NATIONAL IMPACT REPORT

MSP Math and Science Partnership Program

Strengthening America by advancing academic achievement in mathematics and science

National Science Foundation

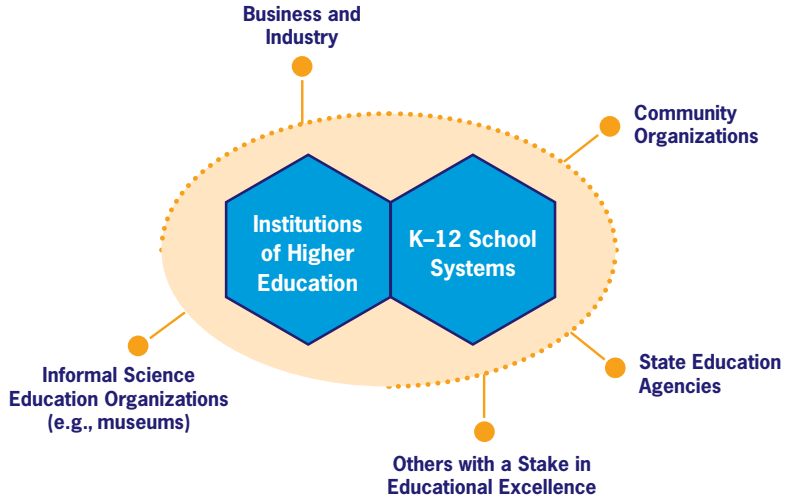
Directorate for Education and Human Resources

http://www.nsf.gov

Introduction

Launched in 2002, the Math and Science Partnership (MSP) program at the National Science Foundation is a research and development effort to build capacity and integrate the work of higher education, especially its science, technology, engineering and mathematics (STEM) disciplinary faculty, with that of K–12 to strengthen and reform mathematics and science education. The MSP program seeks to improve student outcomes and significantly reduce achievement gaps in the mathematics and science performance of diverse student populations. The program was reauthorized as part of the America COMPETES Act of 2007 and provided with additional appropriations in the American Recovery and Reinvestment Act of 2009 and the fiscal year 2009 federal budget. NSF's MSP program coordinates its effort with the Mathematics and Science Partnerships program of the U.S. Department of Education. The shared expectation is that effective innovations in mathematics and science education will be disseminated into wider practice.

FIGURE 1 INSTITUTIONAL MEMBERS OF PARTNERSHIPS



At their core, partnerships contain at least one institution of higher education and one K–12 school system, with other stakeholders encouraged to participate.

Through the MSP program, NSF awards competitive, merit-based grants to teams composed of institutions of higher education, local K–12 school systems and additional supporting partners (figure 1), which can include other stakeholders in educational excellence in the STEM fields.

The MSP portfolio includes six types of awards

Comprehensive Partnerships that implement change across the K–12 continuum in mathematics and/or the sciences.

Targeted Partnerships that focus on studying and solving teaching and learning issues within a specific grade range or at a critical juncture in education, and/or within a specific disciplinary focus in mathematics or the sciences.

Institute Partnerships – Teacher Institutes for the 21st Century that focus on meeting national needs for teacher leaders/master teachers who have deep knowledge of disciplinary content for teaching and are fully prepared to be school- or district-based intellectual leaders in mathematics or the sciences.

MSP-Start Partnerships, for awardees new to the MSP program – especially from minority-serving institutions, community colleges and primarily undergraduate institutions – that are engaged in the necessary data analysis, project design, evaluation and team-building activities needed to develop a full MSP Targeted or Institute Partnership.

Phase II Partnerships, for prior MSP Partnership awardees that focus on specific innovative areas of their work, which, if supported through additional research, will advance knowledge and understanding in the specific area(s).

Research, Evaluation and Technical Assistance (RETA) projects that develop tools to assess the partnerships' progress and make their work more strategic, build evaluation capacity and conduct focused research.

