Beating the Odds:

The Real Challenges Behind the Math Achievement Gap—And What High-Achieving Schools Can Teach Us About How to Close It

By Susan Goldberger, with Katie Bayerl

January 2008

PREPARED FOR THE CARNEGIE-IAS COMMISSION ON MATHEMATICS AND SCIENCE EDUCATION

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JOBS FOR THE FUTURE seeks to accelerate the educational and economic advancement of youth and adults struggling in today's economy. JFF partners with leaders in education, business, government, and communities around the nation to: strengthen opportunities for youth to succeed in postsecondary learning and high-skill careers; increase opportunities for low-income individuals to move into family-supporting careers; and meet the growing economic demand for knowledgeable and skilled workers.

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This fall, Carnegie Corporation of New York and the Institute for Advanced Studies (IAS) established a joint commission to provide a fresh perspective on the kind and quality of mathematics and science education the nation needs for a healthy civil society and an economic future with promise. The Commission will offer an assessment of what is working well and what is not, take account of the challenges associated with implementing new policies and practices, and offer practical and actionable recommendations that can lead to positive change in K-14 education. For more information about the Commission and its work, see http://www.carnegie.org/sub/news/advanced_study.html.

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About the Authors

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Acknowledgments

The authors would like to thank the mathematics teachers at University Park Campus School in Worcester, Massachusetts—Jody Bird, Kate Shepard, Bob Knittle, and Jim Looney—for their insightful comments and invaluable contributions to this paper. This paper tries to capture the magic they work in their mathematics classrooms, transforming resistant and discouraged math learners into confident and inventive thinkers. We'd also like to thank Barbara Masley and Dan Restuccia, two of our colleagues at JFF, for their helpful editing comments and Carol Gerwin for her editorial eye. Finally, we'd like to express our gratitude to colleagues around the country who are working to create early colleges and other quality school options for underserved youth in our communities. Your work offers hope that we can find new and better solutions to close the achievement gap in mathematics education.

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Executive Summary

One of the largest and most persistent inequities in the modern American education system is the gap in math achievement along income and race lines. *Beating the Odds*, prepared for the Carnegie-IAS Commission on Mathematics and Science Education, argues that the math achievement gap is not, as commonly viewed, primarily the result of poor and uneven math instruction in urban schools, though that has exacerbated the problem. Rather, the math gap appears to be the result of two deeper, generally overlooked factors:

- The broader failure in the schooling experience of low-income and minority students that leaves many of them discouraged and disengaged, lacking the confidence to tackle challenging work and the resilience to persist in solving difficult problems.
- The particular failure of math classrooms to address the psychological and learning needs of students who have not experienced success in math previously, without watering down critical content.

But as intractable as the gap may appear, there is mounting evidence that we are capable of closing it. This paper highlights a promising trend—the growing number of academically rigorous small schools that are beating the odds by bringing the highest-need students to high levels of math achievement. Their success stems from their willingness to address the deep-rooted instructional and organizational flaws of traditional school design. Taking the best ideas from the "small schools movement" of the 1980s and 1990s, which created effective learning environments for students at risk of failure in large urban settings, these new small schools have been able not only to retain struggling students but also to prepare them for college work.

Distinguishing Features of "Closing the Gap" Small Schools

A critical difference in these schools is their culture. It is their explicit mission to eliminate the psychological barriers to learning which too often are ignored in traditional schools. Staff strive to create a nurturing yet challenging atmosphere that celebrates small successes and convinces students over time that they can master a college-prep curriculum. Everyone is held to the same high standards, regardless of their entering skill level, and regular help is available for those who need it. The belief that every student can attend college and succeed there permeates every aspect of school life.

This culture of success is reinforced in every lesson with instructional techniques that break down complex concepts into understandable pieces. In math classrooms, teachers routinely provide students a range of ways to grasp difficult material and show they value multiple ways to solve problems. Effort, perseverance, and academic risk taking are revered.

One of the most successful examples of this approach is the University Park Campus School in Worcester, MA. A partnership between the public school district and nearby Clark University, the school serves 226 students in grades 7-12 from the high-poverty neighborhood surrounding it. Despite the poor skills of entering students, UPCS has significantly raised math achievement to the level of the top high schools in the state while keeping dropout rates exceptionally low. UPCS emphasizes depth over breadth in its curriculum, but it also teaches much more than math content; students learn to approach tough problems with confidence, endurance, and a sense of fun. Staff relentlessly send the

message: "You can do this, and we will help you." In grades 7 and 8, students get basic skills instruction along with exposure to higher-order concepts and problem solving to prepare them for four years of rigorous college-prep math in high school. Classes are small and heterogeneous; students get to know the faculty and feel comfortable seeking help. Frequent group activities encourage students to do their part while taking responsibility for ensuring that everyone understands the material. Explaining mathematical thinking, in conversation or in writing, is a must every day.

Some of the emerging early college high schools also are demonstrating success raising the math achievement of low-income and minority students who have struggled in traditional schools. Built on the same premise as UPCS—that at-risk students can succeed in a college-preparatory program with the right motivation and supports—early college high schools take this philosophy a step further by compressing the time to a college degree. While in high school, students earn one to two years of college credit for free on the theory that this can motivate many struggling students. While the schools are still fairly new, early results in New York and Georgia demonstrate that they are outperforming traditional schools in their districts, despite serving higher percentages of low-income students.

Implications for Action: Lessons from High-Achieving Schools

The implications of these successes are clear—closing the math achievement gap will require much more than the conventional solutions of developing more talented teachers and engaging materials. It will require schools that can create a culture of confident and committed learners, no matter what their past educational experiences have been. It is particularly important to encourage the development of new small schools that connect students immediately to college aspirations, use a broad range of teaching methods, and consistently demonstrate the value of effort and persistence. Staff development must focus not only on content knowledge and pedagogical skill but also on the ability to create a classroom environment of mutual support and love of learning. School leadership training must make school culture more central. Leaders and staff alike must observe exemplary math classrooms and schools so they can see these ideas in action.

Beating the Odds concludes by recommending several lines of inquiry to pursue in order to better understand what makes these exceptional schools work and what it will take to implement these practices on a large scale.

Beating the Odds:

The Real Challenges Behind the Math Achievement Gap—And What High-Achieving Schools Can Teach Us About How to Close It

One of the largest and most persistent inequities in the modern American education system is the gap in math achievement along income and race lines. Research and reform efforts have identified several potential reasons for the disparity, while other, perhaps deeper, causes remain understated or overlooked.

