The Algebra Project: Making Middle School Mathematics Count

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INTRODUCTION

Once one takes the position that all children can learn algebra, the traditional expectations of mathematical achievement are called into question. No longer can one accept the notion that most children will not complete an algebra course during high school or that algebra is beyond all but a few exceptional middle school students. No longer can one accept the practice of denying access to algebra to the masses of students. No longer can the failure of students, particularly minority students, to enroll and succeed in college preparatory mathematics and science classes be attributed unreflectively to the students' presumed "inability" to achieve.

The conviction of The Algebra Project is that *all children can learn algebra*. The Algebra Project challenges the assumptions and practices that deny access to algebra and virtually guarantee failure in higher mathematics and sciences as a result. Whereas standard education practice holds that only talented students can learn algebra and that even they must master their arithmetic and computational skills before moving on to algebra, the Project works with the mainstream student population and with students who still have trouble with fractions, division, and other arithmetic operations.

The Project is based on the expectation, which our work has demonstrated to be realistic, that virtually all middle school students can learn algebra given the proper context. This context is comprised of several components including:

- a curriculum that addresses directly the conceptual leap students must make from arithmetic to algebra;
- an experientially based curricular process that links familiar physical experiences to abstract mathematics;
- an expectation of achievement that is reinforced by students, teachers, parents, and administrators; and
- ongoing teacher training, follow-up, networking, and support.

The long-range goal of The Algebra Project is for all middle school students to reach high school prepared to succeed in the college preparatory mathematics sequence. An intermediate goal is for all sixth grade students to complete successfully our Transition Curriculum and to complete Algebra I during grades seven and eight. Once they reach ninth grade, students should be prepared not only to enter college preparatory mathematics courses but also to succeed in them. Increasingly, such success is necessary for individuals to function in American society.

Mathematical Literacy: A New Standard for Citizenship

In 1957 the advent of Sputnik sparked an almost instantaneous and overwhelming concern among the nation's political and scientific communities about the state of mathematics and science education in the United States. That sense of overpowering national concern generated a national context for the design, implementation, and funding of numerous projects whose goals were to update mathematics and science education in the United States and ensure our competitive edge with the technology of the Soviet Union. These programs were aimed at students embarked on pre-professional courses of study and promoted the creation of a mathematical and scientific elite. They did not, however, set out to create a population that was literate in mathematics and science. As we approach the twenty-first century the need for such a population emerges as a question of national importance, not because of a single momentous event such as Sputnik but rather as a consequence of a technological revolution that threatens to surpass the industrial revolution in its political, economic, and educational implications.

There is an important sense in which technology drives education. In medieval England the ability of the industrial technology to create printed material en masse drove the need to provide a literate citizenry among whom to market the new printed Bibles. Today the computer production capacity of the new information technology drives the need to provide a population literate in quantitative critical thinking skills. A second parallel between the industrial and the technological revolutions is the emphasis in each on automating tasks previously performed by people. The industrial revolution addressed physical work and sought to mechanize all rote manual labor; the current technological revolution addresses intellectual work and seeks to computerize all algorithmic mental activity, and thus it carries far-reaching and interlocking political, economic, and educational consequences.

As technologies change, the standards of literacy in a society change as well. The industrial revolution ushered in new literacy requirements for the masses of people. To access the new political and economic institutions and relationship that evolved from the industrial revolution, people were forced to master the tools of reading and writing. In every nation-state, reading and writing literacy became necessary (if not quite sufficient) tools for citizenship. Those without these tools lacked access to the political and economic institutions. Similarly, the current technological revolution is ushering in new literacy requirements. To access the new political and economic institutions and relationships that are evolving from the computer revolution, people are being forced to master the tools of mathematics and science. New requirements for the entire population are being laid down in a way that parallels the experiences of the industrial revolution. Mathematics and science proficiencies are taking their place alongside reading and writing as requirements for citizenship. Those without these tools are fast losing access to the new political and economic institutions.

Because these new educational requirements are driven by deep-seated and enduring technological changes, time must be taken to articulate the dimensions and complexities of the changes to important constituencies in the nation and to the general public as well. One important constituency that has begun to suffer enormously from these changes is a certain configuration of the nation's inner-city minority and poor people. Unless there is a dramatic turnaround in education for these communities, we face the prospect of a permanent underclass who, generation after generation, will live on the margins of the nation's economic and political institutions. These constituencies and their Black and Hispanic subsets are in a crisis which the nation has only begun to articulate with a sense of urgency. Only with an increased sense of urgency and a deep commitment to enabling full access to the political and economic institutions of this society can we hope to develop solutions to this crisis. Overcoming the obstacles to the new literacies required by the society's political and economic institutions is central to these solutions.

