A Report on the National Science Foundation's Urban Systemic Program

What Works Best in SCIENCE & MATHEMATICS Education Reform

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About What Works In Science and Mathematics Education Reform

This report examines the accomplishments, challenges and sustainability of the National Science Foundation's Urban Systemic Program (USP), which ends its funding to the last of three school cohort groups in September of 2006. In total, 30 districts were funded by the USP to improve science and mathematics education under five year cooperative agreements. The USP was organized around six core drivers of systemic change:

- Improving teachers' knowledge of science and mathematics content and teaching methods as aligned to research-based curricula.
- Partnering with community groups, businesses, and other important stakeholders.
- Leveraging funding from many sources to support clear, unified goals.
- Aligning district education policy to support reform throughout the entire school system.
- Improving student achievement in mathematics and science.
- Eliminating student achievement gaps.

What Works Best in Science & Mathematics Education Reform was produced under grant number 0427352, awarded by the National Science Foundation to Potomac Communications Group of Washington, DC. It was written by Principal Investigator Aimee L. Stern and Researcher/Writer Elizabeth McCrocklin.

Aimee Stern is a former journalist who has written and reported for publications such as the *New York Times, Business Week, U.S. News & World Report* and *Money magazine*. She has a degree in secondary education and has worked with the USP districts for several years on message development and outreach strategies. Elizabeth McCrocklin has taught elementary school and worked for *Education Week*. This report was designed by Creative Director Barbara Longsworth, who specializes in enhancing complex information visually and designing multi-media products.

PCG of Washington, works closely with senior executives and administrators, academics, scientists and teachers to communicate the results of their scientific, research and education programs to broader audiences.

For more information about this report or to download a PDF version go to **www.pcgpr.com/education**, or contact Aimee Stern at astern@pcgpr.com.

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Data: *All data used in this document was supplied by the NSF, funded projects or contractors unless otherwise indicated. It was the most current data available at the time of publication.*

Photography: *The majority of photos used in this report were taken in Urban Systemic Program (USP) projects. However, individual student pictures were not necessarily taken in districts they are used to illustrate.*

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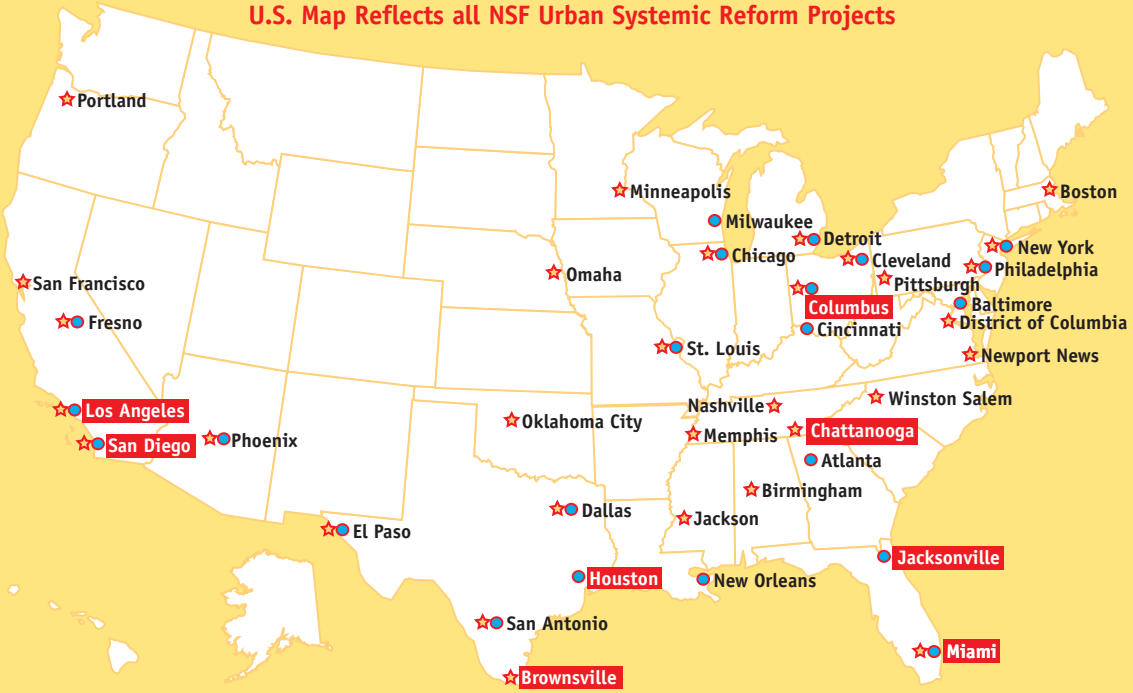
October 2006

U.S. Map Reflects all NSF Urban Systemic Reform Projects



Sites featured in this report
Urban Systemic Program (USP) - Sites since 1999
Urban Systemic Initiative (USI) - Sites since 1994
Source: Systemic Research, Inc.

What Works Best in Science & Mathematics Education Reform

A Report on the National Science Foundation's Urban Systemic Program

In 1994, the National Science Foundation (NSF), a federal agency that funds scientific and education research, introduced a series of programs designed to catalyze science and mathematics education reform in some of the nation's largest urban primary and secondary schools. The aim of the program, which began as the Urban Systemic Initiatives (USI) and was later replaced by the Urban Systemic Program (USP), was to provide a more rigorous science and mathematics education for all students. The funding, which continued in some districts for up to a decade, emphasized improving the academic performance of minority groups.

Having learned from mixed success with previous urban reform programs that targeted specific challenges, the NSF approached the USP districts as systems, pursuing change through several concurrent avenues. Systemic theory, although initially untested in large-scale reform, was a central component of the USI and USP. According to the NSF, systemic reform occurs when all essential elements of schools and school systems are engaged or operating in concert, when the forthcoming improvements become intrinsic parts of the ongoing educational system for all children and when the changes become part of the school system's operating budget.

"This was the first national effort to tackle systemic reform of mathematics and science education on a large scale at the district level," said Beatriz Chu Clewell, Director of the Program for Evaluation and Equity Research (PEER) at the Urban Institute in Washington, DC. "It was really a tremendously brave and optimistic undertaking. The systemic approach was new when NSF's Systemic Initiative started. Before that, district-sponsored reforms were done piecemeal by adopting a particular curriculum or assessment system or introducing a new professional development approach for teachers."

The NSF programs had broad reach into urban school districts. From 1994 to 2003, the USI, the USP, or both, reached close to 13 million students (more than one third of all U.S. public school students), more than 600,000 teachers and almost 51,000 administrators. This report and the map pictured to the left focuses only on those programs absorbed into the USP or funded under that program.

During this period, while many school districts throughout the United States reduced science content, the USPs did the opposite, creating and implementing research-based science curriculum taught by well-trained teachers starting in kindergarten and continuing through high school. In 2005, 29% of the nation's school districts reported having significantly reduced the amount of time devoted to science instruction, up from 22% in 2004, according to a study conducted by the Center on Education Policy, an advocacy group for public education.

"Teachers tell us that the annual testing and accountability provisions mandated by No Child Left Behind in reading and mathematics have greatly squeezed science out of many elementary schools," said Gerald Wheeler, executive director of the National Science Teachers Association. "A solid foundation in science during elementary school gives students a better grasp of science at the secondary level and beyond."

The USPs' greatest impact was in helping the funded districts develop a standards-based science and mathematics curriculum delivered by qualified teachers and measured by assessments aligned to that curriculum, according to *The Final Report: Strategies and Trends in Urban Education Reform,* produced by education research firm Cosmos Corporation of Bethesda, MD in 2005. Elementary and middle school mathematics showed the most positive gains in funded districts. Out of 20 USP sites for which consistent state-level mathematics data were available, 17 made positive gains over the baseline years.

Many funded districts also changed their education policies regarding science, increasing the number of high school science courses students must take to graduate. This links to a broader trend in science education. By 2011, 27 states will require high school students to take at least three science courses to graduate. In 1992, only six states had this requirement.

This report provides a glimpse into the challenges and accomplishments of a few USI/USP districts as they struggled to apply systemic theory in guiding local science and mathematics reforms. These illustrations do not attempt to describe each model and detail individual attributes but to illustrate representative accomplishments and challenges that resulted from the program.

To collect data, eight urban districts were selected based on criteria including geographic location, district population, progress in both science and mathematics, range of funding groups, stability and transition of site leadership, recommendations of evaluators and the NSF and accessibility. Interviews with district personnel, members of the education community, an extensive literature review and reports from evaluators also added to the information for this report. In total, more than 100 classrooms were observed in 40 schools, including 11 elementary, 13 middle and 17 high schools.

Addressing a Critical National Need

USI/USP addressed a critical national need. Despite showing some improvement in science and mathematics performance in recent years, U.S. students continue to lag behind their peers in other developed countries, according to NSF's *Science and Engineering Indicators 2006* report on American education in these subject areas. The NSF expects the demand in these fields to increase at more than double the rate for all other occupations during the next decade. The growing demand for American scientists and engineers requires that minority students be trained to fill these positions.

More than half of the funded districts focused first on establishing science instruction in elementary school. The urban programs encouraged districts to require regular elementary science instruction, and helped familiarize teachers with new experiment-based science kits and teaching methods.

Other districts tackled science and mathematics instruction first at the middle school level, which has a perennial certification problem. While certification requirements vary by state, elementary-certified teachers commonly end up filling middle school positions, teaching science and mathematics at a level exceeding their expertise. Many districts used USI/USP funds to pay their middle school teachers to obtain the relevant certifications.

A few districts turned first to reforming instruction at high school, a task complicated by the fact that high school science and mathematics teachers often consider themselves experts in their subjects and resist change. In the most successful sites, districts raised science and mathematics graduation requirements and used funds to train high school teachers on the teaching methods, strategies and technologies to help students meet the higher standards.

The NSF placed stringent accountability requirements on funded districts. Projects were required to collect and report data on how many students, teachers and administrators were reached by NSF funded activities; how funds from other grant, federal and state programs were used in conjunction with those of the USP; hours of professional development delivered to educators and student achievement trends in both science and mathematics.

In all cases, the urban projects laid the groundwork for science and mathematics education reform by encouraging the following developments in every site:

- **Trained the next generation of education leadership.** Funded districts trained hundreds of teacher leaders, individuals singled out as promising leaders and mentors that could help other teachers improve their performance. Many of these teachers obtained master's degrees, learned new educational techniques, deepened their content knowledge and developed new strategies for mentoring their peers.

- **Improved science and mathematics course work.** Districts embraced inquiry-based science and mathematics curricula in elementary and secondary schools. Inquiry is a problem-solving approach that uses scientific investigations to promote students' critical thinking. Funded districts began to standardize curriculum and write curriculum guides to help teachers cover state standards.

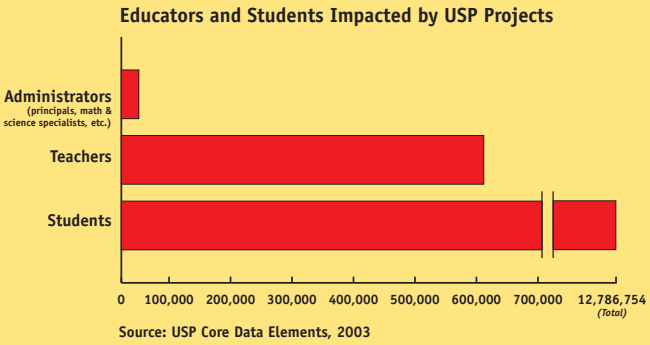
- **Encouraged collaboration among teachers and other stakeholders.** The new focus on science and mathematics instruction spurred district-wide discussions around educational practice. For the first time on a large scale, teachers planned lessons in consultation, principals led school-wide discussions about student performance, and high schools worked with their feeder middle schools to prepare for the needs of incoming students. Partnerships were developed with colleges and universities, businesses, community groups and informal science education sites such as museums and zoos.

