well as what we learned about student outcomes, contributed to our understanding of what the essential elements of the model are and suggested some new dimensions, areas for rethinking, enhancing, and/or refining the model for future use. These things also pointed to potential areas for more research. The four-year cohort experiment suggested that the model has value, but that it is also a work in progress.

The cohort experiments confirmed that the following dimensions of the model were essential:

- The most essential single element of the model for student success is the teacher, and teacher selection was not specified in the model. Teachers need to be experienced, confident math teachers when starting a cohort, open to change and to trying new content and ways of teaching, and willing to and well-positioned to connect with students' lives beyond the classroom. The teacher's understanding of the students' community values, cultural orientations, and racial identities is central to the success or lack of success of cohorts. Where teachers were of different racial or community groups than their students, they were not able to rally the parent and community support needed to advocate for sustaining the cohort model in the school after Cohort 1 graduated and connected differently with their students than teachers of the same race and/or community of their students.

- Persistence of the teacher for all four years of a cohort and having multiple cohort teachers at a school were incorporated in the original model, and are essential to success. Although all sites began the cohorts with more than one cohort teacher per school, in only one school was there more than one teacher after the second year. This school is the only one where the cohort model is continuing beyond the original four-year commitment. The larger implication is that having more than one cohort teacher at a school is important to the model both for teacher support and for sustaining the model at a school. To attract and retain highly qualified teachers, the cohort model also needs to specify remuneration of teachers for the extraordinarily high workload required for creating a successful cohort.
- Professional development and support for teachers goes hand-in-hand with teacher selection and retention as essential to the model. The teachers' experiences confirmed that a variety of types of professional development such as summer and academic year teacher institutes as well as local support for lesson planning and design are necessary to realize a cohort. The project's model for local teacher support specified collaborations with math educators, professional developers and university mathematicians. Teachers themselves found that the most beneficial of these relationships was the ongoing support provided by the local university mathematicians who came into their classes and spent time outside of class with them exploring course content, designing lessons, and planning. However, not all of the teachers had a university mathematician partner, and these teachers struggled more with the materials and designing course content, which underscored the importance of the person in this role. The nature and quantity of the professional development needs refinement to include mentoring, modeling, and professional learning groups to fully prepare and support teachers. It also needs to address a variety of topics beyond what the project addressed. For instance, teachers needed more time for thinking together about how to translate the content and pedagogy into their teaching. They needed professional development in classroom management, which included a focus on the behavior patterns of the target students in the context of 90-minute block classes. They needed professional development focused on developing a peer culture around academics and understanding what it means to demand math literacy for the students in a cohort. Teachers

needed help to learn how to work with students of races and communities different from their own. Professional collaboration between teachers would need to be nurtured to serve as ongoing, reflection-based interaction for teachers both in class and out of class, and multiple cohort teachers need to be at one school to engage in this kind of support. As it played out, online teacher collaboration did not serve as a functional substitute for this kind of face-to-face, collegial support and reflection.

- As conceptualized in the cohort model, a small class size of no more than 20 students—with the same students and teacher together for four years—is essential. These conditions provide a context for trust to build among students and between students and teacher. As a principal said, trust is at the center of the will to learn:

> "We maintain that relationship and not only with the student, but now we have began to develop relationships with the families…Trust is number one in the culture of poverty, and once you cross that bridge and they trust you, they start learning. That takes time and here is where that time factor comes in and that is through looping. Two periods a day, that is critical and looping year to year." --Principal, Cohort Demonstration School

These conditions also offered students time to buy into the cohort concept as a serious math class, which they were often skeptical of at first. "Looping," or staying with the same teacher from year to year, took the pressure off of grading because teachers knew that they would have the same students during the summer and the next year, and could design the next steps in their learning. Longer class periods allowed teaching to move at a slower pace, covering material in more detail than is allowed for by the schedule and curriculum of regular math classes. However, there was evidence at multiple sites that the longer class periods were more useful and important the first two years of the cohort than the last two. Single periods may function equally well as the double-block periods, or better, after the first two years because they allow students to take other course options needed for meeting college entrance requirements such as foreign languages and special programs, which the double math periods preempted.