The Plague of Poor Performance

The ineffectiveness of the mathematics education system in the U.S. has been well documented, particularly in the context of America's slipping position as a dominant force in global trade and industry. Key indicators include the low mathematical yield of American high schools, the below-average performance in problem solving compared with that of other industrialized countries, and the practice of repeating basic mathematics year after year by students deemed unable to grasp higher mathematics.

These indicators are particularly pronounced for minority students (Reyes & Stonic, 1985; Valverde, 1984). On a whole range of tests Black and Hispanic students continue to score significantly below White students in mathematics. Similarly, Blacks and Hispanics are enrolled in advanced mathematics courses at rates significantly below those of Whites. In the most advanced courses Blacks and Hispanics are enrolled at rates half those of Whites. Finally, Blacks and Hispanics are more likely to be enrolled in the "general" and "vocational" tracks in school, and thus are more likely to take fewer and less challenging mathematics courses. The experience of failure and the boredom that typically overcomes a student who must study the same arithmetic year after year conspire to reduce students' self-confidence and esteem and increase the likelihood that they will stop trying or even drop out of school altogether.

Much of the difference in enrollment rates in advanced mathematics among minorities can be traced to a working assumption among educators about who should study algebra. Conventional educational practice holds that ability drives intellectual development and is the essential ingredient for mastering advanced school mathematics. This "ability model" is the current foundation for mathematics curricula at the eighth grade level and accounts for the almost universal practice of offering algebra only to eighth grade students who are mathematically "inclined," "talented," or "gifted."

The assumption that only certain students can understand algebra and the practice of offering algebra only to talented students has had a particularly dramatic impact on the mathematics education of inner-city and minority students. Typically these students are steered away from advanced mathematics, a practice which closes the door to a broad range of academic and, ultimately, occupational pursuits. At a time when the gap between the well-off and the poor in America, especially in African America, is increasing, this rationing of algebra will have devastating long-term effects on the well-being of the entire community.

The Algebra Project: Building Mathematical Literacy

The Algebra Project is a response to the problems surrounding mathematics education in the United States generally. In particular, the Project is concerned with contributing to the mathematical and scientific literacy requirements that are becoming prerequisites both for citizenship and for competing in the emerging global economy. Within the context of the American education system the Project is particularly concerned with the needs of inner-city minority students whose school systems typically exhibit the most exaggerated forms of the more general problems in public education.

From the Roots to the Fruits: The Beginnings of The Algebra Project

The Algebra Project was born out of one parent's concern with the mathematics education of his children. In 1982 Robert Moses was invited by Mary Lou Mehrling, his daughter's eighth grade teacher, to help several students in the Open Program of the Martin Luther King, Jr. Middle School in Cambridge (MA) with the study of algebra. Moses, who had taught secondary school mathematics in New York City and Tanzania, decided that an appropriate goal for these students was to have enough skills in algebra to qualify for honors mathematics and science courses in high school. His efforts prepared students to receive high school credit for completing algebra during middle school and thus qualify for geometry in the ninth grade. Over the years a new pool of students has been added to those taking college preparatory mathematics courses at the Cambridge Rindge and Latin High School.

Moses approached the challenge of preparing middle school students for college preparatory mathematics in a manner similar to that which he and others had used in organizing the African American community of Mississippi to seek political power through the vote in the early 1960s. The apparently straightforward problem of getting people to vote actually involved an interrelated set of issues. To convince people of the importance of voting, organizers had to address the following questions:

(1) What is the vote for? (2) Why do we want it in the first place? and (3) What must we do right now to ensure that when we have the vote it will work to benefit our communities? The answers to these questions provided organizers with a context for understanding what it would take to get people to vote and for implementing a strategy for community organizing.

Similarly, Moses posited that the questions related to learning algebra must be answered in a broader context. Within those questions—What is algebra for? Why do we want children to study it? What do we need to include in the mathematics education of every middle school student? and Why is it important for all middle school students to have access to the college preparatory mathematics curriculum in high school?—a context for understanding the problems of mathematics education emerged and a possible solution, known as The Algebra Project, began to take shape.

Creating a New Vision of Students, Teachers, and Schools

The Algebra Project has three broad goals which, when taken as a whole, point toward a new vision of students, teachers, and school communities. First, the Algebra Project seeks to develop mathematically literate, self-competent, and motivated middle school learners who are able to master the college preparatory high school mathematics and science curriculum and the mathematics necessary for mathematics- and science-related careers or other careers in which mathematics is a necessary tool. Second, the Project seeks to change the way mathematics teachers construct their learning environments by producing teachers who are able to facilitate a mathematics learning environment grounded in real life experiences and to support students in the social construction of mathematics. Third, the Project seeks to build a broader community of individuals including parents, community volunteers, and school administrators who understand the problem of mathematics education as a problem of mathematics *literacy* and who understand the question of students capability as learners as a matter of *effective effort*.