Against this backdrop, some secondary schools are demonstrating their capacity to "beat the odds" and produce consistently strong math performance with students who likely would fail in traditional settings. The success of these high-achieving schools offers hope to those searching for broader, replicable solutions to the national math achievement crisis. Their example teaches important lessons about how to design schools, classroom-level mathematics instruction, and the preparation of math teachers to reach those who are too often considered unreachable.

This paper, prepared for the Carnegie-IAS Commission on Mathematics and Science Education, highlights several obstacles to raising math achievement that deserve more attention, then describes the key characteristics of model schools that are rising to the challenge. In so doing, we point to fruitful lines of inquiry for the Commission as it tries to answer the question: "What is the basis for optimism that mathematics education in the public schools can over time be markedly better than it is today, and how can this be achieved?"

I. Reframing the Problem and Opening the Door to New Solutions

As noted in the charge to the Commission, the problems with math education are not new and the reforms attempted in recent years have had limited impact, at best. In urban schools, in particular, we are far from closing the achievement gap between poor and minority students and their more advantaged peers. To resolve this disparity, the nation must pay more attention to its fundamental causes—issues beyond the usual reform targets of outdated or poorly designed curriculum and inadequately trained math teachers. The following stories, based on my 20 years of experience developing educational programs to boost the achievement of low-income youth, illustrate the deep-rooted problems that must be addressed if we are to make mathematics proficiency the rule for all young people.

PHOTO: DAVID BINDER

The Burden of the "Fixed Mindset"[1]

My father never graduated from high school. I had always assumed that he dropped out to join the military, as did many other young men of his generation at the start of World War II. But the real reason, he recently confessed to me, was math. He left school in the ninth grade after scoring a 29 on his algebra final. He told me he was made to feel stupid in school, particularly in math class, and he did not see the point in continuing. After leaving the service, he worked his way up from "soda jerk" to become the owner of several successful small restaurants, for which he managed all of the finances. Still, he never got over the feeling that he was not smart when it came to academics.

This perception of innate math ability—that there are those who can do math and those who can't—has persisted for generations and remains the most insidious problem for today's students, because math performance is so often a threshold for academic advancement. The world of urban education reform that I began exploring in the early 1990s seemed to sort high school students into two groups—the half that could do college-preparatory math and the half that couldn't grasp the abstract concepts introduced in early algebra. As part of an evaluation of a new Boston Public Schools program, I needed to determine the number of tenth-grade students in the four participating neighborhood high schools who could meet the minimum qualifications of a 2.0 GPA and a C- or better in math. The results shocked me. Only 36 percent of the tenth graders met these criteria, with a poor or failing math grade the biggest barrier to participating in the program.

A few years later, the entrenched nature of the math achievement gap struck me again while I was working with the Milwaukee Public Schools on the district's high school reform agenda. Milwaukee was participating in the Algebra Project, a national initiative to increase the rigor of math instruction in poor and urban communities. The project's primary goal was to have all students pass algebra by the end of ninth grade to put them on a college-preparatory track for future math instruction, bringing the days of watered-down "business math" to an end. Milwaukee's director of curriculum and instruction proudly showed me the results of the district's first year of requiring algebra for all ninth graders. Despite the more rigorous curriculum, math failure rates had not risen. Half of the ninth graders passed their math course and half failed—the same result as in previous years, when all students took pre-algebra.

I was not sure what to make of this good news/bad news story. I could understand her relief that more rigorous coursework hadn't resulted in a higher rate of failure. For the half of students who were prepared to succeed, the initiative had worked as anticipated: higher standards and higher expectations meant they succeeded at a higher level of math, one that put them on the road to college. But for other students, the new curriculum was not enough to reverse their history of poor math performance.

The more I thought about it, the more I realized that this case of higher achievement for some and continued failure for others was emblematic of the problems we face in closing the achievement gap in poor and urban communities. Introducing a high-standards, high-expectations curriculum to students who are already confident and committed learners produces the positive result of getting them the college-preparatory education they deserve. But for those who know only struggle and failure, higher expectations do not, in themselves, translate into greater success. As much as anything else, closing the achievement gap is about helping all students become confident and committed learners, no matter their past experiences. That challenge may seem most daunting when it comes to math, but it is the essence of closing the achievement gap overall. And it will be impossible to close the math achievement gap without instilling an ethic of effort-based success throughout the educational experience of low-income and minority students.

Seen this way, the math achievement gap is not, as commonly viewed, primarily the result of poor and uneven math instruction in urban schools, though that has exacerbated the problem. Rather, the math gap appears to be the result of two deeper factors:

- The broader failure in the schooling experience of poor and minority students that leaves many discouraged and disengaged by the time they reach middle school, lacking the confidence to tackle challenging work and the resilience to persist in their struggle to solve difficult problems; and

- The particular failure of math classrooms to address the psychological and learning needs of students who have not experienced success in math, without watering down critical math content.

II. Promising Strategies for Closing the Math Achievement Gap: Lessons from the New Small Schools Movement

As intractable as the math achievement gap may appear, there is reason to believe we are capable of closing it. In the past decade, we have seen evidence that high levels of math achievement are possible among even the highest-need populations. A small but growing number of academically rigorous small schools are demonstrating that poor and minority youth can succeed in college-prep math when taught in a supportive yet challenging atmosphere. These high-performing schools are benefiting from lessons learned through the small schools movement of the 1980s and 1990s about the structures and practices necessary to create effective learning environments for students at risk of failure in traditional high schools. But these schools have gone a step further, by implementing practices that not only show tremendous holding power for struggling youth but also bring all students to high levels of academic achievement.

These new small schools are beating the odds in math achievement, and their success points to ways of solving the math dilemma.

University Park Campus School: An Exemplar of How to Raise the Math Achievement of Discouraged Learners

For the past four years, I have had the opportunity to work closely with and learn from the faculty of the University Park Campus School in Worcester, Massachusetts—one of the most successful small urban schools in the country. University Park, which serves 226 students in grades 7-12 from the high-poverty neighborhood surrounding the school, presents powerful lessons about the level of math achievement that is possible in a high-need community.