- **Made instruction a priority for district leadership.** With USI/USP training, administrators learned to place a high priority on guiding instructional content and visiting classrooms frequently. Many took ownership of the effort to reform curriculum and built an infrastructure to oversee and support teachers. In some districts, the superintendent focused on instructional leadership, while in others the principals assumed that role.

- **Used data to drive education decisions.** With the NSF's emphasis on data, districts learned how to collect, analyze, distribute and apply data on student learning and academic progress. Before the USP, administrators usually analyzed general data. Now district principals and teachers regularly use student test results to refine their instruction and enhance student learning.

- **Set rigorous science and mathematics requirements.** Districts made science and mathematics an instructional priority, increasing instructional time allocated to these subjects and raising graduation requirements. Districts embraced the idea that all students could and should succeed in mathematics and science, using Algebra I and Biology as "gateway" classes to excite students about learning, rather than weed out those who were struggling.

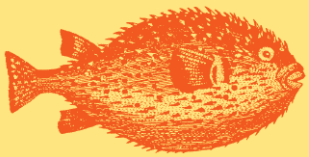
Sustainability of the Urban Systemic Reform Programs



Source: USP Core Data Elements, 2003

While NSF's funding to the urban programs draws to an end this year, the structures and priorities it helped establish will continue. Through participation in this compelling program, key education decision-makers across districts have come to recognize the value of the urban program's school-based training and approaches, and they are now independently funding the teacher leaders initially trained with NSF funds. Recipients of USI/USP funding who received advanced degrees have accepted leadership positions in their own and other districts, developing a foundation of education leadership for years to come.

Educators across disciplines now have a high-level of understanding that students need science and mathematics skills to succeed in America's rapidly changing economy. Students taught from early ages with inquiry science and hands-on mathematics are better prepared to think independently and arrive at answers by exploration rather than by rote formulas. Districts are seeing a marked improvement in their performance as these students move towards the upper grades. The belief that all children can learn, even those in the most challenging urban settings, is becoming an institutional reality.



"These programs taught us what it takes to bring about change, and just as importantly, what does not work. The focus on changing the system, the emphasis on developing standards-based models and the impetus for collecting disaggregated data to inform the progress of change was critical to making a difference," said Shirley Malcom, head of the Directorate for Education and Human Resources Programs of the American Association for the Advancement of Science. "Hopefully, this program's value will be recognized by others committed to improved performance in science and mathematics education."

Brownsville: Using Science to Gain Economic Security

Brownsville, Texas

Schools: 50

Students: 48,261

Mathematic & science teachers: 1,159 elementary, 376 secondary

Student demographics: 98% Hispanic

Economically disadvantaged: 95%

Limited English proficiency: 49%

USP funding: 1999-2004

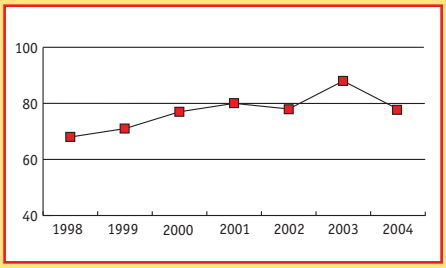
Texas graduation rate: 84%

Brownsville graduation rate: 78%

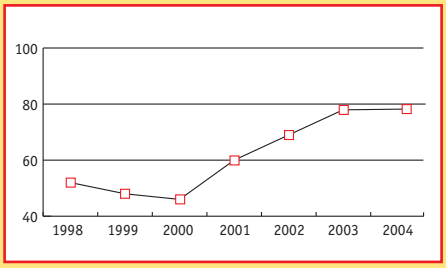
Brownsville adult education levels: 17% graduated high school, 8% graduated college

More Brownsville students are graduating high school and are better prepared for college.

Percentage of students earning diplomas



Percentage of graduates earning "college prep" diplomas



Source: Brownsville Independent School District, USP, 2005.

*The 2004 drop in students earning high school diplomas is due to a change in how the number is calculated.

SNAPSHOT

The Brownsville Independent School District is using science education as a way to break the cycle of poverty that it has struggled with for decades. A predominantly Hispanic border town, Brownsville has one of Texas' highest poverty and lowest adult education rates.

The National Science Foundation's Urban Systemic Program (USP) award enabled Brownsville to take a major step in its leaders' dream of investing in its youth.

Brownsville uses science to keep its children in school and help them to aspire to post-college careers. It is working. Since 1998, the district's high school graduation rate has risen 12 points to 78% – outperforming the state average.

The Brownsville Independent School District used a fully systemic approach in applying its USP award to catalyze science reform at every level of the system and to mobilize district investment in changing its entire instructional culture. As in many other USPs, professional development was a major priority in promoting educational improvement.

A dedicated science administrative team in tandem with the district's curriculum department organized system-wide professional development, not only for science teachers but also for the majority of district employees, including teachers, administrators, paraprofessionals, secretaries and bus drivers. Two mandatory sessions are held each year during the school day to encourage maximum attendance. Science and mathematics are a major content focus.

Brownsville administrators credit the systemic changes to this district-wide dedication to reform. "The manageable size of the district helps, but it was made possible by district investment," explained Roni Louise Rentfro, USP project director.

Frequent professional development sessions familiarized elementary teachers with Full Option Science Solutions (FOSS) kits, pre-prepared labs that introduce science concepts through hands-on experiments, often involving small animals. Seventeen USP-trained mentors facilitated sessions and helped teachers implement their training in the classroom. Their demonstrations and veteran advice helped teachers manage classroom experiments to encourage students' critical thinking and scientific discovery.

"Before, teachers outlined each step of the project," said Dr. Daniel Garcia, assistant superintendent for curriculum and instruction. "Now students come up with their own procedures, learning how to plan and explore deeper in subjects."

Since 1999, enrollment in and completion of high school chemistry has almost tripled and physics has more than doubled.

As the teachers became more comfortable with the material, so did the students. Before FOSS, few fifth graders elected middle school pre-Advanced Placement Science courses. Now, with their fear of science declining, students have the confidence to choose advanced courses without prompting.

Garcia and the science team cite the increasing sophistication and popularity of fair projects as evidence of both independent thinking and a groundswell of science enthusiasm in the district. "There used to be eight parents at the science fair. Now there are hundreds," he said. Brownsville will host four simultaneous elementary science fairs next year to meet the growing demand.

The enthusiasm begun in elementary schools carried through to upper grades. In 2002, Brownsville began recommending four mathematics and three science classes to better prepare its graduates to attend college. Completion of high school chemistry more than tripled in recent years, from 990 students in 1999 to 2,664 in 2004-2005, and enrollment in introductory physics more than doubled, from 382 students to 883 in 2004-2005. Mathematics performance has also improved. In 1998, over 75% of the students enrolling at the University of Texas at Brownsville (UTB) the local university, had to complete remedial math, now less than 50% have to take a remedial math class.

Partnering with a local university

In response to this rising science enrollment, the district further fulfilled USP goals by partnering with the UTB, to create content-rich courses to train the district's large biology staff to teach chemistry and physics.

THE UNIVERSAL LANGUAGE OF SCIENCE

At Ortiz Elementary, a rapt second-grade class learned about life cycles by observing worms. Row after row of small forms hunched intently over meal and wax worms. The students observed the differences between the two types of worms and tested how they responded to stimulus, measuring out water drops with large plastic syringes.

It could have been a scene at any USP site, except that the animated students discussed their observations in both English and Spanish, switching fluidly between the two languages.

Nearly all Brownsville students enter school speaking only Spanish, but leave elementary school fully bilingual. The animals, plants and hands-on activities in the Full-Option Science Solutions (FOSS) kits help students make that transition.

"In order to learn in another language, students need to link concepts with experience," explained Mike Baldwin, an elementary science specialist. "FOSS provides hands-on activities that serve as contexts for learning both language and science."

District data tells a compelling story. In 2005, 63% of Brownsville fifth graders met the state's science standards, nine percentage points ahead of the state's 55% for all Hispanic-American students.

Parents visit science classes at Ortiz Elementary monthly. Here a fourth grader works with her mother and sister to dissect owl pellets.

Since 80% of Brownsville's teachers traditionally graduate from UTB and most of the district's college-bound students enroll there, both institutions stood to benefit from better aligning their instruction. The university, which had planned to grow its fledgling postgraduate science programs, created science courses specifically tailored to district educators. The USP-funded classes offered teachers college credit to encourage graduate study, boosting university enrollment. As a result, 73 teachers earned graduate degrees, and 26 are currently enrolled in graduate programs.

Most importantly, the close district-university collaboration laid the groundwork for a college-preparatory culture. Every Brownsville high school senior is required to fill out at least one college application. More than three-quarters of 2005 high school graduates completed the rigorous college-prep graduation plan of four mathematics and three science courses.

The strong college-preparatory mentality is producing high school graduates better prepared for college. The number of UTB physics and engineering physics majors jumped from three in 1996 to 23 currently, with many pursuing the university's new physics master's degree.

MY STUDENTS WANT TO GO TO COLLEGE

Omar Garcia is emblematic of the new Brownsville student, one who has embraced science largely because the USP put it center stage.

A district graduate and University of Texas at Brownsville (UTB) master's degree candidate, Garcia grew up in a severely poor neighborhood, where only 2% of adults graduated college. Until a few years ago, school buses didn't come in the rain because the unpaved roads turned to impassible mud.

Now he is a mentor coordinator for ENLACE (ENgaging LAtino Communities for Education), whose after-school activities are housed at the Cameron Park Cultural Center in his old neighborhood. ENLACE is a national W.K. Kellogg Foundation initiative designed to encourage Latino graduation. Brownsville was the first ENLACE chapter to use science to promote student involvement.

One afternoon, excited students tumbled into Cameron Park's recreation room, slinging backpacks into corners and clambering into seats. Garcia watched college students from UTB lead the group in a lesson on asthma, with exercises to simulate the breathless feeling of an attack. They discussed ways to reduce asthma irritants at home, soliciting student suggestions.

"When we decided to focus on science in Brownsville, the [ENLACE] national coordinators were horrified," Garcia explained. "They were afraid that kids would be turned off by science, driving them further away from school." Instead, it was so successful that other ENLACE sites are piloting science-focused programs.

Looking at the kids engrossed in their activities, Omar spoke quietly of the hope that has taken root. When he played at the center as a child, the talk revolved solely around sports and the streets. "Now, for the first time," Garcia said, "when I play basketball with the kids, I hear them say they want to go to college."

After doing jumping jacks, students breathe through straws to simulate the feeling of an asthma attack.

Jacksonville: Communicating A Culture of Success

Duval County, Florida

Schools: 170

Students: 127,965

Math & science teachers:
3,456 elementary, 1,208 secondary

Student demographics:
47% White, 43% African American, 5% Hispanic American, 2% Asian, 3% other

JUSI Funding: 1998-2003, extension through 2005

Duval County's graduation rate: 67%

Florida graduation rate: 72%

Duval County's adult education levels: 47% functionally illiterate

In 2005, Jacksonville was the only Florida district to get all of its public schools off the failing list.