To achieve these goals The Algebra Project has taken a four-fold approach. First, the Project focuses on curriculum development at the middle school level. Second, the Project has developed a method of training teachers in both *what* to teach and *how* to teach it. Third, the Project has developed a strategy for sharing the experience of the King Open Program, thus bringing the Project to schools in other cities. Fourth, the Project has developed a strategy to nurture support among parents, community organizations, and the broader community. We will describe each of these areas below.

The Transition Curriculum: Building the Foundation for Success

While working with students in the King Open Program, Moses noted that some of them experienced difficulty at the very beginning of a traditional algebra text. Through observation and discussion with those students he identified the source of the trouble: the students had difficulty making the transition to thinking algebraically, a transition which meant overcoming a critical conceptual barrier. Lack of explicit attention to this barrier, Moses reasoned, limits access to college preparatory mathematics to those who are comfortable with the purely syntactical manipulation of mathematical symbols without any interpretation of these symbols in a consistent and coherent conceptual framework. Moses found that addressing this barrier directly enables students to overcome it and succeed in mastering algebra.

The barrier involves the students' concept of number and the underlying questions available to students to process data pertaining to numbers. For example, very young children learn about the counting numbers (1, 2, 3, 4, 5, etc.) in the following way: They are exposed to many, many different physical events in which the questions, "How many?" and/or "How much?" are asked and they master the activity of counting as a means of answering those questions. From these experiences the question, "How many?" comes to dominate students' minds when they use numbers. To make a successful transition to algebra, students must generalize their concept of number and place a second question about number into their minds. The second question may take various forms but the most accessible form and the one which we use most often is the question, "Which way?" (i.e., Which one of two opposite directions is involved in this context?). This question is familiar to students in any number of contexts but they do not readily associate it with numbers. Numbers, as they traditionally have been taught, deal with quantity, and mathematics is the science of quantity. The question, "Which way?" on the other hand, is viewed as qualitative.

Having identified the conceptual barrier, Moses set out to develop a Transition Curriculum to put together the questions, "How many?" and "Which way?" within the context of mathematics and everyday experiences. Through a five-step curricular process, students build mathematical symbols and objects using familiar experiences as their foundation.

Step 1—Physical Events. The Transition Curriculum introduces each new concept by engaging students in a familiar physical event about which they ask and answer obvious questions. This engagement provides a foundation for developing the abstract concepts used in algebra. Not only does this initial step give students a base to which they can return as they assimilate these concepts, it also demonstrates actively the link between the physical world and the abstractions of mathematics. Participation in the physical event introduces the students to the abstract concept at a preconscious level. The remaining steps in the curricular process increase the students' conscious awareness and mastery of the concepts.

Step 2—Pictorial Representation/Model of Physical Events. The first step in abstraction is for students to make models and draw (or view) pictures representing the physical events in which they have engaged. The act of making and/or viewing pictures also creates opportunities to integrate the humanities into the curriculum, demonstrating the relationships between mathematics and other forms of knowledge.

Step 3—Intuitive Language Response. Before students can make the leap to symbolic representations of physical events they must understand the events and be able to express them in their own words. At this stage in the learning process it is important for students to use their own language. Just as the physical event introduces the concept at a preconscious level, talking and/or writing about the event in their own language introduces students to the concept at a conscious level. The language teachers are looking for here is not necessarily Standard English. Rather, it is the language the student uses in informal social conversation. It may be a dialect of Standard English such as Black English or it may be the student's native language such as a dialect of Spanish, Chinese, or Creole. In a class where many languages are spoken there will be opportunities for a rich cultural exchange focused around language. This can be particularly important for Black students, giving them an opportunity to explain how Black English differs from Standard English.

Step 4—Regimented (Structured) English. When teaching abstract mathematics to young children one must think of entry-level mathematical equations and sentences as direct translations of regimented or structured English. This regimented English is not Standard English in the sense that no group of people actually speaks it. It is simply a device that mathematicians and scientists use to facilitate encoding explicitly in mathematical symbols the concepts that are implicit in the general language and culture. Teachers use such regimented English sentences to lead students from their intuitive language responses into equations to represent physical events. In this way teachers demystify mathematics, demonstrating to students that mathematical language is like all other language: it talks about physical events that are part of their everyday experience. In contrast to the mathematical reforms that followed Sputnik during the 1960s when attention was focused on teaching students the vocabulary, grammar, and structure of mathematical language, the emphasis here is on *using* mathematical language to describe and model physical events. The key word is *use*. From the beginning of their study of algebra students must be able to construct mathematical equations as a response to physical events. They also need to construct physical events in response to simple mathematical equations that model the events.