All projects incorporate a depth and quality of creative, evidence-based strategic actions that extend beyond commonplace approaches to improve K–12 mathematics and science education. The multiple types of award are intended to maximize the generation of new knowledge for and practices in STEM education.

Key features of the MSP program

All MSP projects:

1. Are **partnership-driven**, with significant engagement of scientists, mathematicians and engineers from colleges and universities with local school districts, business and industry, and other stakeholders;
2. Address issues of **teacher quality, quantity, and diversity**;
3. Have visions of students and/or teachers participating in **challenging courses and curricula**;
4. Have **evidence-based design and outcomes**; and
5. Seek **institutional change** as a mechanism to sustain their efforts.

Within over 140 MSP projects funded to date, there is abundant evidence of accomplishments and progress regarding each of these key features. Some highlights and selected examples follow.

Key Features of the MSP Program

PARTNERSHIP-DRIVEN WORK

Scope of the MSP program:

- Encompasses over 900 K–12 school districts, with 4,200 schools working with MSP in some capacity and including 1,250 schools working significantly through school-level efforts to improve STEM teaching and learning
- Potentially reaches 5 million students in grades K–12
- Involves approximately 147,000 teachers of K–12 mathematics and science
- Engages over 200 institutions of higher education that are involved in the partnerships with over 2,600 faculty, administrators, and graduate and undergraduate students contributing to partnership efforts
- Supports active partnerships in 39 states, Puerto Rico, and the Virgin Islands

At a meeting of higher education STEM faculty involved in MSP projects from both NSF and U.S. Department of Education programs, participants discussed impacts of partnership activities, including:

- Mutual benefits of respect and professionalism for MSP partners
  - > Teachers learn from STEM faculty who have deep subject knowledge and can make vertical and horizontal connections across disciplines.
  - > STEM faculty learn from teachers about pedagogy, including the importance of differentiating instruction to different types of students (e.g., second language learners).

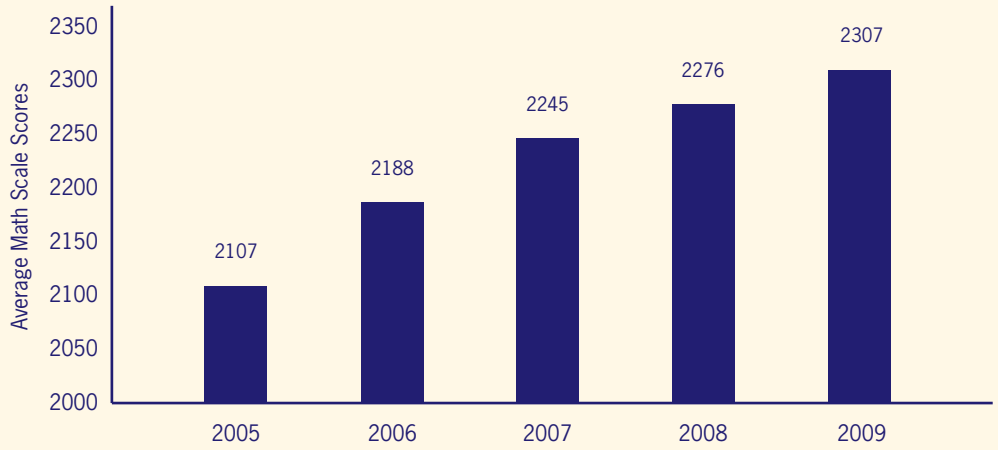
- Increased sophistication in teaching skills and practice of STEM faculty
- Significant postsecondary STEM course redesign
- Greater awareness of the roles of STEM faculty in preservice preparation, including encouraging their students to consider teaching as a career path

To further engage national professional societies in MSP efforts, the program supports a partnership of the Association of Public and Land-grant Universities (APLU), the American Physical Society, and the American Chemical Society. The partnership seeks to harness the leadership of university presidents and provosts through APLU with the engagement of science faculty through the disciplinary societies. The goal is to understand the conditions that promote institutional change while participating institutions implement strategies to strengthen, enhance the effectiveness, and ensure the long-term sustenance of their

STEM-related high school teacher preparation programs. This partnership supports the building of a far larger, potentially enduring national network of the APLU institutions as they are providing their commitment to a Science and Mathematics Teacher Imperative with core objectives to:

- Substantially increase the number and diversity of high-quality mathematics and science teachers prepared by their institutions;
- Identify immediate and longer term needs of science and mathematics teachers in their states (and particular regions), working with appropriate state agencies and other universities; and
- Build partnerships with other universities and community colleges, school systems, and state government and others to address their collective needs on a sustained basis.