SNAPSHOT

In Duval County Public Schools two core beliefs are that "all DCPS children can be academically prepared to reach their dreams," and "the achievement gap in Duval County can and must be eliminated."

These core beliefs are evidenced at the most challenged schools in the district. In 2005, every Duval County public school earned a passing grade from the Florida Department of Education. And six of the county's failing schools raised their grades, the only district in the state to achieve such a milestone.

"There's been a major cultural shift in the district," said Ed Pratt-Dannals, chief academic officer. "We have actualized the belief that all students can perform at the highest levels."

Funding from the National Science Foundation's Jacksonville Urban Systemic Initiative (JUSI) laid the foundation for standards-based reform across the division of Curriculum and Instructional Services, helping to make these beliefs a reality.

Jacksonville's transformation can be attributed to professional development of teachers and administrators and communication at every level of the district. The entire district rallied around a single goal – improving instruction. It started at the top with superintendent John Fryer, a former Air Force General, who believed strongly in setting a mission and sharing it broadly. He created a "war room" at district offices, papering the walls with charts and graphs of student performance by grade level, ethnicity and a variety of other variables. At every meeting with administrators, he reminded them about using data to inform instructional practices.

Annual principals' institutes became forums for Jacksonville's leaders to explain mathematics and science improvement strategies and plans, provide updates on progress and solicit feedback on progress of implementation strategies in schools. Principals were encouraged to establish their own data rooms to raise awareness of student performance at the school and classroom levels. "You can't hide from data,"

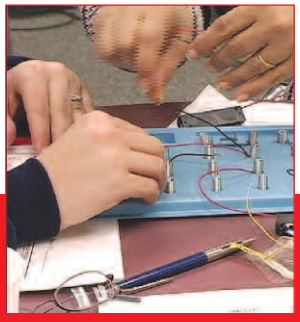
An elementary school student proudly displays a worm grown in her school's classroom.

said JUSI Director Dr. M. Carolyn Girardeau. "Over time looking at data from the teacher and student level became the norm. All the work we do now is grounded in data-driven research."

The majority of Jacksonville's work was championed by district teachers. Thirty-five of the best and brightest educators in Jacksonville were chosen to research and study current findings related to standards-based instruction, inquiry learning and peer coaching. These resource teachers, as they were called, became mentors to classroom teachers at the 24 most challenged schools in the district, so labeled because they received a failing grade from the Florida Department of Education. They also helped – in tandem with school principals and other district leaders – identify mathematics and science teacher leaders at every school. Teacher leaders received additional training in subject content at the elementary level and certifications in earth science and chemistry at the middle and high school level, two areas of weakness in instruction identified by the project's leaders.

Convincing teachers to adopt new curricula and embrace change was a slow and often frustrating process for the resource teachers. Jackie Simms, an AP chemistry teacher at Sandalwood High School said, "To get teachers' attention, I worked with them side by side cleaning out the most awful, disgusting storerooms, organizing and prepping lab solutions and carrying hot plates for experiments from school to school. I did whatever teachers needed done and when they saw that I cared they started to pay attention to me."

Duval County, which spans more than 840 square miles, presents a major challenge for regular communication. Resource teachers

Elementary school teachers learn how to implement inquiry-based science in a professional development session.

IMPROVING EDUCATION THROUGH "ACTION RESEARCH"

In an "Action Research" course, classroom teachers are conducting education research much like university professors would.

As part of a JUSI-funded master's degree program at the University of North Florida, teachers are researching and measuring the effectiveness of education techniques in their own classrooms and determining how they can be modified for different student populations. University of North Florida professors are studying if classroom teachers will change their instruction based upon what they learn.

About 20 elementary, middle and high school teachers received $1,000 grants from the university (funded by a state grant) to develop their research methodology, buy materials for their projects and produce communications products reporting on what they learned. Some of the research questions they are trying to answer include:

- Does a computer-based mathematics tutor help improve student achievement?
- Do male students get called upon more frequently in science classrooms because they are more vocal?
- Can Advanced Placement physics, traditionally a course taught purely by textbook, benefit from including inquiry-based experiments?

As part of "Action Research" teachers develop and present posters on their projects, detailing their research methodology, findings and how the project has influenced their practice. They shared their posters with Duval County school board members prior to their regular meeting and were invited to share their knowledge with peers at local, state and national conferences.

Teacher Bruce Hughes is studying two physics classes. The control group is using a textbook and the test group is doing inquiry. He is applying what he's learned to a textbook he's developing called *Conceptual Physics*. A middle school teacher leader spent several weeks chronicling how often she called on boys and girls in science classes. She learned that the boys got more attention because they were always raising their hands and calling out her name when they had an answer.

The quieter girls, who often had a lot to contribute, were called on far less. Once she had data to document her theory she made a conscious effort to call on everyone equally.

were instrumental in leading district-level workshops for teachers following up with classroom support. However, communicating with teachers, principals and the almost 5,000 teachers in 170 schools required developing electronic and print products to report on the project's products, services, and progress.

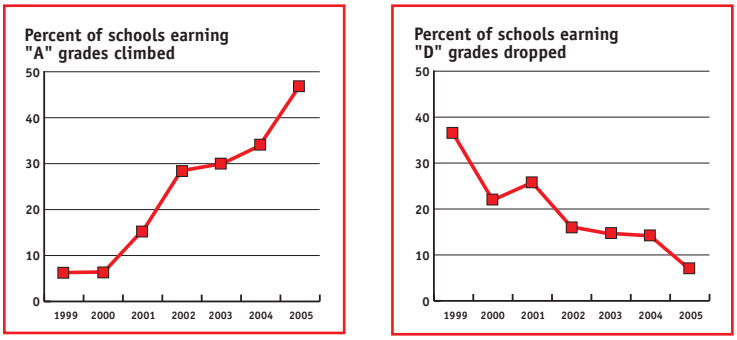
Jacksonville addressed this communications challenge by hiring a professional, rather than relying solely on district resources. Rick Vach, a former newspaper reporter, launched a monthly newsletter entitled "Shop Talk," built a project Web site, and issued email bulletins and press releases on upcoming events to keep the entire district up-to-date on the Jacksonville's work. He also is a regular source of program news, attending funded events and reporting on them.

To earn support from community leaders, Jacksonville formed a Community Consortium, which at its height included nearly 100 representatives from business, faith-based groups, fraternities, sororities and parent organizations. The Consortium was involved in development of a Saturday Stars Program that helped prepare middle school students for rigorous mathematics and science classes in high school. It also convinced religious leaders to emphasize the importance of mathematics and science education during Sunday sermons. A NEW PALS program was also created to help mothers, grandmothers and other guardians, the majority of whom had never finished high school, learn science experiments they could do with their children.

On a winter evening, teams of a half dozen mothers and grandmothers worked to build houses made of spaghetti and marshmallows. They developed a budget, purchased materials and conformed structures to building codes. Facilitators were NEW PALS graduates and their pride in leading the activity was palpable. The participants were told they had just mastered some principles of basic physics and geometry.

Jacksonville's work will be sustained because educators and the community are strongly behind it. In November of 2005, Joseph Wise became superintendent of Duval County Public Schools. He plans to "create a platform for accelerating student achievement that builds on the progress of previous administrations."

All Duval County Public Schools left the state failing list in 2005



Note: School grades are determined by student performance on the Florida Comprehensive Assessment Test (FCAT). Source: Duval County Public Schools 2005.

TURNING AROUND FAILING SCHOOLS

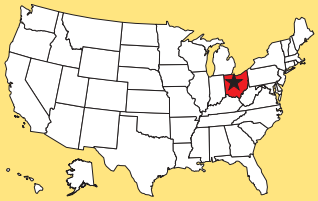
Principal Tony Bellamy of Matthew Gilbert Middle School lifted his school off the Florida Department of Education failure list by launching "Success Days." Two days a week he cancels regular classes so students can undergo rigorous reviews of critical thinking, mathematics and language arts skills.

"I told my teachers that it wasn't their fault if students didn't come in with the basics – but it was their fault if they left Gilbert without them," said Bellamy.

Teachers receive two days of training and special materials. They teach each others' subjects, which helps them better understand their students' skills in a variety of subjects. As a special perk to show appreciation for their efforts, teachers receive free breakfast and lunch on both days. Students recommended the teachers they thought would be particularly helpful on "Success Days." Every two weeks, mini-assessments are held to measure progress.

But Bellamy didn't have to wait for test results to see improvements in teacher and student attitudes. He explained, "I had a student in my office crying hysterically because it was unclear if her test counted. She said, 'Last year I 'Christmas treed' [coasted]. This time I did everything you told me to do and worked really hard. Please, please Mr. Bellamy don't discount my test'."

Bellamy assumed the principal's job at First Coast High School in September of 2006 and intends to employ his creative approach to leadership at that school.



Columbus: Teachers Leading Change in Their Schools

Columbus, Ohio

Schools: 131

Students: 59,621

Math & science teachers:
1,670 elementary, 856 secondary

Student demographics: 62% African American, 30% White, 5% Hispanic American, 2% Asian and other

Economically disadvantaged: 70%

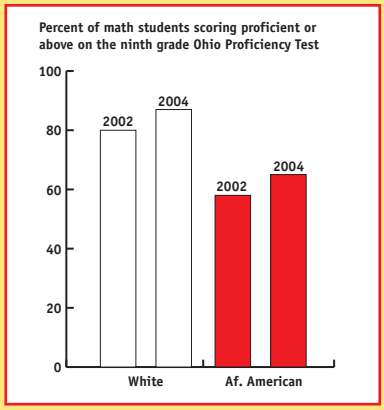
Limited English proficiency: 9%

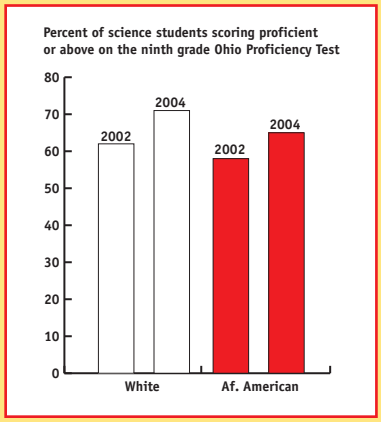
USP funding: 2001-2006

Columbus graduation rate: 68%

Ohio graduation rate: 86%

Columbus high school students are making progress in math and science.





Source: Columbus Public Schools, USP 2005.

SNAPSHOT

Educators from the Columbus Public Schools brought valuable experience to designing their Urban Systemic Program (USP). In a prior National Science Foundation award, they brought outside professional development trainers to district elementary schools, but much of the effort proved unsustainable.

With the USP award, Columbus moved to grooming leadership within its own teaching ranks. It identified and trained teacher leaders, individuals who voluntarily assumed responsibility for mentoring and coaching their peers at their schools.

Columbus Superintendent Dr. Gene Harris credits the USP leadership training with changing teacher perceptions – of their own capabilities and of their students. "The USP is helping us to help teachers understand that all students can learn mathematic and science," she said. "We need to challenge the attitude of 'They can't do it'."

Mentoring may seem like a natural extension of teaching, but leading change among experienced adults requires persuasion and negotiation skills not necessarily learned in the classroom. In Columbus Public Schools, the USP made high school reform its first priority. High school teachers often consider their classrooms private domains, and teacher leaders must earn their peers' respect and convince them to offer their personal teaching practices up for peer review.

Training teacher leaders was a slow and often challenging process. When Dr. Michael Grote, district mathematics and science director, assumed USP leadership in the spring of 2002, he nominated six low performing schools for the program because their leaders seemed willing to embrace change. In those schools, new mathematics and science facilitators (also known as teacher leaders) taught students for half of the day and spent the rest of the time working with teachers. Initially, this arrangement raised questions from other teachers who wanted what they assumed was "free" time too.