Step 5—Symbolic Representation. Once students have assimilated the material presented in the first four steps of the curricular process, symbols are introduced. The Transition Curriculum provides opportunities for students to develop their own symbols for various operations, quantities, and mathematical objects. In this way they come to understand that standard mathematical symbols were created by people to represent physical events just as they have done. Only then are standard notations and symbols introduced.

The idea behind the first three steps of the above curricular process is to involve students in events in which obvious questions generate obvious answers and lead in obvious steps to important and fundamental mathematical concepts. The physical events must be obvious to the students and part of their everyday experiences so that students may exercise ownership over the events, know what questions are appropriate to ask about them, feel comfortable with their pictorial representations, and express confidence in their linguistic descriptions. Though the physical events themselves may be very complex, it is important that they be familiar components of the students' everyday experiences. It is this *familiarity* which enables middle school students to handle and raise questions which distinguish very simple features of the events, features that generate simple components of mathematics. Students acquire ownership of mathematical concepts generated in such contexts only if they arrive at the symbolic representation of the concepts by following through on at least two levels of language—their own native tongue and the regimented English of mathematicians and scientists which serves as a linguistic context for symbolic representations.

The second and third steps (pictorial representation and intuitive linguistic response) develop the symbolic fashions mathematicians design to clothe these concepts. The fabric used to weave these symbolic "clothes"—the native language of the student—is found in the third step: bits and pieces (expressions and sentences) of the students' language are regimented by the mathematician into a stylized English in preparation for designing simple equations and inequalities which have direct interpretation for some aspect of the physical event. These simple equations function for young students of mathematics just as observation sentences function for scientists. Observation sentences tie the theories of science to the data of the real world and these initial mathematical equations tie the symbols of mathematics to the concepts embedded in the physical events.

The Transition Curriculum takes students through this process, teaching the concepts of Algebra ordinarily introduced with the number line. The physical events we use to develop these concepts revolve, for the most part, around metropolitan transportation systems. A trip on such a system is part of the everyday experience of inner-city students or of ordinary people familiar to these students. Such trips provide physical events in which the two questions "How many?" and "Which way?" are joined. Students move on to develop the mathematical concepts of a trip, equivalence in general, equivalent trips, displacements, and subtraction and addition of displacements. Displacements serve as a "half-way house" for the development of the concept of integers. Students complete the curriculum by learning to perform the operations of addition and subtraction on integers. At this point they have joined the two questions about number and are ready for the number line and for work in a traditional algebra textbook.

A Context for Learning: The Pursuit of Intellectual Development

The endeavor of learning mathematics with this curriculum is an exercise in intellectual development. Students participate in frequent discussions which engage them in the twin processes of creating mathematics and integrating their mathematics with the physical world. The curriculum is designed to stimulate students' thinking about both processes. It also helps them to learn, through their own experience, about the social construction of knowledge.

The curriculum is built upon a frank acknowledgment of the social construction of mathematical (and other forms of) knowledge. In other words, the Project acknowledges and demonstrates to students that mathematics is the creation of people—people working together and depending upon one anther. Group work and cooperation, then, are central to the learning process; they are also part of the content of instruction as well. Throughout their work with the Transition Curriculum, students generate data which becomes the vehicle for introducing mathematical and statistical concepts. Thus, cooperation and participation in group activities as well as personal responsibility for individual work become important not only for the successful *functioning* of the learning group but for the generation of instructional materials (data) as well.

The curriculum is based on the conviction that intellectual development is, in part, a matter of integrating knowledge. Rather than build a wall around mathematical knowledge, the Project's goal is to demonstrate the relationship between algebra, the physical world, and other areas of study. Every opportunity is taken to integrate other areas of study such as social studies, language arts, creative arts, and science into the work of learning algebra. Students learn about statistics, use basic arithmetic skills, integrate creative abilities as they make pictorial and symbolic representation of activities and events, and express them in mathematical terms.

In the Project, students have ample opportunity to learn about the role of risk taking in their own intellectual development. Through discussions, they learn the importance of asking questions even at the risk of embarrassment. Further, they learn to respect one another as learners who are willing to take such risks with their peers. Students frequently make presentations to their peers, giving them opportunities to organize their thinking, defend their positions, explain their reasoning, and express themselves in front of their peers. Each presentation helps to build students' confidence and public-speaking skills as well as their grasp of the course material.

When asking the question, "What is needed in mathematics education?" one cannot ignore the pervading cultural message that learning mathematics requires some type of innate ability and that, if one is a person of color, one probably will not be able to learn mathematics. In this context The Algebra Project holds as a goal the creation of learning and teaching environments in which children and teachers understand *learning as a consequence of effort and motivation* rather than innate ability.