- Non-remedial mathematics course content is an essential dimension of the model for all four years. To engage the target students in learning mathematics, the course content must cover different topics in new ways than math classes in which students have previously not performed well. The Algebra Project modules are one source of this kind of course content, but are still works in progress and challenging to teach. Different teachers relied on the modules to different extents and all of them also supplemented with other content. This experience suggests that the modules are not sufficient course content in and of themselves to support students being college ready, and they need further refinements and revisions. The primary lesson learned from the materials is that low performing students need challenging new course content that provides an antidote to remedial classes, where students who failed to master course content are doomed to repeat it until they do.

- A broad repertoire of non-traditional pedagogical practices is essential to the model. It should include, but not be limited to, much of what AP specified: inductive teaching practices, group work, student presentations, tactile and physical experiences, student explanation of work, and the Algebra Project's five-step process. The kinds of learning experiences generated from these practices contributed to students learning new and more productive classroom behaviors and habits of mind. Students learned to work in groups, to support each other, to ask questions, and to express their mathematical thinking. Cohort teachers used a great variety of pedagogical approaches from traditional lecture to their own interpretations of the Algebra Project five-step process, but productive student behaviors predominated in classes where teachers used the practices identified above, and not in the classes where teachers tended to primarily work one-on-one or to frequently lecture. The external evaluation did not have sufficient resources to study in depth the links between different pedagogical practices and the emergence of productive student behaviors in class. Further classroom research is needed to identify which approaches are most beneficial to student success.
- An essential but unarticulated dimension of the model, which all cohorts experienced, is that the students benefit from being cared for, taught by and nurtured by many different people, not just their teacher, over their four years of high school. In addition to their teacher, they get to know the university mathematician, Dr. Moses and other Algebra Project staff, the mathematician material developers, and members of YPP. Having these people come into their class, meet with them, teach them and talk to them over four years was important to growth of self-esteem and their connections with a world beyond their own communities.
- A university mathematician who acts as a liaison between local colleges/universities, the schools, and community is essential to the cohort model. The role of this person varied by site

but in all cases s/he contributed essential coordination in support of the cohort such as designing, coordinating, and sometimes teaching the summer institute for students; initiating and generating community support; providing planning and in-class support for the teacher and students; advocating for the cohort with the school and district administration; and connecting with the university and YPP with the cohort. The Algebra Project would help new cohort efforts by articulating this dimension.

- Local community support for cohorts was an optional, but recommended, dimension of the model. Evidence suggests that for sustaining the cohort model in a school, community support is essential. The cohort model continues at one demonstration site, and this site had well organized community support. At one other site with organized community support, the cohort model did not continue at the demonstration schools, but the community support shifted to a different school, which was new to the district, and began to use AP pedagogy in all math classes. More research is needed to learn more about community support such as how it is effectively seeded and built in different contexts, who manages it, and how to sustain it in different communities and in partnership with schools.
- Working with 8th grade students for a year before the cohort starts may foster success and retention of students. At the one site that tried this approach during a pre-cohort year, the students worked with their future cohort teacher and YPP after school, trained to be Math Literacy Workers, and were paid to work with younger students doing math games and activities in after-school programs. The key players at the site perceived that the cohort students' pre-high school experience not only helped build essential trust between the students and the teacher, it also strengthened the cohort students' math abilities. The principal said,

> "And the piece that [all of] our youngsters don't experience, is the fact that [the cohort students] get to go out and be teachers themselves and they earn a little bit of money toward that, correct? Now being able to teach somebody a concept builds their understanding of what it takes to learn a concept."

This experience suggests that working with students prior to their entrance in high school may strengthen the model. However, since this modification was tried at only one site, more research is needed.