FIGURE 2 GAINS ON THE 11TH GRADE MATHEMATICS EXAM OF THE TEXAS ASSESSMENT OF KNOWLEDGE AND SKILLS FOR STUDENTS OF MLI TEACHERS IN THE ALDINE AND HOUSTON INDEPENDENT SCHOOL DISTRICTS



TEACHER QUALITY, QUANTITY, AND DIVERSITY

STEM professional learning communities are rich exemplars of professional development.

In the Rice University Mathematics Leadership Institute (MLI), a professional learning community emerged among participating lead teachers from the Aldine and Houston independent school districts and continues to sustain itself today. This community, which grew through formal participation and collaboration in intensive summer leadership institutes over multiple years and through informal means, embodies the characteristics of a sustaining knowledge community among participants

within and across schools. It has fostered:

- Knowledge and resource sharing across dis parate school sites, uncharacteristic of the typical isolated culture of most high schools;
- Sixteen teachers receiving Master Mathematics Teacher certification by August 2008, representing 27% of the exemplary teacher certifications received statewide during the time period of 2005-2008; another fourteen individuals are poised to receive the certification in later years;
- Statistically significant gains in achievement for the students of these teachers (figure 2); and
- Greater use of participant teachers' abilities as leaders in their schools and districts.

MSP projects are making new contributions to the STEM education literature related to teacher content knowledge, teacher leadership, and induction practices.

The MSP Knowledge Management and Dissemination (KMD) project, led by Horizon Research, Inc. and Education Development Center, has been synthesizing findings from the empirical literature and practice-based knowledge, identifying contributions of the MSP community to the knowledge base as well as gaps in information, and citing promising practices for further investigation. Detailed information on the methodology and ongoing results of the KMD project are publicly available at *www.mspkmd.net*, with findings available on teacher-related areas of mathematics and science education research and practice, including:

- Deepening teachers' mathematics/ science content knowledge,
- Preparing and supporting teacher leaders in mathematics and science, and
- Supporting beginning teachers of mathematics and science during their induction period into the profession.

The KMD website includes a database of instruments that others can use during their work with teachers as well as links to

presentations and papers that document the KMD processes used to draw conclusions from the fields of STEM education.

Through new long-term and coherent courses and programs, the involvement of STEM faculty and their departments in pre- and inservice education enhances content knowledge of teachers.

In Western Washington University's North Cascades and Olympic Science Partnership (NCOSP), which includes local community colleges and 28 predominantly rural school districts, more than 150 teachers have been engaged in a long-term experience of three 80-hour summer academies and at least 40 hours of professional development during each of the academic years. The sequence of learning experiences included immersion

in science content with connections to instructional materials and classroom practice. Additional experiences focused on collaborative practices, facilitation strategies and leadership skills. Following this strategic, systematic approach to professional development, the partners have found positive and measurable changes in teachers' knowledge, which are strong at the time of the training and largely maintained over time (figure 3; includes both nationally validated measures and ones created by NCOSP), as well as positive outcomes for students as measured on the Washington Assessment of Student Learning (figure 4).