Facilitator: A New Role for Teachers

If a new curriculum and curricular process is the cornerstone of The Algebra Project, teacher training and development is a second stone in the Project's foundation. The Transition Curriculum is experientially based and grounded in an acknowledgment of the social construction of mathematics. This requires that teachers approach the teaching of mathematics and their own role in the classroom in new ways. Rather than focus exclusively on the cognitive content of the curriculum, training emphasizes the curricular process along with how to teach the materials.

In the traditional concept of middle school education the teacher is viewed as one who imparts information to students who are largely passive receptacles. By contrast, The Algebra Project's teachers endeavor to engage students in thinking mathematically and relating their real world experiences to the work of mathematics. Project teachers set up the context for learning and help students to work within that context to discover how various concepts in mathematics fit together with one another and with the world around them. The Project models this approach through its training program, in which teachers learn the materials as though they themselves were students.

Just as the Project developers' vision of the role of the teacher challenges traditional assumptions, it also challenges traditional approaches to student assessment. Unlike traditional mathematics classes that seek to weed out students who cannot "make it," The Algebra Project seeks to cultivate students' minds. In their assessment of students, Project teachers are encouraged to focus broadly—on intellectual development, eagerness to learn, and overall maturation—rather than narrowly, on the assimilation and retention of cognitive information alone. In addition, both students and teachers are asked to observe and encourage (or discourage) patterns of behavior that promote (destroy) the social construction of knowledge such as cooperativeness, willingness to share knowledge, and helping one another (putting down, disruptiveness, and work avoidance).

Regarding the Transition Curriculum's learning objectives, the Project distinguishes between three levels of understanding of course material:

- Recognition—Students should be able to comprehend a topic and follow along with discussion.
- Recall—Students should be able to remember a topic independently, though strict memorization is not required.
- Assimilation—Students should be able to use a concept, employ a technique, and apply ideas learned in one context to new situations.

In keeping with the experiential base of the curriculum, The Algebra Project does not rely on traditional paper-and-pencil tests; rather, Project teachers are encouraged to use portfolios of students' work, records of students' performance on work station tasks, and other tools to assess their students' progress toward achieving the curriculum learning objectives.

The Project recognizes and addresses the relationship between teacher and student expectations and student performance. Despite the abundance of literature about the impact of teachers expectations on student performance, a gap exists between that knowledge and standard educational practice. In several schools where the Project operates, teachers also have participated in an Efficacy Institute seminar designed to underscore the principle that all children can learn and to give teachers strategies for putting that principle into action in their classrooms.[1]

In order to help Project teachers in Cambridge, Boston, and Atlanta sustain a new vision of themselves as teachers and develop the skills and expectations necessary for the Project to succeed, their initial training

[1]The Efficacy Institute focuses on teaching both teachers and children about the process of intellectual development and ways to overcome the obstacles to development.

has been supplemented with ongoing support. Long-term plans call for establishing a Summer Teacher Training Institute to serve additional cities. An additional component of this institute will be a "Train the Trainer" program to prepare local coordinators to train and support teachers on an ongoing basis.

Disseminating and Implementing the Project in Boston

Building a Community Base

In Cambridge the Project began as an effort of one parent, Robert Moses, to impact the mathematics education of his children. Access to the school system was facilitated by that parent's organic relationship to a particular school, and receipt of a MacArthur Fellowship enabled Moses to devote substantial time to his efforts. In contrast to its public school beginnings in Cambridge, the Project first took root in Boston at Freedom House, a community-based organization. During the spring of 1988 Moses and Jacqueline Rivers approached Toye Brown, president of Freedom House, about conducting a summer algebra camp. (Since 1986 Rivers had been coordinating a group of college students who tutored Algebra Project participants at the King Open Program.) Brown agreed and the Summer Academy, featuring the Transition Curriculum along with language arts activities, was initiated. Freedom House staff were so pleased with the Academy that The Algebra Project was incorporated into Freedom House's after-school program during the following school year. Rivers trained and supervised a college student to deliver the Transition Curriculum for the program. In October 1989, after a one-and-a-half year association with The Algebra Project, Freedom House decided to shift the emphasis of its after-school program to focus on algebra and hired Rivers to direct the new program, Algebra Centered Enrichment (ACE).

Even before establishing this base for the Project, Rivers and Moses began to gather support from a variety of sectors. Both were teaching at local universities (Rivers at the University of Massachusetts/College of Public and Community Service [CPCS] and Moses at Wheelock College.) Each institution assisted the Project in a variety of ways. CPCS gave Rivers release time to devote to outreach efforts with the Boston Public Schools (BPS). Wheelock College raised funds to bring Moses on staff as a special projects coordinator, enabling him to continue full-time work on the Project once his MacArthur Fellowship had ended in 1987. To formalize and expand this support the two institutions developed The Algebra Consortium, an organization composed of faculty and staff from local universities, community agency representatives, and interested individuals. Consortium members helped the Project to identify both financial resources including funding through Northeastern University to support the coordination of the Boston outreach and in-kind resources such as photocopying, assignment of work-study students to the Project, and the use of a van. A local contact also helped the Project to apply for a grant from the Hasbro Children's Foundation, the receipt of which enabled Rivers to continue her work as Boston coordinator for the Project.