Recognized as a national model by the Education Trust, the Alliance for Excellent Education, and *Newsweek* magazine, UPCS has compiled an unparalleled record of academic achievement since opening its doors in 1997. Founded as a partnership between the Worcester Public Schools and Clark University, UPCS demonstrates the critical components of a learning environment in which all students can excel in math. The majority of students accepted through the school's lottery system typically arrive with weak mathematical skills, with many struggling to perform basic arithmetic. Entering reading and writing skills are similarly weak, and 64 percent of new entrants do not speak English as their first language.

Despite the low skills of most entering students, UPCS has ranked consistently among the top high schools in Massachusetts in academic achievement. In fact, UPCS students have outscored their peers at all other urban schools serving primarily low-income youth[2] on the state's tenth-grade graduation exam (MCAS) since the test's inception in 2002. UPCS also has ranked in the top quartile of all Massachusetts high schools on the tenth-grade MCAS exam each year. No UPCS student has ever failed the English portion of the MCAS test, and only one has failed the math exam (and this student passed the test on a subsequent attempt).

Averaging test scores from the past six years, 85 percent of UPCS students scored at proficient and advanced levels on the tenth-grade MCAS math exam, compared with 35 percent of their Worcester public school peers and 59 percent of students statewide. In 2007, nearly two-thirds of UPCS students scored at the advanced level on the math MCAS, and *The Boston Globe* ranked the school 29th out of 312 high schools in the state.[3] More than 95 percent of students from UPCS's five graduating classes have gone on to college, and nearly all of them are first-generation college attendees. And the school has accomplished all of this with the same per-pupil expenditure as all other high schools in the district.

The outstanding performance of UPCS students on the state's math exams is the result of the school's success in raising the performance of its weaker students. A recent analysis of changes in MCAS scores for two cohorts of UPCS students—the graduating classes of 2006 and 2008—illustrates this

point. Only 36 percent of the students from the class of 2006 entered the school performing at grade level in math as measured by scoring proficient or advanced on the state's fourth grade MCAS math exam; that percentage jumped to 86 percent by the tenth grade. Of the 64 percent of students who entered UPCS with low fourth grade math scores, all raised their math achievement by at least one level by the tenth-grade exam, and 93 percent raised their scores to a proficient or advanced level. Examination of the change in MCAS math scores for the class of 2008, which took the tenth-grade MCAS last year, shows the same pattern of growth among lower performing math students.[4]

UPCS has earned recognition not only for its success in raising the math achievement levels of its students, but also for its ability to hold onto the vast majority of students who enter as discouraged learners. A 2003 study commissioned by MassINC, a nonprofit think tank, named UPCS the *only high-performing urban high school* in the state.[5] Eight other schools were named higher performing but did not receive the top designation because either they failed to show sufficient growth in MCAS scores for entering students or because student attrition rates were too high. Among those urban schools recognized for high tenth-grade MCAS scores, UPCS stood out as the only school that had not lost many of its weaker entering students by the end of the tenth grade.

The Defining Features of UPCS Instruction

The success of the UPCS math program is inextricably linked with its success in addressing the deep-rooted issues constraining math achievement among disadvantaged youth: their lack of confidence and disengagement resulting from years of poor schooling and the inability of traditional math instruction to reengage them without watering down the curriculum. At UPCS, a culture of success, buoyed by effective instructional supports, permeates every aspect of school life:

- UPCS staff have created a school culture that says, "You can do this, and we will help you!" Everyone who works at UPCS believes that success in a rigorous college-preparatory program is within reach of every student, including the large percentage of youth who enter the school significantly below grade level and with limited English proficiency. This philosophy manifests itself in every classroom and in a success-oriented peer culture that students protect fiercely.
- UPCS math faculty make it possible for all students to succeed with the challenging curriculum by implementing instructional practices that explicitly remove the psychological and intellectual obstacles to math comprehension. They know that these obstacles, even more than specific gaps in content and skills, are what prevent discouraged math learners from achieving competence in quantitative reasoning skills.

Beginning in grade nine, all UPCS students pursue a rigorous college-preparatory curriculum consisting of all honors classes. The focus is on the core; there are no electives until the eleventh and twelfth grades, when students who qualify may take college courses on campus at Clark. (The grades 7–8 curriculum is designed as an academic "boot camp" to address the significant academic and English-language skill deficits of entering students.) Instruction is individualized to connect to each student's particular level of development—including English language learners and special education students. There is no tracking. Instead, there are small, heterogeneous classes; supportive relationships with faculty; flexible instructional periods with additional support before and after school; an emphasis on literacy development across content areas; and collaborative group-work assignments in every classroom.

Particularly important to student success is the sense of collective responsibility and mutual support in every classroom. No student allows another to fall behind. Frequent group-based activities demand that each individual completes his or her share of the work, while taking responsibility for ensuring that everyone understands the material. Students regularly see—and benefit from—one another's strengths in small groups. They celebrate multiple solutions for complex problems. Those experiences

help build a school community that values the contributions of each individual and promotes the belief that "we can all do this, together."

The Particular Features of Math Classrooms at UPCS

The supportive culture of UPCS and the school's high expectations for all students undergird its success in raising math achievement, but there is more to it than that. A number of small schools have had similar success in fostering a culture of excellence and support and have seen significant growth in students' general academic performance. But those practices have not been enough to address the challenge of discouraged math learners.[6] Most new small secondary schools are still struggling to find effective ways to raise the math achievement of their students to college-ready.[7]

What distinguishes UPCS is both the deliberate college-preparatory design of the math program and the finely honed pedagogy to match the design. The UPCS mathematics curriculum is mapped backwards from college-level expectations, so that by the time students graduate, they have mastered the core skills and analytic processes needed for success in college. In the middle-school grades, teachers combine basic skills instruction with problem solving and exposure to key higher-order concepts necessary to understand algebra and other advanced mathematics. Beginning in the ninth grade, all students participate in a rigorous, untracked honors-level program consisting of Algebra 1 in grade 9, Geometry in grade 10, Algebra 2 in grade 11, and Pre-Calculus/Calculus or Probability and Statistics in grade 12.

At every stage of this rigorous course sequence, UPCS math faculty teach much more than math content. They teach each student to approach tough problems with confidence and endurance. During their first two years at UPCS, middle-school students work with Kate Shepard, a veteran math teacher who says that building confidence is her number-one objective in the beginning. She makes it her mission to "develop thinkers first who aren't afraid to approach anything," as she puts it.

The Shepardean Oath

We will show respect for ourselves and others at all times.