FIGURE 3 GROWTH IN TEACHER LEADERS' CONTENT KNOWLEDGE FROM NCOSP SUMMER ACADEMIES (SA)

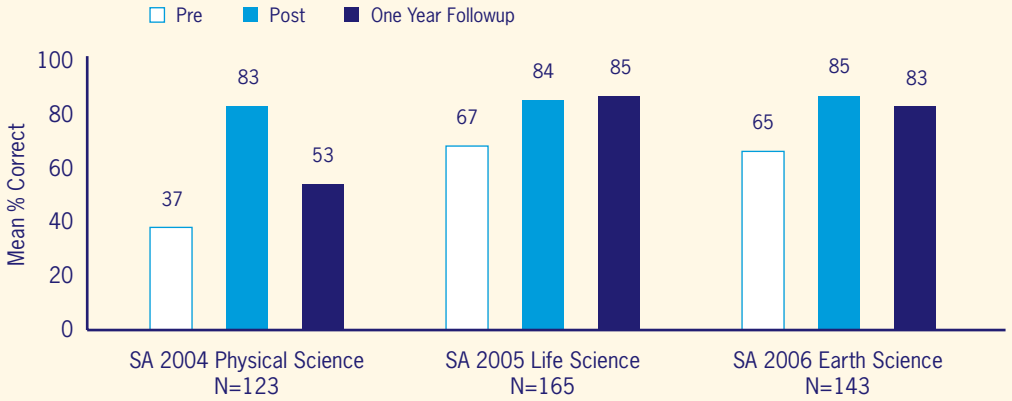
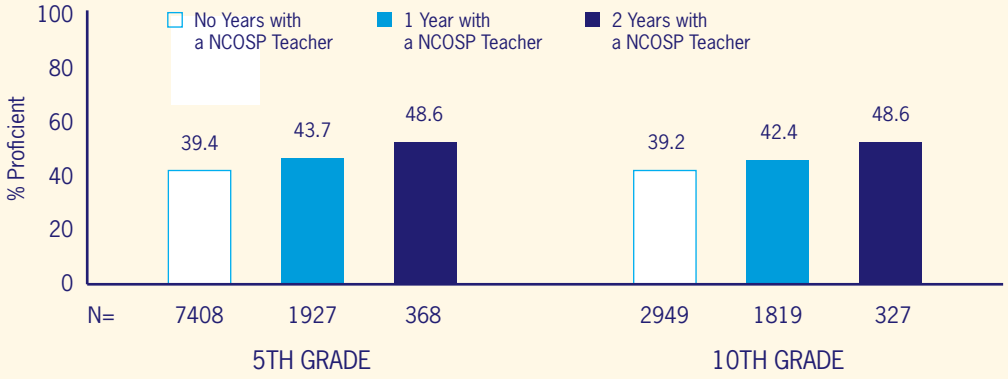