Gaining Access to the Boston Public School System

Support from the universities and other Consortium members enabled Moses and Rivers to undertake an extensive outreach process to cultivate interest in the Project among teachers, principals, and central administrators in Boston. The initial strategy was to identify one school that could serve as a model within the system. Moses and Rivers met with principals from three schools during the spring of 1988, with less than encouraging results. At one school contact ended after the initial meeting. At another the principal arranged for a meeting with the community superintendent for his district and his own mathematics specialist. Concerns about making the transition from traditional algebra courses to the Project's new way of thinking about mathematics brought the process to a halt at that school. At the third school the principal arranged a second meeting to introduce the Project to teachers; however, some of the teachers apparently were unwilling to try the Project because they were concerned about their students' basic skill levels.

By December 1988 a new strategy was developing. Moses and Rivers met with a school committee member, who arranged a meeting with the BPS's deputy superintendent for curriculum and instruction. She, in turn, invited the system's mathematics coordinator, who endorsed the Project. A plan was discussed to invite 11 schools with high percentages of minority students to participate in the Project on a pilot basis. Project staff also held another round of meetings with principals at three schools and with teachers at one of them. One of these schools had participated in the earlier discussions about the Project.

In March 1989 the *Boston Globe* ran an article about the Project which elevated the Project's visibility and helped generate interest in it among the city's teachers, principals, and administrators. After a second meeting with the deputy superintendent, Moses and Rivers began a series of meetings with the personnel of the 11 schools to ensure interest at all levels in those schools that chose to participate. First, the BPS invited the 11 principals to a session which introduced The Algebra Project and presented the idea of a joint project featuring the Project and the Efficacy Institute. A majority of the schools was represented at this meeting and five principals indicated interest in taking the next step in the process.

The second step was a meeting with principals; sixth-, seventh-, and eighth-grade mathematics teachers; and directors of instruction. One principal asked for an additional workshop for all of the teachers at his school. Algebra Project staff also met with teachers at two of the schools. Those who were interested in pursuing the Project further were invited to make a half-day site visit to the King Open Program. Three BPS schools—the Dearborn School, the Martin Luther King, Jr. School, and the Oliver Wendell Holmes School—chose to take this step.

After the site visit each school agreed to participate. In May, Algebra Project staff and the BPS mathematics coordinator met with administrators and teachers at each of the three schools to discuss the grant proposal that would be submitted for the Project in June. (During the summer, however, the Holmes School was closed as part of a BPS school consolidation effort. A shortened, top-down process was set in motion during the early fall to select a replacement school.)

The Algebra in Middle Schools project (AIMS) was conceived as a five-year pilot program that would provide the basis for a BPS decision about implementing the Project throughout the system. AIMS would offer the Transition Curriculum and the Efficacy Curriculum to sixth graders and a traditional algebra curriculum in grades seven and eight. Developed by the Efficacy Institute, the Efficacy Curriculum is designed to teach students about the process of human development, which it defines as "building identity, character, analytical and operational capability and self-confidence."

In October 1989 the Boston Foundation approved a grant for AIMS and indicated its willingness to consider repeat funding of the longer term project. The BPS contributed support for teacher training, in the form of stipends for teachers trained during nonschool hours and the hiring of substitute teachers to fill in for teachers who attended training during school hours. Further, within the guidelines of the teachers' contract, the BPS agreed to help address concerns about potential changes in the teaching staff within the Project from year to year.

With three schools on board, discussions about the training schedule began. Because the training program spanned 40 hours, there was some difficulty developing consensus on a training schedule that addressed concerns about both the demands on teachers' nonschool hours and the challenge of maintaining classroom coverage for several staff at once. One school preferred a training schedule using after-school time and weekends only while another school would agree only to a school day schedule. In the end the Project agreed to hold training on two separate schedules to accommodate these concerns. Between November 1989 and January 1990, 14 teachers and 1 administrator were trained in delivering the Transition Curriculum.[2]

Two schools held their opening day Project field trip in February 1990; the third school started in March 1990. Current challenges for the Project include clarifying a decision-making apparatus that includes all three schools, planning for the 1990–91 school year, and developing a "net" to catch students who move into or out of an AIMS school after the sixth grade.