We will act as a team of mathematicians, discovering, discussing, and learning together.

We will regard the word "can't" as a swear word. We can achieve anything; we just may need a different approach or a little guidance.

We will never say the following phrase "I am done," as there is always something more to learn or someone else to help.

Shepard works to break down the math phobias that students have built up over their elementary school careers by showing them that they do have the necessary skills to tackle complex problems.

During their "August Academy" induction to UPCS, seventh-grade students traditionally do a series of engaging, hands-on problems that can be answered using a variety of methods. She explains to students that they only need to be able to count and think in order to arrive at a solution, and she encourages them to draw on every tool they have at their disposal, including manipulatives and their fingers. Shepard celebrates each solution, and at the end of the two-week Academy, every student can boast of having solved a problem successfully—setting the foundation for their math career at UPCS. Once her students understand that they know how to think like mathematicians, Shepard is able to introduce increasingly challenging problems.

Through the grades, UPCS math teachers remain attuned to their students' confidence levels. They understand the importance of celebrating small successes and consistently reinforcing the message that every problem is within a student's capacity to solve, though each teacher may approach it in a different way. UPCS teachers explicitly, and tirelessly, express their belief in students as mathematicians. As part of that message, they tell students that facing challenges with hard work is part of the job. In math class, effort matters.

"The Shepardean Oath," visible on a small poster in Kate Shepard's classroom, is the mantra that sums up the UPCS philosophy of math instruction (see box).

Over time, these shared values and confidence-boosting comments are internalized by UPCS students, who begin to believe in themselves as capable math learners. With carefully crafted lessons and the encouragement of their teachers, students quickly accumulate a record of math accomplishments that exists as tangible proof of their ability to handle challenging problems and concepts.

UPCS teachers relish a challenge themselves and approach challenge playfully. They demonstrate their own passion for mathematics by getting excited about daunting problems and new ways of looking at old questions. In introducing new concepts, UPCS faculty often begin with a fun problem—something that is at once a big challenge and intellectually stimulating. These "playful" problems often have a hands-on or inherently engaging component. Jody Bird, for example, opens her tenth-grade logic unit with a game she calls "Sez You," in which students make up definitions for strange-sounding words. Students then have to guess which definitions are real and which are made up, and in the process learn how to construct definitions. The game gets silly, but in the end, students have constructed a deep understanding of an important concept that will guide their work for the unit.

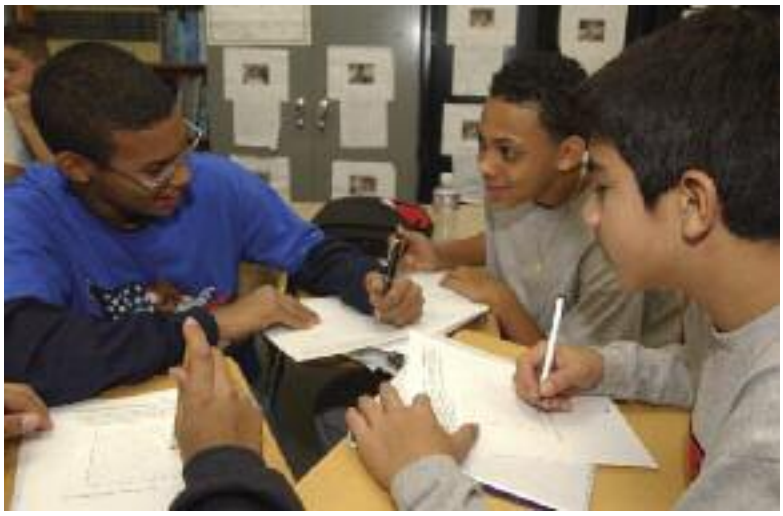

PHOTO COURTESY UPCS

Bird explains, "My first and most important job is to convince my students that they can do math and that the problem-solving and thinking aspects of math are interesting and challenging." The tougher the problem, the more opportunities there are to incorporate fun activities and novel ways of finding solutions. Each student discovery is celebrated; even errors are highlighted for their usefulness in deepening everyone's understanding of the math behind each concept. Examining how students come up with incorrect answers often helps the class learn how to avoid such pitfalls in the future. Like professional mathematicians, UPCS students are encouraged to take chances and try new approaches to problems without worrying about whether each one will be "right" per se.

There is no one-size-fits-all approach to learning math at UPCS. Differences in problem-solving approaches and in learning styles are celebrated—because everyone learns more when they are exposed to multiple methods of instruction. Students always have the option to draw from a box of manipulatives in Ms. Shepard's classroom, and she encourages use of graph paper, sketches, or any other tool that will help students find a solution. Even the "high flying" student, who might have learned a particular formula quickly in a traditional math classroom, is forced to look at problems in multiple ways when peers bring varied solutions to the class. Encouraging students to try different methods builds their confidence by showing them that they have the tools to approach any problem, while simultaneously fostering a deeper understanding of mathematical concepts.

Shepard once used a textbook end-of-chapter test to prove this point. Though she had not yet covered all of the test's content in class, she told her students that they would earn extra points for answers to problems that went beyond what they had studied. She was not surprised when many of the students successfully solved those problems; her students had developed the confidence to think through even unfamiliar problems, and each applied methods that s/he knew would help find a solution. This level of confidence, coupled with students' comfort with varied, flexible thinking, is probably the most important factor in their extraordinary success on the state's exit exam in math.

The math teachers at UPCS make two deliberate curricular decisions that support this multi-method, confidence-building approach to math instruction: First, they prioritize depth over breadth in content coverage. Second, they make time available for students to constantly explain their thinking, orally and in writing.

It is important to note that UPCS teachers do not always try to cover every state curriculum standard in each grade level. Rather, they take a longitudinal approach. For example, Kate Shepard knows that she has two years to teach her students all of the important middle school math content. The state standards for grades 7 and 8 have a lot of repetition, so Shepard decided not to cover everything that is required in each grade, but rather to teach everything once and teach it well. For that reason, UPCS students tend to score lower on the state's seventh-grade math exam than they do on the tenth-grade exam. Along the way, they achieve a depth of understanding that is the necessary basis for succeeding in a rigorous high school math curriculum, which is more abstract and conceptual. By the time students take the state's high-stakes math exit exam in the tenth grade, they have mastered all of the standards.