The six new teacher leaders attended a week-long professional development session that focused on leadership skills for mentoring other adults and building content knowledge outside their areas of expertise. Despite the training, implementation of the new program was an uphill battle.

"We need to challenge the attitude of 'I can't do it'."

– Superintendent Gene Harris

"When you become a teacher leader there is a specific skill set that you need," said Tonya Milligan, a teacher on special assignment. "You have to be strong in communication and conflict management and have the political savvy to know how to say things so you won't be misinterpreted. It took me at least half of the first year to get more comfortable in that role."

Cultivating collaboration

The teacher leader program expanded beyond the original six schools to others interested in developing professional study groups, often termed learning communities. Enthusiastic principals helped the teacher leaders launch regular study groups in which teachers plan lessons together, review student work and analyze the quality of work assigned to students. The guided study group structure helped focus teachers around a common goal.

"We had staff meetings, but they were always perfunctory," explained Dave Fawcett, a veteran chemistry teacher at Columbus Alternative High School. "The USP turned our meeting time into something substantial, because we had a reason to."

Science teachers at Whetston High School liked their study group so much that they applied for and received small stipends to continue study group meetings over the summer to plan for the coming year. Study groups helped teachers identify gaps in student performance and come up with creative solutions.

A high school mathematics teacher leader organized school-wide student programs to target weaknesses in test scores through hands-on activities. During Northland High School's Math, Science and

Seventh graders construct the tallest possible towers out of spaghetti, marshmallows and masking tape, modeling the properties of the human skeleton.

EMBRACING CHANGE IN THE CLASSROOM

A teacher leader's biggest challenge is convincing peers to try a wider variety of instructional approaches, including inquiry methods, experiments and hands-on activities to engage students and help them better understand mathematics and science, a central USP goal. Traditional teaching often requires memorizing a process or a formula that may produce the right answer without necessarily cementing the underlying concept.

But if teachers understand the reasons for inquiry-based learning they may give it a try and warm to it over time. For example, Belinda Clark, a science teacher leader at an alternative high school in Columbus, showed her teachers an interview with graduates of the Massachusetts Institute of Technology about fundamental science concepts, such as the cause of the seasons or the growth of a tree. The graduates' surprising misconceptions emphasized the point that students may know the correct answers without understanding them.

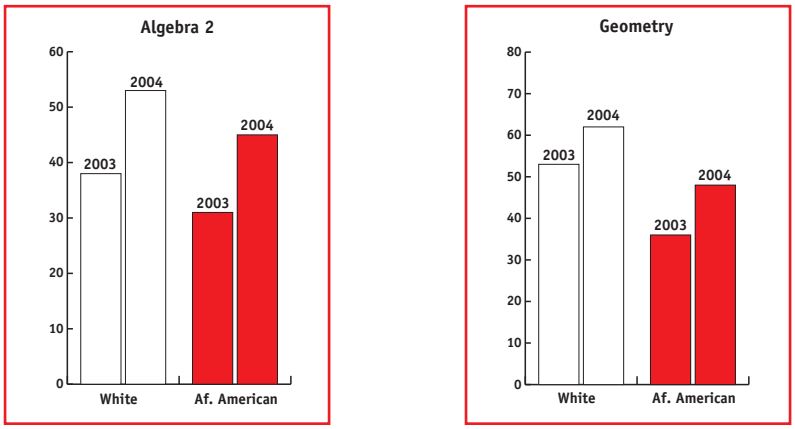
"The video is so powerful," Clark explained, "because teachers look at those kids' faces and see their students' faces. And they start thinking maybe [they] should be doing something differently."

The science teachers studied student work and realized that they could benefit from a problem-solving, discovery-oriented approach to their labs, rather than just skimming through a prescribed process. David Fawcett, a chemistry teacher, now sets a lab goal and lets the students determine how to get there, allowing them to learn from their missteps along the way.

"Having a teacher leader in the building who keeps bringing inquiry to the forefront of your mind is very valuable," Fawcett explained. "Trying new things hasn't always been positive, but occasionally it's been very positive."

Northland High's school-wide mathematics effort raised scores in year one.

Mean percent correct on math end-of-course assessments



USP half-day release time and intensive professional development began in 2003. Source: Columbus Public Schools, 2005.

Technology Day, students spent their lunch period conducting experiments linked to everyday life by calculating the energy output of pedaling a bike or sprinting to measure speed.

The results are striking. End-of-course tests show marked mathematics learning gains at the school — at every level and in every subgroup. The teacher leader also held several school-wide mathematics events the following year.

Continuing the existing activities and expanding teacher leader training to additional high schools still poses both challenges and opportunities for Columbus. Teacher reassignment among schools regularly scatters program participants. Budget realities cut prep time from a half day to one hour for the original teacher leaders, leaving them far less time to prepare materials for their peers. At some schools, scheduling changes resulted in study groups meeting after school or during lunch.

But the district is moving to institutionalize many USP innovations. Teacher study groups were so well received that the district is working with the union to make study groups a priority for every discipline. District leaders are also considering creating teams of teachers in different buildings, particularly in science, so teachers from the same subject area such as biology or chemistry can collaborate.

"We do not want to sustain a specific way of doing things forever," said Grote of the USP. "We want to build learning communities that will support the continuous improvement of classroom effectiveness forever."

REACHING OUT TO EVERY CHILD

Gene Harris is a rarity as a school superintendent. She graduated from Columbus Public Schools and worked at the Ohio Department of Education prior to her appointment in 2001 as Columbus' superintendent. She is uncommonly in tune with the realities of the district, a sensitivity she cultivates by making a point of listening to the opinions of others — students, parents, teachers and the community at large.

She reaches out to students, meeting regularly with a team of high school "ambassadors" to learn what's going on in the schools and makes changes based on their feedback.

Parents are an important part of the equation, Harris says, and they need to encourage students to attend college and succeed in mathematics and science. She even brings her own parents to school events and takes calls from angry parents because she says they give her good advice about people.

Harris knows that she must show district-wide support for the USP to sustain its work, so she attends meetings with mathematics and science teacher leaders to let them know she cares. She also served as leader of a national organization of USP superintendents.

Her ultimate dream is to have all Columbus students graduate with the skills to finish college. With her goal of raising the high school graduation rate from 68% to 90%, she has her work cut out for her, but she is embracing the challenge.

"If our kids don't graduate high school, what is the alternative?" Harris asked. "The answer is not pretty. We can be successful with every kid but first we need to believe that they can do it."

San Diego: Turning Principals into Instructional Leaders

SNAPSHOT

When the Urban Systemic Program (USP) began in the **San Diego City Schools** in 2001, it benefited from steps taken during the "Blueprint for Student Success," a massive literacy and mathematics initiative begun five years earlier.

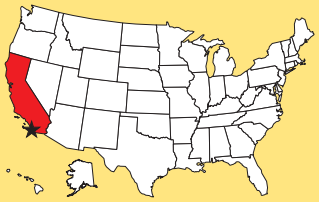
Under the initiative, principals were expected to act as the instructional leaders of their buildings, participate in and provide intensive professional development to their teachers and spend about two hours each day in classrooms. By the time the USP began, principals were well-prepared to become the champions of science in their buildings.

"We deliberately introduced science later because development of literacy and mathematics skills is critical to succeeding in science," said Kim Bess, USP project co-director.

In San Diego City Schools, the USP built on reforms begun several years earlier by a former superintendent, Alan Bersin, who from his experience in areas other than education, took a detached look at the district and decided that San Diego's instructional culture needed to change. With the help of Anthony Alvarado, former chancellor of District 2 in the New York City Schools, Bersin plotted a "Blueprint for Student Success" in literacy and mathematics, an ambitious and controversial reform effort he likened to "removing a Band-Aid quickly."

San Diego focused on creating school leadership teams in which principals, vice-principals, and teachers received intensive training in reading and mathematics and later science content. This core group acts as a catalyst at its site, modeling good instructional practice and coaching their peers. Not only teachers, but also principals, can identify quality teaching and work with those who need extra help.

"Principals are the linchpin to the improvement of teaching and learning," explained Debbie Beldock, head of instruction and curriculum.



San Diego, California

Schools: 216

Students: 132,482

Math & science teachers:
3,008 elementary, 792 secondary

Student demographics:
43% Hispanic, 26% White,
14% African American, 3% Asian,
5% Indio Chinese, 7% Filipino, 1% other

Economically disadvantaged: 54%

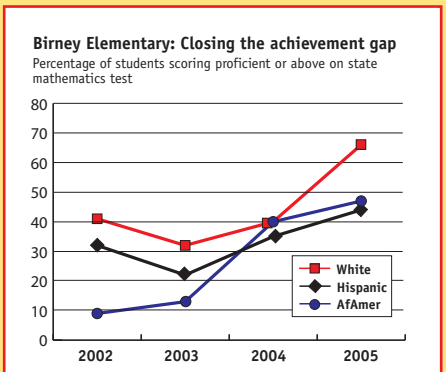
Limited English proficiency: 27%

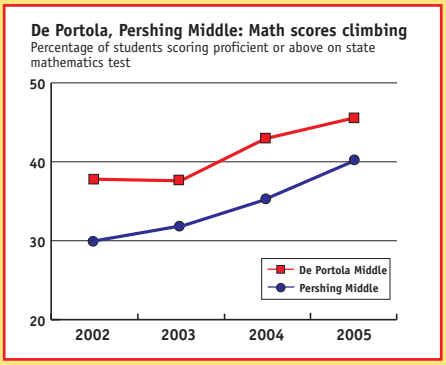
USP funding: 2001-2006

San Diego graduation rate: 81%

California graduation rate: 85%

Strong school leadership improves test scores.





Source: San Diego City Schools, Communications Office, 2005.

Science is the hook for my students

Principal Sarah Sullivan of Pershing Middle School grew up with 12 brothers and sisters and learned to believe in the power of the collective group. She directly links her commitment to collaborative learning and individualized instruction back to her family. "My parents organized us so we all contributed positively to our family," she explained. "I never felt lost in the crowd."

When she became Pershing's principal in 2001, Sullivan focused on getting teachers and students to collaborate. She restructured the schedule to allow common planning time and encouraged science, mathematics and English teachers to integrate their lessons, a partnership culminating in the annual science fair.

"I want kids to spur each other on. When students work together, they master important concepts and become problem solvers. These skills readily transfer to other academic areas."

Illustrating this approach in action, Sullivan identified a group of sixth graders performing just below grade level and pulled them into smaller classes. She assigned the school's best English, mathematics and science teachers to the group, all of whom worked together to provide 90 rich minutes of science every day with English support infused into the lesson. Those students' once-marginal scores skyrocketed.

She credits the professional development sessions she attended as a new principal for introducing her to the possibilities of teaching and learning science in new ways. "The focus on inquiry transformed me," she said. "I learned to use inquiry to get students and teachers to work together and refine their own thinking."

Conversations with San Diego principals reveal how their role differs from the purely administrative duties of their peers in other districts. At DePortola Middle School, Principal Listy Cullingham, writes a school plan for the year and a personal profile for each

San Diego principals spend about two hours every day observing and analyzing classroom instruction.

teacher. She spends about two hours each day in classrooms, and once a week she and her content co-administrators walk through classrooms and observe lessons. "If you really believe instruction is the most important part of your day, you structure your day around it," she said.