FIGURE 4 POSITIVE IMPACT ON THE STUDENTS OF NCOSP TEACHER LEADERS ON THE WASHINGTON ASSESSMENT OF STUDENT LEARNING



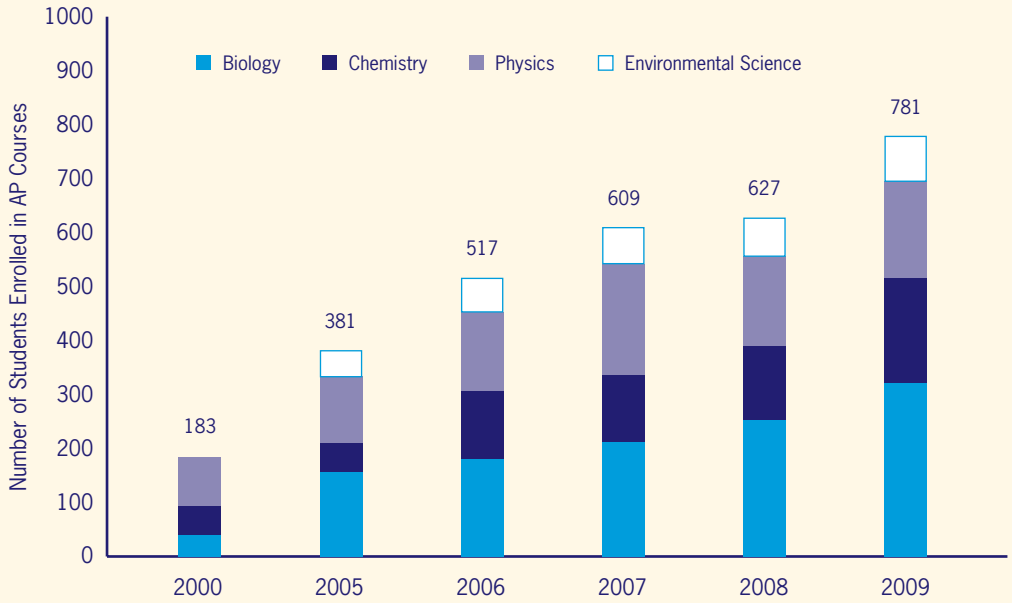
CHALLENGING COURSES AND CURRICULA

MSP schools encourage students into challenging stem courses.

An essential feature of the Math and Science Partnership program is that projects develop strategies to ensure that students are prepared for, have access to, and are encouraged to participate and succeed in challenging mathematics and/or science courses. In Boston, the Boston Science Partnership (BSP) provides intensive, year-round support to Advanced Placement (AP) science classrooms throughout the Boston Public Schools to assist in the district's growth of student enrollment in AP science programs (figure 5). In collaboration with the College Board and Harvard Medical School, the BSP core higher education partners – the University of Massachusetts–Boston and Northeastern University – have provided workshops and institutes for teachers, university-based laboratory programs for students and teachers, summer "bridge" programs for entering AP students, classroom volunteer support, and a full-length practice exam for students.

To help lead some of these activities, the BSP recruited experienced AP teachers with the long-term goal of developing them into endorsed College Board consultants. Between 2000 and 2009, the number of Boston Public Schools students taking AP science exams has increased dramatically from 183 to 781. The BSP expects that there will be further growth in numbers, particularly due to the effort to vertically align learning expectations for Boston students, and that more students will succeed on the challenging AP exams.

FIGURE 5 GROWTH IN ADVANCED PLACEMENT SCIENCE ENROLLMENT IN THE BOSTON PUBLIC SCHOOLS 2000-2009



Higher education STEM faculty, often aided by teachers-in-residence on college campuses, are broadening their discussions of teaching and learning and supporting new efforts in teacher preparation.

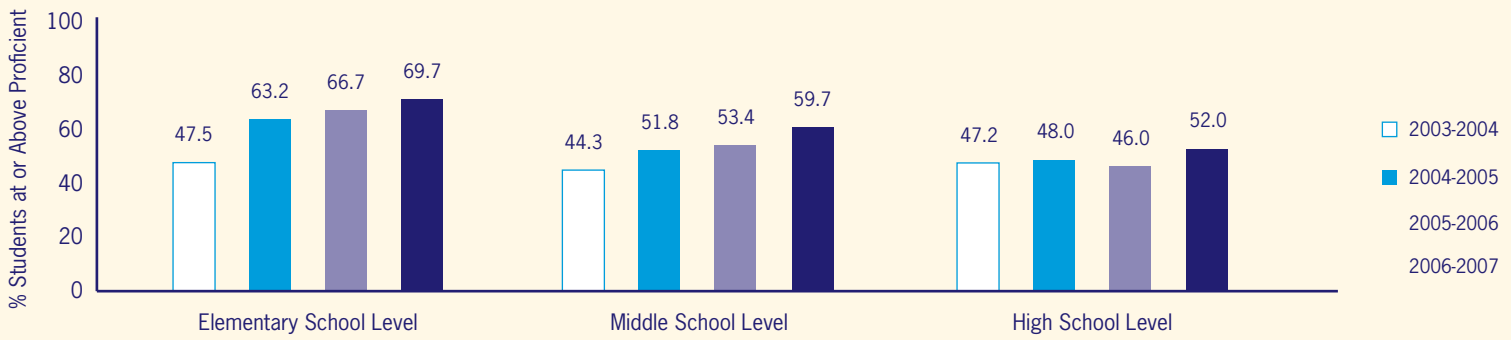
Evaluators of the MSP program have documented that many institutions of higher education engaged with MSP have developed, modified, or enhanced course offerings in STEM departments in order to improve the quality of undergraduate STEM learning, to attract more undergraduates into teaching or to offer content-intensive professional development for current teachers. As of the current reporting period, over 400 such undergraduate or graduate courses have been affected. Moreover, these courses are frequently accompanied by the development of new degree programs and majors. The approval of such new courses and programs generally requires a rigorous review process, involving multiple faculty members, committees and/or review panels. For public sector colleges and universities, the review process also often involves external bodies such as the university system office or state higher education board. Overall, the depth and formality of the review process requires substantial buy-in by faculty and administration, suggesting that the new courses and programs are likely to be continued to be offered into the foreseeable future. While drawing on the content expertise of the faculty, change in the manner that the courses are taught also has been a consistent theme, breaking down the large lecture format of many STEM courses. New teaching approaches include peer-led team learning, studio courses combining lectures and labs, and just-in-time teaching. Students in these courses include preservice and inservice teachers, as well as undergraduates pursuing STEM careers.