Across all grade levels, teachers make ample time for students to work through complex problems and to explain their thinking in conversation and in writing. Through collaborative group assignments, frequent partner assignments, and whole-class discussions, students explain their thinking verbally every day. They also write about math on a regular basis—composing "Dear Confused" letters to explain tough concepts to peers, composing "math stories" that illustrate equations, or simply writing extended explanations of how and why they approached a particular problem they way that they did. When students explain their thinking, they deepen their own understanding of mathematical concepts, often either self-correcting or making their misunderstandings visible to peers and teachers, who then can help them see where they went wrong.

The UPCS approach to math instruction is deep and time-intensive, but UPCS graduates appreciate their experiences as they approach tough content in college. One UPCS graduate, who now attends Clark University, tells a story of her eleventh-grade math teacher who used metaphor after metaphor to explain the concept of an arc to a student who did not grasp it. The story is humorous because it shows the lengths to which UPCS teachers will go for their students. But it also illustrates the commitment of UPCS teachers to sticking with a concept until it is understood and to employing every instructional technique at their disposal to find a method that works. This former UPCS student has used the same approach when faced with difficult material in her college classes.

UPCS graduates have matriculated to a range of colleges and universities, where they are applying the lessons they learned at University Park to tough college courses. All of them benefited from a small school culture that nurtured their academic progress at every stage, and that made college the goal for everyone. They were further supported by a math curriculum designed to build confidence, encourage persistence, and promote the deep and flexible thinking required in a college environment.

Early College High Schools: Extending the Lessons of UPCS and the New Small Schools Movement

In my work at Jobs for the Future, which coordinates the Early College High School Initiative, I've had the opportunity to work with other small schools that, like University Park, have the explicit mission of increasing academic rigor for traditionally underserved and struggling students. The Early College High School Initiative takes lessons from UPCS and the new small schools movement a step further by designing schools that blend high school and college in a rigorous, yet supportive, academic program that compresses the time to a college degree. Early college students can earn an Associate's degree or one to two years of transferable college credit—tuition free—along with a high school diploma. Like UPCS, early college high schools are built on the premise that students who have not previously been successful in school, or who come from communities where high levels of academic achievement are not the norm, can succeed in a college-preparatory program with the right motivation and supports.

The almost 160 early college high schools that have opened since 2002 are all fairly new, none of them more than five years in operation. However, early results show that these small schools are outpacing the average performance of high schools in their districts, while serving a higher percentage of low-income students. The most recent evaluation of the initiative reported that in 2005-2006:[8]

- Early college high school students passed state English language arts exams at a rate of 81 percent, compared with a 69 percent average passing rate for their districts.
- Early college high school students passed state exams in math at a rate of 66 percent, compared with a 57 percent average for their districts.

The evaluation also reported that 52 percent of students enrolled in early college qualified for free or reduced lunch, and that over two-thirds of early colleges were serving a higher percentage of low-income students than other high schools in their districts. Minority enrollment was similar between early colleges and their district schools, with 71 percent of early college students coming from minority groups.

Data on the incoming academic characteristics of early college high school students and the growth achieved by early college students compared to district peers with similar characteristics is not yet available. We expect future evaluations of the initiative to provide more detailed analyses as early colleges mature and longitudinal data becomes available.

However, there is a small set of early college schools for which we have data on students' academic growth, and some of these schools are already showing strong gains in math achievement. For example:

In Brooklyn, New York: Students at the Science, Technology and Research (STAR) Early College High School have outpaced students from schools with similar populations[9] and the district average on the New York State Regents Exams for the past two years. STAR received a B performance rating from the NYC Department of Education in 2007, a grade that reflects a weighted Regents pass rate that emphasizes student growth from one year to the next. STAR did particularly well with students who were in the lowest third academically. STAR students who began in the lowest third had a weighted Regents pass rate that was in the 90th percentile citywide and in the 62nd percentile as compared to schools with similar students.[10] STAR has simultaneously demonstrated strong student holding power—a 92 percent stability rating two years in a row.

Manhattan/Hunter Science High School, another early college high school in New York City, showed similar progress in math on its DOE report card.[11] It received an A rating overall.

In Milledgeville, Georgia: At one of the newest early colleges, Georgia College Early College, its first class of seventh graders made a dramatic leap in math achievement after just one year. GCEC, which includes middle school grades in its design and draws heavily on lessons from UPCS, saw scores rise from 40 percent of students meeting or exceeding standards on the state's math exam the year prior to entering the school to 89 percent meeting or exceeding standards in the 2007 exam. This jump of 49 percent in the math pass rate outpaced the change in pass rates of its two sending counties, despite serving a more academically challenged group of students.[12] Baldwin County seventh-grade students had a 63 percent pass rate in math in 2007, and Putnam County seventh-grade students had an 86 percent pass rate, while the previous year, sixth-grade students from Baldwin and Putnam counties passed at rates of 43 percent and 59 percent, respectively.[13]

The early colleges noted above are still too young to have earned as many accolades as University Park Campus School, and they are still experimenting with designs that will best serve their students. But their early successes bolster the evidence from UPCS about what factors make a difference in closing the math achievement gap. Like UPCS, these small schools combine a rigorous academic program with a "you can succeed" culture that is explicitly focused on preparation for college.

Early college high schools go further than UPCS, however, in pushing the boundaries between high school and college and experimenting with school designs that blend both. While many students at UPCS take college classes at Clark University in addition to their high school classes, the early college model makes college courses the core academic curriculum in the upper grades. The Early College High School Initiative is based on a provocative theory: that the opportunity to take college courses during high school is a powerful way to motivate students to work hard and meet serious intellectual challenges.

To help them succeed in this challenging atmosphere, early college students are buoyed by a college-going culture that is built into every aspect of the academic program. From the beginning, early college students, like their UPCS peers, hear the message that "you deserve to go to college, and we will make sure you get there." But all early college students are also told they are smart enough to start doing substantial college work while still in high school. These early and engaging experiences in college classes, and in the formal and informal induction activities provided by the partnering higher education institutions, help early college students create a strong academic identity.[14]

Early college high schools, including the three mentioned above, have benefited from national and intermediary-specific professional development opportunities that introduce teachers to the classroom practices that support a college-going culture. Faculty from UPCS, including Kate Shepard and Jody Bird, have been active in delivering professional support to their colleagues in the early college network—through residencies at University Park, interactive workshops with teachers, and published descriptions of their work. While instructional practices are by no means uniform across early college high schools, or even within every school, some of the most effective practices from UPCS have carried over into many early college math classrooms. Widely adopted practices include collaborative group work in which students explore and discuss complex math problems and frequent use of writing-to-learn activities that ask students to explain their thinking.