At Birney Elementary, Principal Amanda Hammond-Williams said her teachers are continually refining their instruction, meeting two hours each week to discuss how to improve student learning. The school's minority students made marked progress on annual mathematics tests, progressing towards closing the gap between African American and White students in 2004-2005, a critical USP goal.

Professional development of teachers can be credited for much of the improvement. In the 2004-2005 school year, more than 30 percent of San Diego's 3,800 K-12 teachers participated in professional development focused on science with time spent in these sessions ranging from as few as six hours for some elementary classroom teachers to over 80 hours for coaches and lead teachers.

Focusing leadership teams on science as the USP expanded to all San Diego schools, the teams applied new approaches to teaching science content and directed the majority of funding to science teachers. Each elementary school has two science leaders, one to coordinate materials and another to lead peers in lesson study.

The school coaches followed up district professional development by introducing a new K-8 science curriculum, with school-based group work in Collaborative Lesson Study (CLS). In CLS groups, teachers meet regularly by subject matter and grade level to design lessons. They might discuss, for example, how to supplement the required instructional materials with activities relevant to students, rewriting questions to convey concepts by relating them to students' interests and experiences. As a result, students may be asked to use physics to determine how to improve athletic performance in track and field events or produce a brochure explaining ultra sound to expectant mothers.

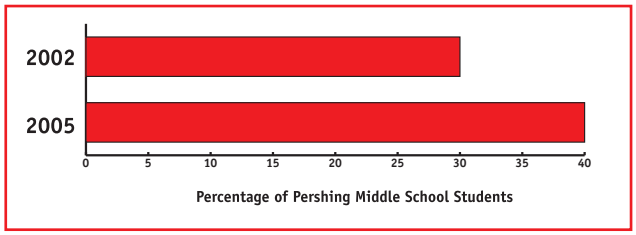
Ongoing professional dialogue allows teachers to share experiences and fine-tune classroom strategies. "We're always in each other's classrooms," a science teacher explained. "It's all about teachers talking to teachers. We feel like the professional development and curriculum stems from us."

The focus on inquiry-based science instruction has taken root in the district with 98% of all science teachers using these materials often or sometimes as a basis for their lessons, according to an evaluation study conducted by Inverness Research Associates of Inverness, CA.

San Diego's mathematics and science reforms are still too new to provide conclusive data about impact on district-wide student test scores in these subjects. But the USP built on the changing school culture to make science education a priority, and reforms in elementary and middle schools enabled the district to set stricter science requirements for high school students and better prepare them for college. All students must complete physics, chemistry and biology, in that order, to graduate.

And San Diego City Schools are showing marked progress overall, an indication that changes made through the "Blueprint for Student Success" and the USP are bearing fruit. In 2004-2005, 82% of city schools met their Academic Performance Index (API) growth targets, an increase of 14% over the previous school year and 31% of schools scored above 800, a measurement that demonstrates schools are excelling, a jump of 6% over the previous year.

Pershing's students scoring proficient or advanced in math



A NEW WAY TO USE NOTEBOOKS

Sixth graders at Pershing Middle School are studying volcanoes and discussing the pros and cons of using Yucca Mountain as a proposed site for disposal of nuclear waste. They take notes in their journals, record data from a lab experiment and type persuasive essays to the state's governor, supported by evidence collected in science experiments and analyzed using mathematics.

In San Diego, literacy strategies are integrated into both mathematics and science. Teachers use a technique called notebooking, in which students record class activities in data notebooks. They might record data from a lab experiment, mathematically analyze that data and write a persuasive essay on the results – all recorded in their notebooks.

One student writes that he is in favor of the site because the waste must be put somewhere. Another argues against it, fearing the effects of a potential accident on nearby Las Vegas.

"Students are able to express their ideas better when reading and writing are part of science and mathematics," said science teacher Kellie Macarelli, "They'll turn to a partner in science and ask 'What's your hypothesis?' When they get into the upper grades they will be much better prepared for deeper thinking."

Miami: Using Data to Improve Student Performance

Miami, Florida

Schools: 367

Students: 361,550

Math & science teachers: 10,829 elementary, 3,635 secondary

Student demographics: 60% Hispanic American, 28% African American, 10% White, 2% other

Economically disadvantaged: 61%

Limited English proficiency: 16%

USP funding: 2000-2005

Miami graduation rate for standard diploma: 78%

Miami had a data champion who convinced every school in the district to use it.

Dr. Yuwadee Wongbundhit explains the capabilities of her data creation, the Student Performance Indicator templates. Dr. Wongbundhit's work helped focus all schools on using data effectively.

SNAPSHOT

The Miami-Dade County Public Schools are using data to assess student performance and improve student learning throughout the school system. A district with a diverse population, Miami's overall student performance was masking the struggles of ethnic and language subgroups.

With the leadership of the Urban Systemic Program administrative and implementation team, the district created tools to help scrutinize and understand the reasons students were lagging.

The clear and accessible results focused the entire district, from top administrators to individual teachers, on steps needed to improve student performance. They engaged in increasingly sophisticated discussions of student learning and targeted instructional support for every student.

From the outset of its award, Miami-Dade County Public Schools embraced the USP's emphasis on data-driven decision making, beginning with fundamental questions such as: How are students performing and how should their performance inform classroom instruction?

Answering these questions in detail proved more complex than expected. The state of Florida collects student results on the annual Florida Comprehensive Assessment Test (FCAT), and the district stores these results in a centralized data warehouse.

But the sheer amount of information available hindered school-level analysis. Isolating specific information from years of data on more than 365,000 students was laborious, deterring busy teachers and administrators.

"It used to take forever to break down test results," explained Pablo Aquerre, assistant principal at Highland Oaks Elementary School. "I used to go through stacks and stacks of paper with a highlighter and a ruler."

Nor was a ready technological solution available. Sorting the numbers by computer required advanced knowledge of spreadsheet software. The district's mathematics and science director, also the leader of the USP award, realized that people would use the data only if the process were simplified.

"Some of these kids would never go to a beach or in the ocean without a school-based program." – *Dr. Gustaro Loret-de-Mola, Miami USP*

With the strong support of Miami's mathematics and science administrative director, Dr. Constance Thornton, Dr. Wongbundhit set about making the student performance data easy to use.

First, she created the Student Performance Indicator (SPI) template, a user-friendly software tool for sorting FCAT information, so that school administrators and teachers could quickly isolate data based on individual characteristics such as performance of an ethnic group, particular school, grade level, classroom, teacher subject area or student.

Next, the Miami-Dade USP team began a campaign to encourage use of the SPI template. They presented the new data tool to teachers and principals, assuring them that importing data into the report templates required only a few keystrokes. They also enlisted the help of the USP team of curriculum support specialists, teachers who lead professional development throughout the district, to convince school-based educators to use the data over the long term.

Students examine crayfish, horseshoe crabs and other sea creatures at an indoor lab during a field trip to Miami's Biscayne Nature Center.

Word of the helpful templates spread rapidly throughout the district. Miami-Dade estimates that 60% of its schools use the SPI templates, which now can be downloaded from the mathematics and science division's Web site. Thorton explained that clear, immediate access to data is a powerful tool for convincing teachers and principals to examine their own practices. "The teachers can try to deny the facts at first, but if they look at the data long enough, they will draw some conclusions," she said.

BRINGING SCIENCE TO LIFE

At the Biscayne Nature Center for Environmental Education, Miami-Dade students tromp through mangroves, wade in sea grass and pick up giant horseshoe crabs. Every year more than 11,000 fifth graders spend two full days at the center actively investigating the region's natural habitats and studying ocean life first-hand.

The USP funds such field trips so students can learn about science in an environment that brings lessons to life.

On a spring morning, a group of fifth graders, squinting into the sun, dug their toes into the hot Miami sand and pondered the questions: Will more light reflect on the beach down by the water's edge or up by the beach grass? Why?

Hypotheses in mind, the students were dispatched to collect their scientific data. They used calculator-based laboratories — light sensors, funded in part by NSF, that are attached to graphing calculators — to record and display data in real time.

Running up and down the beach, the students excitedly measured the reflected light levels, using the instruments with sophistication. Each group then presented its findings in a lab report illustrated by graphs drawn in the sand with sticks and shells.

"Some of these kids have never been to a beach or in the ocean before, and they would never have this opportunity unless through a school-based program," said Dr. Gustaro Loret-de-Mola, the USP liaison to the Biscayne Nature Center for Environmental Education. "This is an excellent environment to learn about science."

CLOSING KNOWLEDGE GAPS

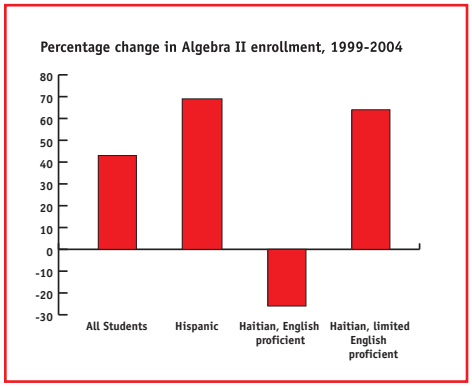
Data use is a core NSF requirement, but what does it actually mean in day-to-day activities? At each level of the district, Miami-Dade educators use data differently.

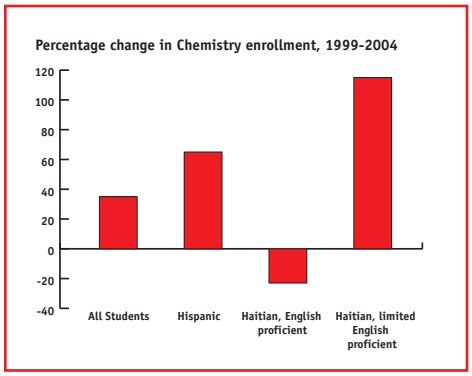
Administrators use data to assess overall learning, both of the general population and of ethnic, linguistic and socioeconomic subgroups. For instance, curriculum directors identified a low-performing subgroup of Haitian students with limited English proficiency and provided additional support. While Miami's general Hispanic enrollment in second-year algebra increased 50% from 1999 to 2005, the enrollment of its limited English-proficient Haitian population increased over 400%, from 38 students in 1999 to 194 in 2004.

Principals also use data to identify groups of underperforming students. In Miami-Dade, state test results record student performance by subject scores and by content areas or strands. Every mathematics question, for example, tests one of five content strands: number sense, measurement, geometry, algebraic thinking or data analysis. An elementary principal runs reports by strand, forming after-school tutorial groups of students who would benefit from enrichment on the same concept. "Not only did I use the Student Performance Indicators, I used them on the first day," he said.

Teachers use data to address class and individual knowledge gaps. Andrew Kerns, a high school math teacher begins the year by reviewing his classes' test performance from the previous year. "I looked at the data and realized the students lacked basic number sense," Kerns said. Algebra students, for example, could define an acute angle, but couldn't draw one. So the teacher frequently peppered his lessons with activities to encourage students to think about what the numbers and terms actually signified.

Challenged groups are excelling in advanced courses





Source: Miami-Dade County Public Schools, USP, 2005.

By identifying and working with underperforming students, Miami was able to dramatically boost Haitian student enrollment and proficiency in advanced science and mathematics courses.

With access to these data, principals are beginning to lead staff dialogues on current and future student needs. Some high school principals are working with counterparts at feeder middle schools to better prepare future freshmen for the challenges of high school mathematics and science courses. Others are leading cross-departmental data retreats to study student achievement across disciplines, enlisting all teachers regardless of subject specialty in school-wide remediation efforts.