CONCLUSION

The answers to the questions, "What is algebra for?" and "Why do we want children to study it?" play an important role in The Algebra Project. The Project is built upon the emergence of a new standard for assessing mathematics education—a standard of *mathematical literacy*. This literacy is becoming increasingly important not only to gaining access to college and mathematics- or science-related careers but also to participating fully in the economic life of American society. In the not-

[2]Training for delivering the Efficacy Curriculum was scheduled for completion later (during March, April, and May 1990).

so-distant future a form of mathematical literacy will join traditional communication skills as a minimum necessity. Our schools must improve their record of developing among minority students the mathematical and scientific skills required to meet the new literacy standard—particularly the higher order skills of reasoning, inference, and problem-solving—if these students are to find a meaningful place in changing political and economic institutions.

In this context The Algebra Project has as its goals the development of children who will be mathematically literate and the training of a community of educators including parents, teachers, and school administrators who understand the paramount importance of mathematics education in providing access to the economic life of society. The experience of The Algebra Project in the classroom supports the belief that curriculum changes of the sort described above, energy and commitment, support for both students and teachers, and high expectations among all concerned are key ingredients for achieving these goals.

Algebra is a Reasonable Standard for Middle School Mathematics

Our work with the King Open Program has demonstrated that studying algebra in the seventh and eighth grades is a reasonable standard of mathematics literacy for all students. Since 1982 the Project has worked with more than 80 students. During that time students in the Project have "escaped the parking lot" where many students would otherwise have remained in basic mathematics courses. Rather, students engage in serious, ongoing work in mathematics during seventh and eighth grade. Students also have succeeded in entering the college preparatory mathematics sequence. Before the advent of The Algebra Project virtually no graduates of the King School took the optional ninth grade mathematics placement exam; of the few who did, none passed. In contrast, during the first five years of the Project (1982–87) more than one-half of the Project's students took the exam and 79 percent of them passed it.[3] These students account for some 40 percent of all King Open Program students during those years. All students who participated in the Project were prepared to enter the high school algebra sequence in the ninth grade. A number went directly to honors algebra or geometry rather than regular algebra classes.

The experiences of two students in the King Open Program highlight the impact of the Project on students' motivation to learn mathematics. One parent explained it this way:

> My son was in despair about math when he came to the Open School [sic] and would not even complete the placement test. Five years later, he eagerly gets up and leaves for school an hour early (during the school year *and* the summer) to study Algebra, which he intensely enjoys.

Another parent, who is a mathematician and tutor in the Project reported:

> One child who had great difficulty with his basic math facts excelled with this work and it motivated him to overcome some of his problems with the math facts.

[3]Data for the 1987–88 and 1988–89 school years are unavailable at this time.

Not only has the Project affected students' motivation, but it has fostered a culture and expectation of excellence in mathematics among parents, teachers, and students. Many current students, who were first exposed to the idea of studying algebra in middle school when their older siblings participated in the Project, have come to expect that they, too, would learn algebra before going to high school.

We have seen similar results with the ACE program. Both parents and teachers have reported that the academic performance of their children in mathematics has improved, in some cases dramatically, as a result of their participation in ACE. Students have adjusted their expectations of their mathematics achievement upward to include the study of algebra and higher mathematics. Many are also heightening their expectations about their future beyond high school. Students in the ACE program are demonstrating social gains as well. As a result of students' losing some of their fears about mathematics, "acting out" in the classroom, both in ACE and in school, has decreased. Most students are developing greater confidence in themselves as learners. Many are becoming more independent and interested in directing their academic futures. Greater confidence and facility in interacting with adults and peers also has been noted among ACE students.

Elements of a Strategy

Middle school mathematics must provide both a sense of mathematical and intellectual achievement and a solid foundation. Inner-city middle school students in economically disadvantaged areas desperately need an overarching sense of purpose in their lives, a sense that their lives are going somewhere. Middle school mathematics must contribute to that sense of purpose. It must be a mathematics of access providing, above all, access for all middle school students to the college preparatory mathematics courses of the high school years.

The students with whom The Algebra Project currently works will be attending high school during a time of great ferment about the goals, content, and methods of middle and high school mathematics. The Project wholeheartedly supports the reforms in mathematics education being championed by the National Council of Teachers of Mathematics and others. At the same time the Project is working to ensure that current students are not lost in the transition. For such an effort to succeed it must deploy its resources to enable students, teachers, parents, and the broader community to understand, control, and master both the academic and social context in which mathematics learning takes place.

For students the road to such empowerment has several way stations. First, students must develop the expectation and the confidence that they *can* and *will* learn algebra if they apply themselves to the curriculum. Second, the curriculum must be structured to ensure success by addressing directly the conceptual gap between arithmetic and algebra. Third, the curricular process must build mathematical abstractions on an experiential base that is familiar to students, and it must both acknowledge and support the social construction of mathematical knowledge. Fourth, the learning environment must support students in setting goals, taking risks, and assessing their own progress relative to those goals.