Of course, the development of these innovative small schools presents challenges, as well. Like many other small schools that have implemented a rigorous college-preparatory curriculum for all their students, early college high schools struggle with holding onto their weaker students. Some, like the three schools described above, have been able to raise the achievement of lower performing students without losing many along the way. Other early colleges have experienced high attrition rates, and are taking steps to address this issue. For example, more early college high schools are opting for five-year or middle-high school designs that build in more time for ramping up students' academic skills before entry into credit-bearing college courses. Also, schools are experimenting with different entry points into the college curriculum (e.g., non-credit mini courses, strategic use of electives, and two-semester "stretch" courses)[15] and supplementary supports to ensure student success (e.g., academic support labs and courses co-taught by high school and college faculty).

A significant piece of the rigor challenge for early college high schools is their faculties' lack of experience with the type of teaching required to support and accelerate the learning of traditionally underserved students. Several early college high schools, and many individual teachers, are already showing progress. But the initiative as a whole is confronted with the same capacity issues that face their district counterparts:

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- An inadequate supply of teachers who have both the academic content knowledge and the pedagogical ability to make rigorous curriculum accessible to diverse learners; and
- The difficulty of finding and retaining school leaders who are able to foster a culture of high achievement while continuously developing teacher capacity.

III. What High-Achieving Schools Can Teach the Field

The schools described in this paper are among a relatively small number of schools with high-need populations that are beating the odds in math achievement. The example of University Park Campus School and the emerging Early College High Schools suggests broad implications for school design, teacher training, and school leadership training in considering strategies for closing the math achievement gap.

Implications for School Design

A focus on changing math classrooms is necessary but not sufficient to make significant progress in closing the achievement gap. Motivating academic effort from discouraged math learners is a Herculean task and math teachers can't do it alone.

PHOTO: DAVID BINDER

Through extraordinary effort, highly skilled and experienced math teachers can sometimes create isolated pockets of excellence in underperforming schools. But relying on exceptionally talented teachers is neither a reasonable nor a sustainable strategy for the nation. Providing math teachers with curricular materials that make difficult concepts accessible and engaging would help students learn, but it would not be sufficient to overcome long-term discouragement and resistance to the idea that effort results in success. Nor would new professional development programs to help teachers implement the practices described in this paper. Significant improvement in math achievement is possible only when more effective math classrooms are nested within broader school environments that explicitly encourage all students to tackle challenging subject matter and consistently employ instructional strategies that make complex material accessible to diverse learners.

In order to succeed, math teachers need help from the rest of the school. They need their students to receive continuous reinforcement of the messages that effort matters and that they have the ability to be academically successful. Most important, they need their students to experience academic success in other classes so that they can transfer their newfound confidence in their ability to tackle difficult subject matter in the subject that many fear the most—math.

Those who want to close the achievement gap in math can't sit on the sidelines in broader debates about how to create more effective middle and high schools for poor and minority students. Creating schools that combine a rigorous college-prep curriculum with the supportive, personalized attention discouraged learners need is critical.

There is reason to believe that these schools are more likely to succeed if they are small and created explicitly for this purpose. An ethic of effort for success requires constant reinforcement—daily, student by student, class period by class period. Students need to hear the same messages from every adult they encounter, and they need to be surrounded by fellow students who are all getting the same messages in the same relentless fashion.

It may be possible, theoretically, for that to occur in a large institution, or for such a challenging yet supportive school culture to be introduced and developed in an existing institution over time. But it's harder to imagine that level of mutual reinforcement in a place where adults and students can be virtual strangers and a preexisting culture can be so ingrained. Furthermore, it's hard to believe it is coincidence that the schools in which we have seen evidence of success are both small and new, either started from scratch or carved out of an existing school and begun with a cohort of newly entering students and grown year by year.

Therefore, it is particularly important to encourage the development of small schools such as UPCS and early colleges, which connect students immediately to college aspirations, use teaching methods that engage a diverse range of learners, and reward faculty for fostering a culture that prizes effort.

Implications for Training Math Teachers

The highly successful math faculty members at University Park Campus School argue that while teachers certainly need a nuanced understanding of math content, it is not enough. Equally important are the "soft skills" they employ daily to create a classroom culture of encouragement and support and to model perseverance with difficult problems. They have learned that they need to be extroverts, consistently demonstrating their own love of math and their firm belief that, with effort, every student will succeed.

At the same time, UPCS teachers have the ability to present lessons from many different angles to reach the school's diverse group of learners. They are constantly revising their strategies and tweaking lessons to address varied student needs. These skills are supported by a curriculum that starts with the fundamental building blocks of mathematics and then explicitly shows students have to make connections between new concepts and skills and content they already have mastered.

When asked how they learned these skills, the math teachers at UPCS all described two key factors: the ability to observe model classrooms and schools in action and the opportunity to experience this type of instruction in workshops and teacher preparation classes run by expert faculty. It is clear that both a new understanding of the skills required to be an effective math teacher and more effective methods of teacher preparation are critical components for meeting the challenge of raising math achievement for all.

Implications for Training School Leaders

In contrast to the training of business leaders, where building an effective corporate culture receives substantial attention, the subject of culture development gets short shrift in traditional educational leadership training programs. Rare is discussion of creating a school culture that can hold onto discouraged learners and put them on track to college, let alone of how to do so. As the success of UPCS and the Early College High School Initiative demonstrates, developing school leaders who can implement these ideas is a critical component in closing the math achievement gap. More attention must be paid to designing leadership training and new-school development programs that make school culture central to the process. In addition, school leaders must have the opportunity to observe exemplars of strong school culture and strong math classrooms cocooned in these schools to help them see what these ideas mean in action and how to replicate them later.

IV. Fruitful Lines of Inquiry for the Commission to Pursue

The Carnegie-IAS Commission on Mathematics and Science Education has the opportunity to reframe the problem of the math achievement gap, opening the door to bold and effective solutions. Doing so will require challenging conventional understanding of the reasons for the gap and the usual politically expedient solutions. It also will require the same fearlessness and relentlessness displayed by the faculty at UPCS and other high-achieving schools who refuse to accept anything less than success for their students.