USP administrators see the data-driven dialogue continuing and accelerating even as the project itself draws to a close. What began as a software program evolved into a district-wide collective consciousness on the importance of data, an emphasis sustained through the rapid succession of three superintendents during the five-year USP.

Miami-Dade leaders are now investing in a powerful online processing tool. In addition to the SPI template, the district is using this new tool to give principals and teachers even more options for analyzing their data. Thanks to persistent USP efforts, those principals and teachers are now more able and willing to use such tools to increase the quality of education for every student.

Houston: Involving the Entire City in Science

Houston, Texas

Schools: 306

Students: 210,292

Math & science teachers:
6,477 elementary, 1,214 secondary

Student demographics:
59% Hispanic American, 30% African American, 9% White, 3% Asian & other

Economically disadvantaged: 82%

Limited English proficiency: 28%

USI Funding: 1999-2005

Houston graduation rate: 76%

Texas graduation rate: 84%

Houston's informal science sites reinforce core state curriculum standards.

What Houston Coalition Partners Provide

Universities/Colleges – Offers programs, facilities and research related to professional development activities for Houston teachers and administrators based on district curriculum.

Informal Science – Provides teachers, students and families with science training, field experience and Family Adventures.

Business/Industry – Implements the Texas Scholars Program, which encourages students to take the highest level courses and helps students obtain college scholarships.

Government – Organizations such as Keep Houston Beautiful and the Houston Fire Department provide awards and conferences to students and their families.

Parents – The Parents Learning Network of the Texas Association of School Boards works with the USP to create Web sites and outreach forums for families.

Educational Support Coalition – Region IV Education Service Center, Mathematics & Science Alliance and the Harris County Department of Education initially helped develop the professional criteria for the lead teachers and provided targeted science, technology and mathematics courses for teachers.

SNAPSHOT

In the Houston Independent School District, the Urban Systemic Initiative (USI) tackled science reform with typical "Can Do" Texas attitude. Houston even provided a laptop for every teacher and built a computer network to share instructional tools and reform progress throughout the district.

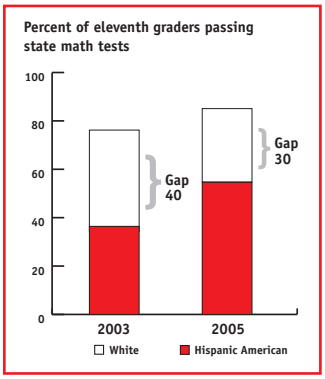
The focus on science instruction and collaboration involved the whole city – universities, businesses, government officials, museums and families. "Our vision was to bring all of Houston's resources together," explained USI Co-Project Director Anne Meyn. "We marketed science to the entire city."

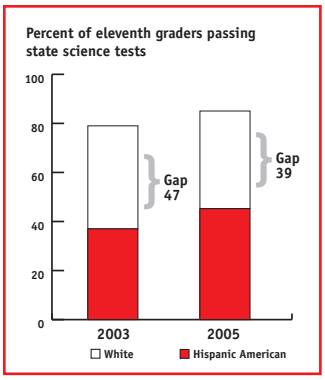
The USI's vision is bearing fruit. Since the award began, the gap between the performance of African American, White and Hispanic American students on state tests has narrowed, in both science and mathematics.

When Houston first pursued NSF's USI award, education leaders reached out to everyone they thought could help win it and make it succeed. The Houston Urban Learning Initiatives in a Networked Community, or HU-LINC as the USI is called, became the buzzword for science education in the district. Six coalitions were formed to help schools meet their science education goals, help students prepare for careers, and help teachers learn about university offerings and award opportunities.

Each coalition contributes according to its strengths. Executives from the business coalition make annual presentations to all eighth and ninth graders, explaining students' financial prospects as dropouts versus college graduates. Members of the college and university coalition work with the USI on teacher training, curriculum development, and improving district-wide communication. Rice University, for example, donated computers and personnel to create an electronic community of teachers and developed a Web site that gives them access to information 24 hours a day.

The performance gap between White and Hispanic-American students is closing – in both mathematics and science





Source: HU-LINC, 2005

"Without our partners, HU-LINC's impact on our district would have been far less," said Charlotte Haynes, former HU-LINC project director.

The USI's Informal Science Coalition includes museums, parks, foundations, an arboretum, zoo and NASA's Space Center. Coalition members work with all of the district's 212 elementary schools, each group adopting certain schools. The USI supports field study by taking students to and from the informal sites, a major expenditure that encourages broad participation in the Initiative.

This collaboration with the community provided opportunities for teachers that link with the district's needs. Houston's field trips to informal science sites are closely linked to state curriculum standards that students must master to excel. Prior to a field trip to a member site such as the Museum of Health and Medical Science, the Children's Museum or the Houston Zoo, teachers receive a packet of materials that explain the upcoming activities so they can prepare students for the trip. Potential follow-up activities are also offered to reinforce the concepts covered.

At Houston's Museum of Natural Science, students observe butterflies in a sea of greenery, obtain a rare glance into invertebrate life and watch Foucault's pendulum, a device that physically demonstrates the rotation of the Earth. While leading tours, museum volunteers emphasize scientific facts that complement what students are learning in class. Ninety-five percent of fourth graders, or about 12,000 students, visit Houston's Museum of Natural Science each year.

While learning about animal adaptation, fourth graders attended a museum science lab that showcased wildlife from every continent. Students could see and feel a stuffed penguin, touch a polar bear hide and examine a tiger skin and

"STUDENTS WANT TO STAY ALL DAY BECAUSE SCIENCE IS FUN"

To build leadership capacity, about 600 elementary science lead teachers, 30 of Houston's master science lead teachers and 50 secondary school coaches, received intensive professional development and led science efforts at their schools. Comments on their growth during the USI award tell the story.

- "Professional development takes a reluctant science teacher and turns him or her into a super-excited science teacher."
- "Students have taken ownership of the science. They come into lab class and want to stay all day because science is fun."
- "I felt like an island unto myself. I thought I was the only one struggling with science, but the specialists saw things in me I wasn't aware I was capable of doing."
- "I considered myself proficient in mathematics and science before the program, but I couldn't understand why my students weren't performing up to standards. With the training, I realized the importance of language. It gave me a way to analyze data that wasn't overwhelming to students."
- "Before training, I knew I loved science. Now I know how to implement it."
- "I see my role as a cheerleader for science. My students see my enthusiasm and internally transfer it. 'When are we going to do science?' is a question I hear all the time."

A docent at Houston's Museum of Natural Science discusses inverterbrates with fourth grade students.

"Elementary science began with HU-LINC, and we plan on continuing to improve it."

– Superintendent Abelardo Saavedra

elephant tusk. They discussed how the thickness and texture of the animals' coats reflected their habitats, the process of migration and how animals adapt to their environment.

"Our research shows that 98% of the students who come here have never been to a museum before," said Dr. Carolyn Summers, director of astronomy/physical sciences for the Museum of Natural Science. "The idea of petting a penguin, putting it on a scale to see what it weighs, and examining its different parts is new to them."

To involve families, the USI and coalition members created "Family Adventures," evening or weekend trips that provide venues for parents to explore science with their children. Again, the lessons directly enrich the concepts the children are learning at school. Museum curators meet monthly with the schools to identify curriculum weaknesses and discuss how to tie those concepts to the adventures.

When the schools identified a weakness in fifth-grade understanding of environmental science, the partners developed an environmental health focus. The Houston Arboretum and Nature Center sponsored twilight walks to search for nocturnal animals. Parents received materials on enhancing their backyards for nocturnal neighbors, and bird feeders to help them observe how birds function in natural and artificial habitats.

The district is so enthusiastic about USI accomplishments that the school board approved Superintendent Dr. Abelardo Saavedra's recommendation to continue funding several USI programs beyond the end of the award. The $250,000 budget funds five follow-up training sessions for teachers, the USI Resource Center that maintains and refurbishes inquiry-based materials and support for science and mathematics training through the district's professional development department and HU-LINC's Science Resource Center.

"Elementary science began with HU-LINC," said Saavedra, "and we plan on continuing to improve it."

Jarrett Reid Whitaker and Houston's superintendent, Dr. Abelardo Saavedra after Whitaker won an H-E-B Excellence in Education award. He was one of 10 winners from a field of 6,000 nominees.

PUTTING DULL SCIENCE IN "JEOPARDY"

Jarrett Reid Whitaker, a former fifth grade science teacher, talks a mile a minute and bounces rather than walks. His boundless energy is particularly useful in his position as associate director of Houston ISD/Rice University's Elementary Science Lab. Whitaker spends much of his time training his former peers in science education by concentrating on the most engaging and effective ways to teach science.

Whitaker can be very persuasive because he has implemented many of the creative approaches he suggests to teachers. He also knows how to lead a classroom. When Whitaker teaches students just don't pay attention, they listen intently and, most importantly they learn.

During his first year of teaching, the 27 year-old Whitaker underwent a transformation from a teacher who taught science once a week to one that took charge of all science training in his former school, Port Houston Elementary. His inspiration? Graduate-level USI funded courses in both science content and pedagogy that helped Whitaker launch an after-school science program, start a garden club, coordinate family science nights and spearhead fundraising to buy new computers.

Whitaker employed several techniques to help students struggling with scientific terms learn to love the subject. He integrated vocabulary into every science lesson, emphasizing not just memorization but conceptual understanding of each term. He also reviewed science standards at the end of each lesson to ensure that students really understood them.

To encourage science literacy, Whitaker had his students keep journals and create glossaries defining words that they didn't know. Whitaker also launched a "Jeopardy-style" science game that is played throughout the school district based on defining and understanding scientific terms in English and Spanish.

Whitaker's enthusiasm for professional development and his boundless energy are a potent combination. He credits the USI with helping him get to where he is today. "My training taught me the district's science objectives and experiments related to those objectives," he said. "It also taught me how to make science fun."

Chattanooga: Raising Expectations, Improving Performance

Chattanooga, Tennessee

Schools: 80

Students: 40,423

Mathematics & science teachers: 1,491

Student demographics: 61% White, 34% African American, 3% Hispanic, 1% Asian, 2% Native American

Economically disadvantaged: 52%

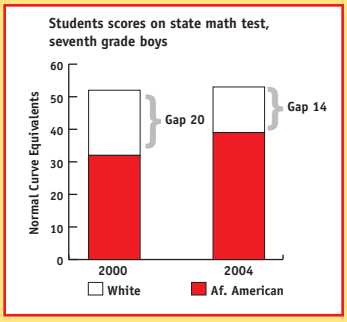
Limited English proficiency: 2%

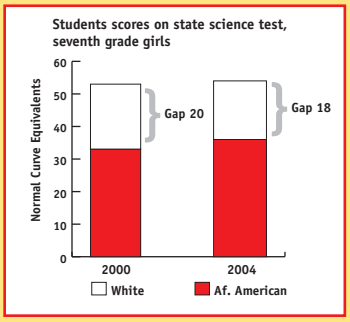
USP funding: 2000-2005

Chattanooga graduation rate: 70%

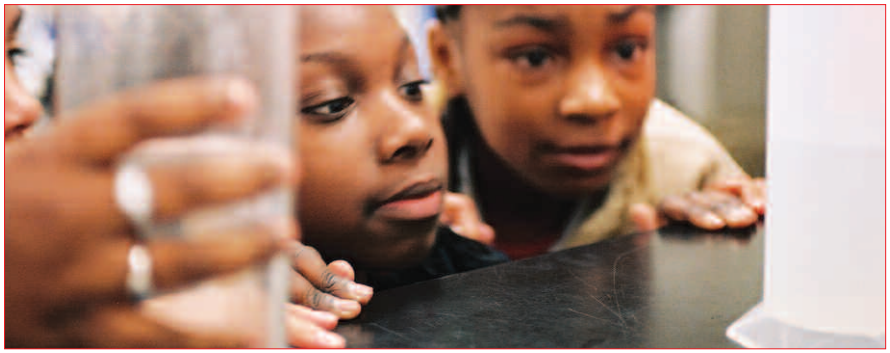
Tennessee graduation rate: 78%

The performance gap between African American and white students is closing.