IMPACTS ON STUDENTS

MSP schools show positive outcomes.

As measured on state assessments, schools participating significantly in MSP projects continued to show improvement in student mathematics and science proficiency over the four-year time period from school year 2003–04 to 2006–07 (2007 is the latest year for which a full analysis has been completed; future reports will document trends in later years). In mathematics, there was an overall increase in mathematics proficiency in MSP schools from the first year (2003–04; within 672 schools in the sample) to the end year (2006–07; within 1,666 schools in the sample) at all school levels (figure 6). The sustained (first year to end year) increase in mathematics proficiency was found to be statistically significant at the elementary, middle, and high schools levels. In a substudy of elementary and middle schools within MSP projects, researchers found that those that focused their efforts with mathematics-specific strategies had a particularly powerful and sustained impact on student

FIGURE 6 INCREASED PROFICIENCY OF STUDENTS ACROSS THE MSP PORTFOLIO ON STATE MATHEMATICS ASSESSMENTS



achievement in mathematics as compared to schools in other projects that did not have such a focus. Similar findings have been found for science at the elementary and middle school levels, as overall there have been strong increases for the entire MSP portfolio and particularly for projects that focused on science interventions.

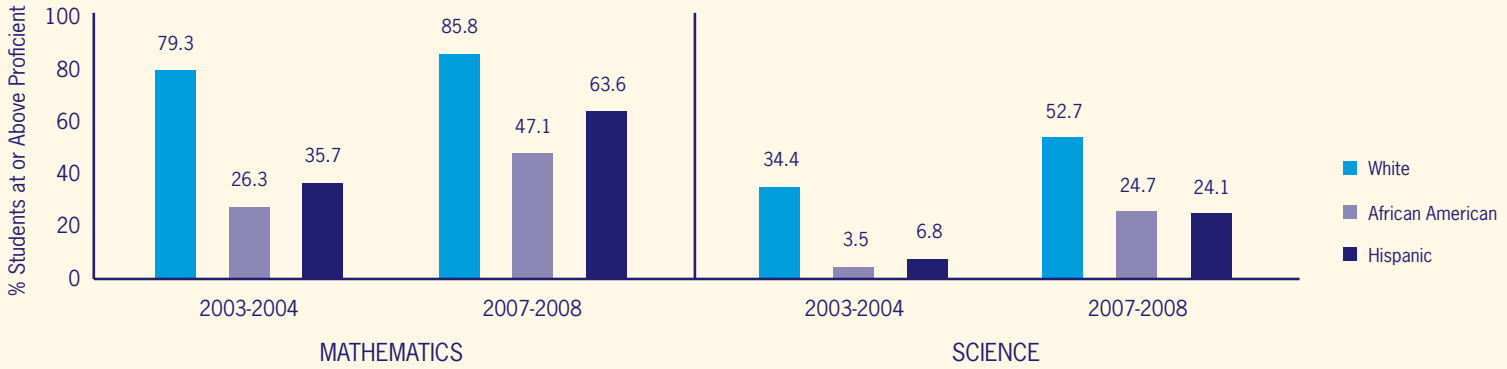
While the above data indicate improved proficiency among all students at all grade levels, there also has been a closing of achievement gaps in MSP schools between both African American and Hispanic students and white students in elementary school mathematics, middle school science and high school science; between African American and white students in elementary school science; and between Hispanic and white students in high school mathematics. For example, figure 7 shows closure of gaps for elementary school students in MSP schools that could be followed over five years; these student achievement results were drawn from 124 schools in mathematics and 83 schools in science. Such positive results have also been found in MSP schools for students with limited English proficiency, as well as for schools for which data is only available for three or four years.