This paper begins to draw out the broader lessons learned from schools like UPCS that are demonstrating how to raise the math performance of low-income and minority students to a college-ready standard. These initial observations suggest several fruitful lines of inquiry that we recommend the Commission pursue in order to better understand what makes these exceptional schools work and what it will take to implement these practices on a large scale.

What factors account for the success of UPCS and other new small schools in closing the math achievement gap? How do these schools motivate students who enter as discouraged learners to put forth the effort required to master a college-preparatory math curriculum? How do their teachers make abstract concepts accessible to those with a history of failure in math?

What enabling conditions are needed to create and sustain schools like UPCS that combine a supportive culture for learning with highly effective teaching practices for raising the achievement of underserved students? The most effective new small schools, whether district-sponsored or charter schools, tend to share important features that distinguish them from traditional public secondary schools. For example, leaders of effective small schools generally have much greater autonomy when it comes to staffing, curriculum, scheduling, and budget decisions. It will be important for the Commission to identify the most important enabling conditions and to advocate for their implementation. School districts like Boston, which allow pilot schools with substantial autonomy over personnel and budget as well as traditional schools, and New York City, which has extended the management powers enjoyed by principals in "empowerment schools" to all schools beginning in the 2007-2008 school year, provide two models for how to do this.

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What are the most important skills and attributes that math teachers need in order to be effective with a classroom of diverse learners? What are the implications for teacher preparation programs? Would we allow medical students and residents to be trained by non-physicians or physicians who were many years removed from actual clinical practice? Of course not. Yet we allow schools of education to be staffed by professors who have not been required to demonstrate success in the kind of classrooms they are preparing students to enter. Nothing short of a revolution is needed in the way we deliver pre-service and in-service training to prepare new teachers to execute the strategies described in this paper.

What are the most important skills and attributes that school leaders need in order to create motivating school environments and effective classroom instruction for diverse learners? How can we best train school leaders to lead schools that can beat the odds? Just as the training of math teachers requires overhaul, so too does the training of school leaders, to prepare them to create effective schools for diverse and discouraged learners. What can we learn from other industries about the best ways to train leaders to build and sustain a motivational culture and support expert professional practice? What can we learn from new school-leadership programs like New Leaders for New Schools and Jobs for the Future's UPCS Institute for Student Success?

What are the most promising strategies for spreading the effective culture-building and teaching practices of schools like UPCS to the growing number of small secondary schools that states and districts are developing to replace failing urban high schools? The question of how to efficiently transfer knowledge and expertise developed in exceptional schools like UPCS to the broader field is both complicated and critical to answer. Recently, the Bill & Melinda Gates Foundation made a signifi-

cant investment to help JFF build out the UPCS Institute—which currently provides short clinical residencies and summer programs for school leaders, instructional coaches, and teachers involved in starting small early college secondary schools and related college-preparatory school designs—into a vehicle for training school leaders and teachers on a larger scale.[16] These funds will allow the Institute to experiment with a range of new training products and services to expand the audience and impact of the Institute. In developing these products, we will be grappling with questions such as: How can we make better use of multimedia technologies to make the experience of observing model teaching practices and classrooms available to thousands of school leaders and teachers who won't have the opportunity to participate in a clinical training residency at the school? What are the most effective ways to train and utilize instructional coaches to improve classroom practice? What are the most effective follow-up training services to help leaders and staff of new small schools reproduce the culture of effort and support that permeates UPCS classrooms?

While the creation of new small schools like UPCS seems the most promising option for raising the math achievement of urban students, are there ways to adapt the practices developed by high-performing small schools to large urban high schools to help students during the long transition period? Cities like New York and Boston are demonstrating that it is possible to replace failing secondary schools with small, more effective designs, but a transformation like this will take years to implement. In the meantime, what can be done to raise the math achievement of underserved students? Is it possible for ninth-grade "academies" to nest intensive, catch-up math instruction within a supportive team environment and made significant improvements in math achievement? Can twelfth-grade math courses be reconceived so that students who have not previously been successful have the opportunity to revisit and master the foundation math skills required to pass college-level math?

Are there lessons to be taken from secondary schools that are beating the odds with low-income and minority youth and applied to the community college sector to help raise their success rates with low-performing math students? The vast majority of academically unprepared low-income and minority high school graduates who enroll in post-secondary education begin their college careers at a community college. The success rates of community college students who enter with significant math remediation needs are discouragingly low. A recent study of 35 colleges serving a majority of low-income and minority students found that nearly three-quarters of entering students were referred to developmental math education, and only 23 percent completed the developmental math requirements.[17] How can we apply lessons learned from effective school and classroom environments at the secondary school level to improve the performance of community colleges with discouraged math learners?

This paper is a beginning attempt to answer the questions above. If it suggests any solutions at all, it is thanks to the courageous and inventive work of the outstanding staff at UPCS and the early college high schools Jobs for the Future has had the honor of working with. Here's hoping that the Commission can help make the schools and practices featured in this paper become the standard rather than the exception in urban education.

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Endnotes

[1] The term "fixed mindset" is borrowed from Carol Dweck, who in her book *Mindset* uses this term to describe people who see their intellectual abilities and personal qualities as fixed and unchangeable features of their identity. See Carol Dweck. 2006. *Mindset: The New Psychology of Success*. New York: Random House.

[2] According to 2007-08 school enrollment figures, 76 percent of UPCS students qualify for free or reduced price lunch; 64 percent are students of color; and 64 percent do not speak English as their first language.

[3] http://www.boston.com/news/special/education/mcas/scores07/10th_top_schools.htm.

[4] Forty-eight percent of the students from the UPCS class of 2008 entered the school performing at grade level in math, as measured by scoring proficient or advanced on the state's sixth grade MCAS math exam; that percentage jumped to 90 percent by the tenth grade. Eighty-two percent of students who entered UPCS with low sixth grade math scores raised their scores to proficient or advanced on the MCAS tenth-grade math exam.

[5] *Head of the Class: Characteristics of Higher Performing Urban High Schools in Massachusetts*. 2003. Boston: Center for Education Research and Policy at MassInc.