Source: Chattanooga USP Annual Report, 2004



SNAPSHOT

Hamilton County's former superintendent Dr. Jesse Register actively sought USP support to help the district raise science and mathematics academic standards for Chattanooga's newly unified school district. Facing upheaval and opposition created by merging the formerly disparate city and suburban districts, he seized the opportunity to create an emphasis on science and mathematics achievement from elementary through high school.

The reorganized district curriculum offered increased opportunities for students to choose advanced coursework and concentrate on mathematics, science and technology. To help meet the intense need for concurrent professional development, the USP funded highly trained district-based consulting teachers to increase the system's capacity to improve instruction in mathematics and science. The goal was to increase student achievement for all students. Principals were steeped in up-to-date learning theories and standards to help them recognize and encourage teaching excellence.

Hamilton County's USP, known as Project Mathematics and Science Synergy (MaSS), combined strong central leadership with school-based support. Wholly responsible for mathematics and science instruction in the district, the USP enjoys support from the top down.

Key to the instructional reform effort was Jesse Register, its former superintendent, who was hired to merge the city and rural/suburban districts in 1997. Register led the combined district for the past nine years and retired this past summer. One of the few superintendents to take an active role in the USP award, he has consistently championed increasing academic standards in spite of fierce opposition from many of the city's residents. "The merger presented an opportunity to create a new culture in the district," he explained.

Register quickly focused on setting higher standards for science and mathematics performance. At the elementary and middle school level, the district adopted interactive, standards-based materials in mathematics and science. Middle and high schools started implementing Cognitive Tutor programs, a technology shared mathematics curriculum to help students progress at their own levels. In 2005, high school graduation requirements were raised to four mathematics and science courses.

Superintendent Register quickly focused on setting higher standards for science and math performance.

To effect such a profound change, Hamilton County reorganized the district curriculum. Schools began offering high school credit for completion of introductory algebra and physical science in eighth grade, freeing up time for students to work towards high school "majors," such as concentration in mathematics, science or technology. In the district's non-magnet high schools, Hamilton County introduced career academies, small communities within a school that structure studies around a theme such as environmental science or engineering.

Training teachers and principals

To prepare teachers to deliver the rigorous course load, Hamilton County supported system-wide professional development with in-classroom support for teachers. Inheriting a district with no budget for staff development, Register allocated 5% of total spending to conduct six days of professional development for all teachers, squeezing in the time by using snow days when necessary.

To follow up sessions with constant training, the county used USP and other funds to create consulting teacher positions, highly trained teachers who rotated among classrooms across the district helping teachers teach mathematics and science lessons with inquiry.

Consulting teachers received more than 200 hours of professional development, learning strategies to teach adults and assess student learning. When the district underwent a budget crisis in 2004, the USP picked up the salaries of seven consulting teachers who specialized in mathematics and science to continue working with teachers at schools. This ongoing support has enabled Hamilton County to implement new science curricula in all K-2 classrooms, create a physical science program for eighth and ninth grades and adopt and implement *Everyday Mathematics* and *Connected Mathematics* curricula in grades K-8.

SCIENCE ACADEMIES PROMOTE CAREERS, ADDRESS WORKFORCE NEEDS

Changing the culture of high schools is often one of a district's most intractable challenges. Teachers, specialists in their subjects, tend to resist collaboration or critique. Through its career academies, Hamilton County is making science and mathematics courses a stepping stone to careers in science and medicine, addressing the key USP goal of expanding the technological workforce.

At Red Bank High School, for example, students can opt to participate in the Health Sciences Academy, a "school within a school" program. Academy classes center around a single theme, with teachers working together across disciplines to devise a curriculum rich with real-world health industry applications.

Funded by a Carnegie Foundation award with additional support from the USP, the academy serves both community and student needs, in keeping with NSF's emphasis on combining resources for broader, system-wide impact. Twenty medical facilities in the vicinity of the school needed qualified employees; students needed marketable skills and were attracted by the opportunity to feel noticed among Red Bank's 1,300 students.

The 140 academy students attend classes together, studying core concepts across different disciplines. In chemistry, they might learn about radiation decay. In mathematics, they might calculate acceptable dosages. Reading projects include summarizing articles from the *New England Journal of Medicine* or researching the geographical origins of sickle-cell anemia. Students often apply their lessons to scholastic internships at the medical facilities.

A sense of camaraderie at school plays a role in decreasing dropout rates, which are far lower in the academy than in the larger school. Wednesdays are professional dress days for academy students, whose medical scrubs turn the halls into a sea of blue. Over 70% of academy students go on to two- or four-year colleges.

"Before, we were afraid that some students would not get jobs at all, [even] if they finished high school," said Sandra Cox, a chemistry instructor in the academy. "But now I see those students involved and really interested in what they're doing. Not only will they have jobs, but they're also starting careers."

Technology helps tutor students on core mathematics and science concepts.

"Our job is to create instructional leaders," said Register, who led some professional development sessions himself, until he retired. "We want them to understand good teaching and learning. We had good leadership when I came. Now we have instructional leaders."

Hamilton County also focused on training principals to identify and encourage excellent teaching, prompting them to become actively involved in instruction at their schools. Some principals participated in a course entitled "Lenses on Learning," a series of workshops that brought them up to date on current instructional ideas such as theories about how students learn, standards-based curriculum and the value of professional development.

"Principals' meetings used to be about business," explained the USP director Barbara Fulmer. "Now they talk about instruction and walk through their buildings focused on science, literacy and mathematics."

Reaching out with results

The results of Hamilton County's USP focus on instruction have begun to show in student performance. The achievement gap between White and African American students is decreasing in grades three through eight in both mathematics and science. The number of eighth-grade students receiving high school credit for introductory algebra has more doubled since 2000 and tripled for physical science since 2002, driving greater enrollment in advanced courses in high school. African American students are making particularly notable mathematics and science gains on both middle and high school state assessments.

The USP is also raising the visibility of the importance of mathematics and science to the community through advertising. It funded public service announcements on billboards featuring photos of students and teachers engaged and excited about both subjects, placed near schools where the pictures were taken. The USP also created a four-page insert that ran in the *Chattanooga Times Free Press* explaining its accomplishments through letters and articles from students and teachers.

District leaders are determined to sustain the work. "We're training people the best way that we can so they can carry on once the money is gone," said Fulmer.

TECHNOLOGY IN THE CLASSROOM

In a computer lab at Tyner Middle School, eighth graders, entirely minority and largely poor, work intently on answering algebra word problems with an interactive program called Cognitive Tutor. As they work at their own pace to determine how many T-shirts they need to sell to break even or make a profit, the program records their success at mastering specific skills. The teacher, seeing that one student misunderstands intercepts and another needs help graphing, addresses their needs individually.

In a science classroom upstairs, students use handheld computers to beam in their answers to an impassioned class competition of physical science *"Jeopardy."* As individuals correctly answer questions on the structure and properties of atoms, electronic coins pour into team coffers. Good-natured groaning erupts when the girls beat the boys for a second day in a row.

The USP-funded teacher training on the new technology has paid off in ways that make former principal Pam Dantzler proud. "When I started here four years ago, half of these students would never have taken Algebra I," she said. "Now 80% of them are passing the state algebra exam."

Los Angeles: Building a Science Vision

SNAPSHOT

Substantially changing an educational system begins with a vision. In the massive **Los Angeles Unified School District**, *establishing a vision for science excellence requires rallying tens of thousands of teachers and administrators around a single goal: Making science instruction a district priority.*

The seeds of this vision lie in the National Science Foundation's Urban Systemic Program (USP). While the USP award contributes only a fraction of the money spent on education, its impact as an organizing force for reform is profound.

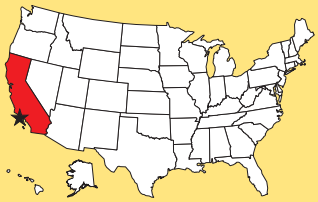
With the guidance of USP principles and experiences, Los Angeles has marshalled enormous resources to reform science instruction and to build new laboratories and facilities.

The Los Angeles Unified School District faces similar reform challenges to most urban school districts. But in a district that covers 704 square mile and educates one out of every six California K-12 students, reform must take place on a massive scale.

Introducing new ideas to more than 700 schools requires a vision compelling enough to capture the attention and commitment of the entire system. The USP program alone, a drop in a sea of competing initiatives, was unable to reach such a vast audience.

Los Angeles educators realized that they must channel the multitude of programs into a single voice. Called the Theory of Action, the district set out clear, concrete steps for how it would pursue reform in all disciplines.

In science, this Theory drove the creation of a District Science Plan, a sweeping initiative to put science on the instructional map. With the rollout of the plan in 2004, the district is holding USP ideas of science instruction up to a multi-million dollar microphone. It has begun building structures to support its vision which include



Los Angeles, California

Schools: 721

Students: 741,283

Math & science teachers: 18,265 elementary, 3,477 secondary

Student demographics: 72% Hispanic American, 12% African American, 9% White, 6% Asian & other

Economically disadvantaged: 82%

Limited English proficiency: 43%

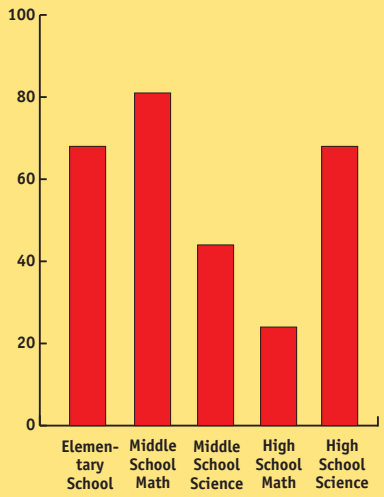
USP funding: 2001-2006

Los Angeles student graduation rate: 66%

California graduation rate: 85%

Sixty-eight percent of LA science and mathematics teachers received additional training.

Percentage of LA Teachers Receiving Professional Development, 2003-2004



Note: Out of 24,095 teachers in the district, a total of 68% received professional development. However teachers are counted more than once if they attended multiple initiative-sponsored events. These are the most recent numbers reported by the USP.

professional development, coaching and collaboration, periodic assessments, leadership and outreach to parents.

Los Angeles began by tackling curriculum. To operate the 704-square-mile district, Los Angeles traditionally awarded its eight regional sub-districts great autonomy in curriculum choice and professional development decisions.

As a result, science instruction was an uneven patchwork of instructional materials and practices. This was especially evident in high schools, where biology teachers taught from a selection of 24 different textbooks.

The Los Angeles science team set about aligning the district's science curriculum, ensuring that all teachers covered the same content in roughly the same order. In a district with high student mobility, the alignment aims to ensure that students changing schools mid-year receive consistent and high-quality instruction in every classroom.

To that end, 88 teachers collaborated to write instructional guides, which walk teachers through material lesson by lesson. Whenever possible, they included USP-advocated activities and materials, encouraging teachers to use inquiry.