Efforts to empower students will be fruitless, however, without efforts to empower teachers as well. Teacher involvement in the decision to participate in the effort is an essential first step. Training in both curricular content and process are critical if teachers are to gain the skills and confidence to succeed in teaching algebra (for the first time, in many instances). The issue of teacher expectations must be addressed as well because teachers with low expectations invariably will communicate those expectations to their students, thus reducing their motivation and performance. Once trained and oriented, teachers must be allowed regular time to meet and discuss the changes needed to support them in the classroom and extend their empowerment within the effort as a whole. As teachers become organized and articulate their needs, mechanisms must be established to coordinate those needs with the needs of various administrators across the school system.

Teachers we have encountered in our work have expressed a range of needs and interests. The King Open Program recently received funding for a mathematics lab in which teachers will be able to develop skills, activities, and products in a variety of areas outside the classroom including administration, training of fellow teachers, curriculum development, program evaluation, student assessment, mathematical studies, counseling particular groups of children (e.g., females, Black males, and teenaged mothers and fathers), and working with parents. Efforts must be made to contribute to teachers' development by meeting their needs for professional growth; however, the particular direction that teacher involvement takes in any given effort should be open and decided by the teachers themselves in coordination with various administrators.

Parents constitute the third constituency that must be addressed if efforts to improve the mathematics education of children are to succeed. As with teachers, parents' expectations must be raised. From there parents can be oriented both to the content of the mathematics education (through parent courses in the subject matter) and to the political implications of that educational content. Teaching algebra to parents empowers them not only to grasp mathematical concepts that may have been unfamiliar to them and reduce any associated mathematics anxiety but it also equips them to be active partners in their children's mathematics education. By delineating the long-term educational and socioeconomic impacts of studying algebra in middle school and the expected sequence of study during high school, a project can enable parents to advocate for change that will ensure that their children have access to the educational content they need to meet the emerging literacy requirements.

Finally, community agencies, business, universities, philanthropies, and other local institutions can play a critical role in improving mathematics education. From its beginnings The Algebra Project has encouraged and actively promoted community and parent participation shaped by the needs and capacities of the schools and school districts in which it operates. We have discussed the many ways that local institutions have contributed to the Project in Boston and Cambridge. Community and parent participation also has taken the form of school-sponsored study halls before and/or after school (some using college students as tutors), parent-sponsored study cells, parent algebra classes, and "Honors Bound" groups to focus students and parents on honors mathematics.

The ACE program provides a compelling model for involvement of community organizations in mathematics education. ACE has succeeded in providing access to algebra to middle school students who are not studying algebra at school. This success is informing our plans for addressing the problem of high student transfer rates in Boston, which will include an array of after-school and other community-based programs to assist students who move to middle schools where algebra is not being taught as well as seventh and eighth graders who arrive at an AIMS school with no background in algebra. Also, as a community-based program ACE is uniquely positioned to affect students' expectations about both their school performance and what they do with their free time, acting as a buffer against negative role models and peer pressure in the community. It provides a link between what students do in school and the rest of their lives, a link that is likely to be missing for children whose parents do not work at jobs where mathematics and science are important.

Community-based programs like ACE also can function as a training ground for a new generation of activists and community workers. ACE has provided college students and recent graduates an opportunity to act concretely on their values about community service. This, in turn, has reinforced their commitment to community work. In this way The Algebra Project can pass from one generation to another skills and opportunities that make an important contribution to their communities.

As the BPS outreach proceeded, word of The Algebra Project spread among Boston-area educators and beyond. Three local independent schools serving African American children approached Project staff about participating in the Project. The mathematics teacher at one school, the Berea School, trained along with the BPS teachers and began implementing the Project's approach with his students in February 1990. The Algebra Project is operating in Atlanta (GA) as well as Boston and Cambridge. In January 1990 the "Algebra on the MARTA Line" project began in several Atlanta middle school classrooms. Six of the 13 middle schools in the Atlanta public school system have chosen to participate in the Project, involving 22 teachers and some 1,500 students. The Project has received a grant from the Edna McConnell Clark Foundation to conduct outreach in five cities where the Foundation is active: Baltimore, Louisville, Milwaukee, Oakland, and San Diego.

References

Reyes, L. H. & Stonic, G. M. A. (1985). A review of the literature on Blacks and mathematics. *Information Bulletin, 1*, pp. 2–10.

Valverde, L. A. (1984). Underachievement and underrepresentation of Hispanics in mathematics and mathematics-related careers. *Journal for Research in Mathematics Education*, 15(2), 123–133.