[6] Recent studies of new small schools developed in New York City have found that these schools are significantly outperforming traditional district high schools in rates of promotion and graduation of low-income, at-risk students, but they are not yet outpacing traditional high schools in the percentage of graduates who meet college-ready academic standards as indicated by earning a Regents diploma in New York. See Foley, Eileen, Allan Klinge, & Elizabeth R. Reisner. 2007. *Evaluation of New Century High Schools: Profile of an Initiative to Create and Sustain Small, Successful High Schools*. Policy Study Associates, Inc. http://www.newvisions.org/schools/downloads/PSAfinal92707.pdf and *Multiple Pathways Research and Development: Summary Findings And Strategic Solutions for Overage, Under-credited Youth*, 2007. New York: New York City Department of Education, Office of Multiple Pathways. http://schools.nyc.gov/NR/rdonlyres/BB8FE392-4B44-44D7-B893-242C87E1BE8A/15814/FindingsoftheOfficeofMultiplePathwaystoGraduation.pdf.

A study conducted for the Bill & Melinda Gates Foundation of their initiative to develop new small high schools around the country found the quality of student work produced to be higher in English/language arts classes but slightly lower in mathematics compared to traditional comprehensive high schools serving similar students. *Executive Summary: Evaluation of the Bill & Melinda Gates Foundation's High School Grants, 2001-2004*. American Institutes for Research/SRI International. http://www.gatesfoundation.org/nr/downloads/Ed/researchevaluation/ExecSummaryYr3.pdf.

[7] Steve Barr, the founder of Green Dot Schools, a network of ten charter high schools in Los Angeles, California, that have received national recognition for the academic success they are achieving with students from some of the city's poorest neighborhoods, described the challenges his schools faced trying to duplicate their success in literacy in the area of mathematics. (*Presentation at the Boston Foundation, April 19, 2007.)*

Only three of the eight Green Dot high schools with reported math scores met or exceeded the L.A. Unified District rates of proficiency on last year's Algebra 1 California Standards Test (California Department of Education. 2007. http://dq.cde.ca.gov/dataquest/).

[8] *Evaluation of the Early College High School Initiative: Select Topics on Implementation*. 2007. American Institutes for Research and SRI International.

[9] Students are admitted to STAR through the New York City school lottery process, through which both schools and students rank their top choices; STAR seeks to enroll students from a range of academic levels each year. Over 85 percent of STAR students are black, largely of Caribbean origin, 7 percent are Latino, 4 percent are of mixed origin, 2 percent are Asian, and 1 percent is white; 54 percent report eligibility for free and reduced lunch. In 2005, incoming students had met the eighth grade Regents standards had rates of 50 percent in English Language Arts and 73 percent in math. In 2006, they passed the rigorous math exam at rates of 99 percent (Math A) and 81 percent (Math B), compared to citywide rates of 83 percent and 69 percent, respectively. (Students in New York City schools with similar populations passed the two math exams at rates of 93 percent and 74 percent.) In 2007, STAR students passed the math exams at even higher rates of 97 percent (Math A) and 94 percent (Math B). More detailed pass rate information can be found by downloading the New York City Supplement Report at http://schools.nyc.gov/SchoolPortals/17/K543/AboutUs/Statistics/default.htm). STAR Early College High School is located in Erasmus Hall and is a partnership of the New York City Public Schools and Brooklyn College. It is supported by the Woodrow Wilson National Fellowship Foundation.

[10] The New York City DOE Report Card includes a weighted student progress ranking, which measures the ability of a school to enhance performance levels of its students from one year to the next. The measure takes into account students' achievement levels prior to entering high school on the eighth grade Regents tests. Each school is ranked citywide and against a smaller set of 40 "peer" schools that enroll students with similar achievement levels. STAR was rated 83.9 percent citywide in its weighted math Regents pass rate (i.e. 84 percent of schools had less success than STAR in raising their students' math achievement). STAR's weighted math rating for its "peer" school group was 66.9 percent—putting STAR in the top two thirds of this similar group of schools. STAR also ranked high when only the lowest third of students were taken into account; STAR received a 62.3 percent rating

compared to similar schools and a 90.3 percent rating compared to the city in mathematics. (To access this information, download the 2007 Progress Report from http://schools.nyc.gov/SchoolPortals/17/K543/AboutUs/Statistics/default.htm.)

[11] With its lowest third of students, Manhattan/Hunter received a 61.3 percent rating compared to similar schools and a 90.7 percent rating compared to the city in mathematics. (To access more detailed information, download the 2007 Progress Report from http://schools.nyc.gov/SchoolPortals/17/K543/AboutUs/Statistics/default.htm.) Like, STAR, Manhattan/Hunter also participates in the New York City lottery system and seeks to enroll students from a range of academic levels. Manhattan/Hunter Science High School is a partnership between the New York City Public Schools and Hunter College. It is supported by the Woodrow Wilson National Fellowship Foundation.

[12] Students from Putnam and Baldwin counties (rural communities in central Georgia) apply to GCEC through a lottery. GCEC targets lower-performing students (i.e., those who score in the 25th-45th percentiles on the Iowa Test of Basic Skills), and only students who meet that criterion are eligible to apply to the lottery. Only 40 percent of incoming seventh graders had passed the sixth grade criterion-referenced math test, compared with a 59 percent pass rate for Putnam County and a 43 percent pass rate for Baldwin County in 2005-2006. In 2007, the GCEC student population included: 95 percent low-income students, 99 percent first generation college goers, and 67 percent African American, 29 percent white, 2 percent Latino, and 2 percent Asian students. GCEC overrepresents students of color, particularly African American students, compared to the two counties as a whole. Baldwin County is 54 percent white and 43 percent African American. Putnam County is 68 percent white and 30 percent African-American. Both have small numbers of Asian, Latino, mixed race, and Native American residents. GCEC is partnered with Georgia State University and is supported by the Board of Regents of the University System of Georgia, the intermediary organization for Georgia's statewide early college initiative.

[13] For more detailed information on results from the 2006-2007 Georgia Criterion-Referenced Competency Tests, go to: http://public.doe.k12.ga.us/ci_testing.aspx?PageReq=CRCT2007DATA.

[14] Nakkula, Michael and Karen Foster. 2007. "Academic Identity Development: Student Experiences in Two Early College High Schools." In Joel Vargas, et al. *Minding the Gap*. Cambridge, MA: Harvard Education Press.

[15] "Stretch" courses teach a one-semester college course (e.g., college algebra) over two semesters.

[16] More information on the UPCS Institute for Student Success can be found at http://www.upcsinstitute.org.

[17] *Data Notes, November/December 2006.* Achieving the Dream: http://www.achievingthedream.org/_pdfs/datanotes/datanotes-novdec-2006.pdf.

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