Instructional guides for grades four through eight rolled out during 2003-04, with remaining grades completed in 2006.

Improving instruction and training

While the guides provide structure, professional development is helping teachers become more effective at delivering curriculum. But for professional development to be meaningful, teachers need the resources to bring what they learn back to the classroom.

While Los Angeles is rapidly upgrading its school facilities, and recently approved more than $20 million in funds to update science facilities in secondary schools throughout the district, it simply cannot afford to outfit more than 1,800 science classrooms with hands-on materials. Centralized professional development sessions aren't practical because overcrowded

Before the USP high school biology was taught from a selection of 24 different text books.

CREATING A SCIENCE HAVEN

Teacher John Zavalney and parrot Frootloops engage students at San Pedro MST Center.

Los Angeles' science centers provide rich learning environments not only for teachers but also for students. Teachers from neighborhood schools are encouraged to bring their students for science labs run by center staff.

Learning science with living organisms encourages student excitement and appreciation of scientific discovery. At the East Los Angeles Math, Science and Technology (MST) Center, roughly 350 students a week come to tend their vegetable plots, carefully weeding and watering their plants.

At the flagship San Pedro MST center, students care for an entire urban farm, complete with gardens, lagoon and livestock, including a pony and a 300-pound hog affectionately named Miss Piggy. Lessons feature regular appearances by the center's animals – pythons, piranhas and a parrot with a knack for uncannily accurate mimicry. Thirty-five hundred students visit the center each year.

On a spring afternoon, eleventh-grade students from a nearby school clamored to hold a 10-foot python. The teenagers' faces, some with scars or tattoos, beamed as they handled the snake. The rapt class was led by John Zavalney, a pony-tailed animal behavior expert who likes to demonstrate bug-eating and spends his vacations working for renowned primatologist Dr. Jane Goodall.

"The students' behavior here is totally different than when they're at school," explained San Pedro MST Director Lillian Valadez-Rodela. "It's safe and it's their space. They respect the space because they own it."

It is precisely that personal investment and understanding of science that LAUSD is working to nurture among its leadership, teachers and students. In spite of the district's challenges, it is steadily building the environment to help that investment grow.

MST Center Usage, 2004-2005

Teacher visits to center	5,179
Items loaned to teachers	11,910
Workshops offered	147
Teachers attending workshops	1,952

Source: Los Angeles Unified School District, USP, 2005.

schools rotate three tracks of children and teachers through on a year-round schedule.

The district is developing a number of structures to share science resources in each community and to communicate about the transformation in science across the district. A science communication plan was developed in 2005 and key parts are being implemented. Six existing Math, Science and Technology (MST) centers are staffed with elementary and secondary teacher advisors and use USP grant money to fund professional development sessions at their facilities.

"The MST centers provide a resource for science materials since we can't afford to put them in every classroom," said Dr. Todd Ullah, science director.

The MST Centers range from nondescript bungalows to sprawling urban farms and provide teachers with everything needed to teach a science experiment: a seminar to demonstrate a lesson, materials to take back to the classroom, books for reference materials, expert advice from center staff and computers with software to create or evaluate tests.

In 2004-2005 over 5,000 teachers visited the centers and checked out nearly 12,000 free items such as FOSS kits, microscopes, books, models and even animals such as crawfish or turtles.

The teachers praise the centers for providing professional development that is immediately applicable to their classrooms. If they attend a lesson on magnetism, they leave with everything they need to teach that lesson the next day. This is especially helpful for elementary teachers, whose schools often lack in-house materials to teach science.

The centers also have a longer-term effect of grooming leadership. Nearly all center visitors return frequently, continuously improving their own practice and acting as emissaries among their peers.

Los Angeles is creating a number of tools and processes that will help further this effort. The USP is working on a brochure for educators and parents explaining its work and why science matters to LA's children. Science competitions are planned, as well as pilot programs encouraging students to take more science classes in high school.

With its leaders plotting an ambitious course, Los Angeles is steadily working to chip away at the obstacles and unite the district in the pursuit of science excellence.

TEACHING THE TEACHERS

After teaching science for nearly four decades, many teachers believe there is nothing left to learn. But at a week-long summer professional development retreat, veteran Los Angeles science teachers were abuzz with excitement.

Their animated discussions centered on a very simple suggestion for teaching a middle school physical science lab on acceleration. A student running 20 meters will speed up as he runs. In other words, he will accelerate. But students often confuse speed (how fast am I running) with acceleration (how much faster am I running now than I was before).

Instead of timing the whole run, teachers tried timing each five-meter segment individually, making it simple to compare the change over time.

"My textbook has a lesson on acceleration, but it was never clear to me. But this makes it clear because we're checking the instantaneous speed at each interval. We're teaching both speed and acceleration," explained Agnes Asiedu-Kumi, science teacher at Cage Middle School.

"This is very impressive because I have been teaching acceleration for a very long time now," added Eddyce Moore, a teacher at Daniel Webster Middle School with 38 years of experience. "As a teacher getting ready to exit the system, I value professional development very, very much. It is giving me that charge, that shot in the arm, to add in new content so that I'm not just teaching the same thing in the same way. Now, after these last couple days, I'm thinking I really don't want to retire. I have all these new ideas I want to try!"

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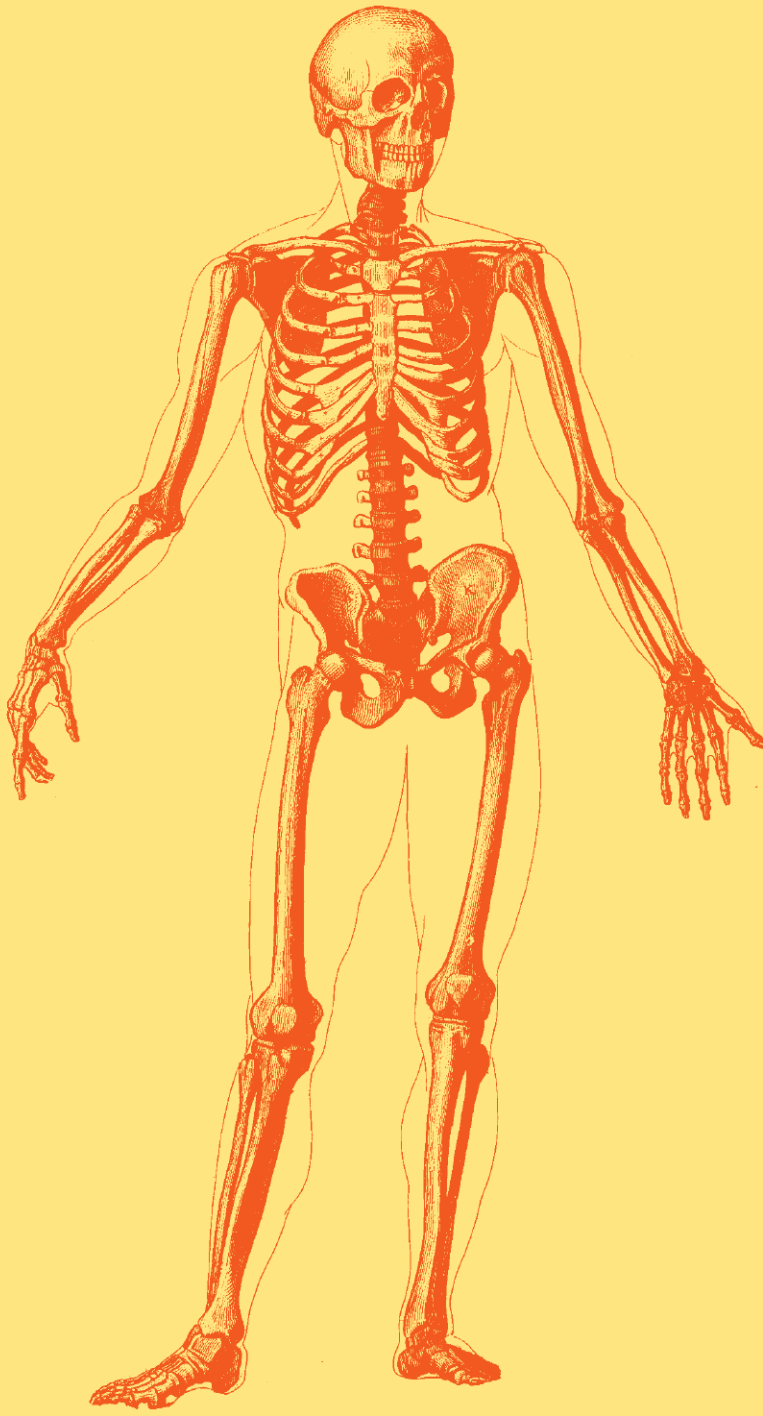

For More Information on USI/USP Projects

The USP Program concludes in September of 2006 and many of the project leaders have moved on to new positions within their districts or with other organization. Here is a list of how to contact them for additional information.

Brownsville USP in K-12 Science, Mathematics, and Technology Education
Roni Louise Rentfro
Brownsville Independent School District
1900 E. Price Rd.
(956) 548-8227
roni.rentfro@bisd.us

Columbus USP
Dr. Michael Grote
Director of Staff Development, Innovative Programming and Reform Initiatives
Columbus Public Schools
6655 Sharon Woods Blvd.
Columbus, OH 43229
(614) 365-8661
fax: (614) 365-5027
mgrote@columbus.k12.oh.us

Hamilton County/Chattanooga USP
Stacey Roddy
Internal Evaluator/Professional Development Coordinator
Director, Elementary Math and Science
Hamilton County Dept. of Education
6703 Bonny Oaks Drive
(423) 209-8480
roddy_s@hcde.org

Houston Urban Learning Initiatives in a Networked Community (HU-LINC)
Charlotte Haynes
Consultant
Houston Urban Learning Initiatives in a Networked Community (HU-LINC)
15 E. Greenway Plaza, # 2B
Houston, TX 77046
(713) 960-9484
charhaynes10@yahoo.com

Anne Meyn
4011 Milton St.
Houston TX, 77005-2735
(713) 665-6196
fax: (713) 665-3490
ameyn@houston.rr.com

Harry M. Selig
Research and Accountability Department
Houston Independent School District
4400 West 18th Street
Houston, TX 77092-8501
(713) 556-6703
fax: (713) 556-6730

Jacksonville Urban Systemic Initiative (JUSI)
M. Carolyn Girardeau, Ed.D.
Director of High School Acceleration Programs
Duval County Public Schools
4037 Boulevard Center Drive
Team B-Room 108
Jacksonville, Florida 32207
(904) 348-7790
GirardeauC@educationcentral.org

Los Angeles Unified School District USP
Todd Ullah Ed.D
Director of Secondary Science Education
Los Angeles Unified School District
333 S. Beaudry Ave., 25th Floor
Los Angeles, CA 90017
(213) 241-6880
todd.ullah@lausd.net

Miami-Dade County USP
Yuwadee Wongbundhit
Executive Director
Current Instruction, and School Improvement
Miami-Dade County
1500 Biscayne Blvd., Suite 327
Miami, FL 33132
(305) 995-1988
ywongbundhit@dadeschools.net

San Diego USP
Kris Acquarelli
Director of Mathematics
San Diego City Schools
(619) 725-7301
kacquarelli@sandi.net

Kim Bess
Director of Science
San Diego City Schools
(619) 725-7315
kbess@sandi.net

PCGpr

Potomac Communications Group, Inc.
2025 M Street, NW, Suite 350
Washington, DC 20036
202-466-7391
www.pcgpr.com/education