The work of the demonstration sites suggests that to better support schools, districts, and universities that want to work together to offer students cohort experiences in the future, the Algebra Project needs to make the assumptions behind the model explicit and build its capacity to support sites in understanding and realizing the model. Some of the areas of focus might be the building the Algebra Project's capacity and resources for communicating the model and nature of the work to interested sites; refining the nature and quality of the project's professional development to support teachers in fully realizing the cohort model; specifying roles, responsibilities, and support for developing student culture; designing and offering extracurricular enrichment activities for students; and local university connections.

Value of the Cohort Model

The model makes a valuable contribution to the field as a viable, if costly and challenging, alternative to remediation. When fully realized, the model offers new hope for stopping the downward spiral of failure by shifting the mindset about what works for students who are low performers in mathematics away from remedial classes to fresh, rigorous math courses taught with engaging pedagogy.

The per-student investment for establishing and sustaining a cohort was high in terms of the cost to districts and schools. Just based on scheduling, the program costs four times more than a regular math class. A double period AP cohort class had 13-18 students by Year 4, whereas two periods with standard class sizes can accommodate over 80 students. The level of professional development and outside support for teachers to be effective, and the extra people and time outside of class required for student enrichment activities, college preparation, connecting with parents and community all escalate the cost. Administrators pointed to the high cost of the program as a barrier to widespread implementation in addition to the mixed results on standardized tests scores.

> "The costs. What price do you put on a child really? Nevertheless, the cost. We are looking at 24, 23 kids [in a class] when we could be using, if we were single blocked, that would be 46

> kids and so now what we have had to do is add sections of math and so that is the cost back that we have to absorb." --Cohort School Principal

Another way to think about the investment is that 73 students who may not have graduated high school, and who most certainly would not have taken four years of non-remedial mathematics, succeeded in doing both. Perhaps we need to recalibrate our expectations around what reasonable costs are for an intervention program that starts with high school students who have well-established histories of poor performance, negative attitudes towards math, and lack of confidence as students. Offering these kinds of students similar experiences to the cohort but earlier in their years of schooling may be a less costly alternative to this cohort model. Indeed, the most successful retention record in the cohorts was in a class where the site began working with 8^{th} grade students the year prior to starting their cohort experience.

Feasibility of the Cohort Model

The experience of the demonstration sites suggests that district-wide commitment to using Algebra Project approaches, or establishing cohorts as an option in a regular high school math department's program, may be the best contexts for realizing by a math cohort. These two approaches avoid single, isolated cohort classes, which are difficult to sustain. With the district model, students are introduced to AP mathematics and pedagogy early in their educational experience, so when they get to high school, they are better prepared for the learning experiences that seemed so unusual to the students at the demonstration sites. And at the high school level, a whole department approach would mean that multiple teachers would participate in professional development for teaching cohorts and could collaborate. Involving the whole department may also alleviate some of the scheduling problems experienced by the demonstration sites.

The model is complex and costly. Any school or district interested in establishing a cohort should be prepared to fund additional personnel to coordinate community support, student enrichment opportunities, local university mathematician liaisons to support the teacher, and remuneration for cohort teachers' out-of-class time. The school must have the capacity and resources to connect with local colleges and universities and resources to support teacher professional development and in-class support. As mentioned above, in order to support other schools and districts in taking up the work of offering math cohorts to their students, the Algebra Project has work to do to codify the model, including selection criteria for cohort teachers, how to create university-school partnerships that support a cohort, and how to create and sustain community involvement around a demand for math literacy in partnership with schools, suggesting models for who can do community work and how to engage them.

VI. Lessons Learned and Implications for Future Cohort Work

- When *fully* realized by a highly competent teacher, the cohort model holds some promise as a viable alternative to remediation for low-performing students in mathematics. The model is flexible enough to implement in very different contexts, but was most successful in a moderate size district, which embraced the AP approach in their K-12 math program. The caution is that the program needs the support of a larger context than math class, which is focused on not letting low performing students fall through the cracks.
- The Algebra Project needs to codify the model and learn how to effectively communicate their experience and knowledge to those who want to take up the work, so new efforts to offer AP cohorts learn from those who have gone before rather than reinventing the wheel.
- The per-student investment in terms of the cost to schools is high and calls for recalibrating expectations around what reasonable costs are for an intervention program that starts with high school students with well-established histories of poor performance, negative attitudes towards math, and lack of confidence.
- The most essential single element of the model for student success is teacher selection. A cohort teacher is a practiced teacher who has strong knowledge of mathematics, is committed to social justice, is open to change and willing to learn non-traditional content and ways of teaching, and knows how to relate to and engage with the community of their students. She is willing to devote more time to the cohort than to a typical class. For the right teacher, the experience can be a rewarding, life-changing professional experience.
- Cultural and racial identities are important considerations in cohorts for students, teachers and community members and need to be addressed explicitly in teacher selection, professional development, and classrooms. The student population targeted by the cohort model is one that is

typically not strong in mathematics or college bound, which often excludes them from participation in our information-based society. Students of color and from other under-resourced communities are disproportionately represented in this group. An understanding of this dynamic is important to teachers connecting with students and their communities and for students learning to advocate for themselves.

- At a minimum, teams of two teachers who are geographically close enough to get together face-to-face are recommended to fully realize the potential of a cohort. Teachers benefit when they collaborate regularly with colleagues who are having similar experiences in their classrooms to support each other in understanding and realizing the many curricular and extra-curricular demands that are put on them.
- Teachers need expanded professional development opportunities that include regular meetings with other AP teachers to reflect on quality of teaching and student work; classroom management; design for 90-minute classes; developing an academic student culture; the role of race, ethnicity, and community in math literacy and college success; and visual models of cohort classrooms.
- Community support and engagement is essential to the cohort model. It serves to sustain cohorts because without community advocacy, the program becomes isolated and loses visibility. The bulk of evidence suggests that one teacher teaching a cohort class in a school is insufficient to generate the advocacy needed to sustain and expand the cohort model within schools and districts. Multiple teachers at a school and community support are needed to sustain a cohort. The Algebra Project notion of situating a cohort within a movement that demands math literacy relies on community engagement. However, to organize the community requires special skills, knowledge and connections that most sites needed outside support to learn how to do. The Algebra Project needs to provide this support.
- The Algebra Project materials are useful in that they provide teachers and students fresh, rigorous high school course content that is not remedial. However, teachers found them challenging to use, incomplete, and requiring more preparation time than standard curricula. The most successful cohort used the AP materials most consistently and the teacher of this cohort was a strong, carefully selected teacher. When the teacher is strong, the AP materials can contribute to a successful cohort. The major lesson that the materials brought to light, however, is that using non-remedial mathematics that is new to the students is essential to a successful

cohort. An alternative approach may be to offer a portfolio of materials for teachers to choose from that includes the Algebra Project materials as well as other options such as a course in geometry and art, for instance, or mathematics and computing.

- Creating a school-wide climate and culture of support that is larger than math class and concerns itself with keeping the students front and center is important for student success and survival of the cohort. The grant proposal for the cohort experiment recommended that students receive support in English language arts and from school counselors as well as support in mathematics, and the experience of the cohorts suggests that this is important to the model. The most successful cohort offered students support in English language arts as well as math.

VII. Final Thoughts

The target population for the Algebra Project cohort model is students who score in the lowest quartile on standardized tests. Students of color and other students from under-resourced communities are disproportionately represented in this group. Our educational system is failing to prepare millions of these young people for successful participation in an information-based society. The cohort model makes a promising contribution to the field as an alternative to the current dominant practice of remediation in mathematics for these students, shifting the mindset towards engaging students in learning new habits of mind.

Even though the per student investment for establishing and sustaining a cohort is high in terms of the costs to districts and schools, consider the cost to society if these students dropout and discontinue their education. Beyond the lessons learned about the model, the cohort experiments generated valuable knowledge for the field about the nature and scale of the investment needed to support high school students with histories of poor performance in attending college.