EVIDENCE-BASED DESIGN AND OUTCOMES

Research methods in ethnography and social network analysis help document change in institutions and partnerships.

The Milwaukee Mathematics Partnership (MMP), led by the University of Wisconsin–

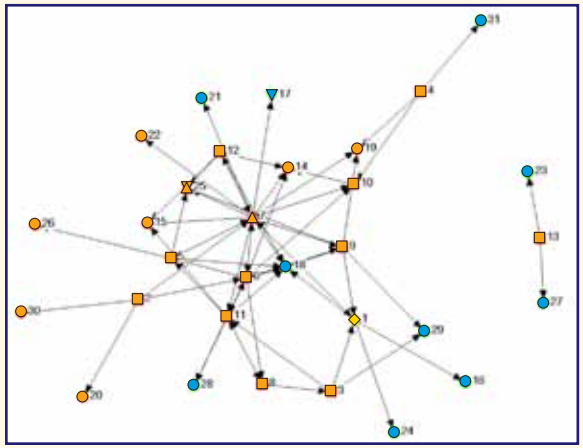
FIGURE 7 PROFICIENCY OF ELEMENTARY SCHOOL STUDENTS ON STATE MATHEMATICS AND SCIENCE ASSESSMENTS IN SCHOOLS THAT HAVE BEEN SIGNIFICANTLY INVOLVED IN MSP PROJECTS OVER 5 YEARS

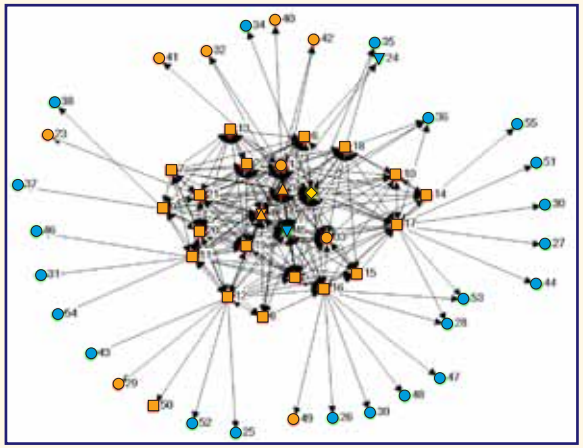


Milwaukee, distributes leadership across Milwaukee's schools based on the premise that students will achieve better in schools (1) where there are stronger collaborative networks among teachers, principals and other personnel and (2) where key personnel, such as a school-based mathematics teacher leader (MTL) and a district-based mathematics teaching specialist (MTS), play important roles in that network. The project has employed Social Network Analysis – the study of relationships within the context of social situations – as a method for assessing distributed leadership. Results have helped define a continuum of distributed leadership along which the Milwaukee schools may be placed in regard to mathematics. Emerging distributed leadership is represented by a loose network with few connections to key teacher leaders such as the MTL or MTS (figure 8, left side). Conversely, schools where distributed leadership has taken hold (e.g., figure 8, right side) have tightly webbed networks, the teacher leaders are in central positions, and many individuals report connections to these key actors.

Additionally, and central to the project's aspirations, schools with high MMP involvement, which included incorporating the concept of distributed leadership, demonstrated statistically significantly

FIGURE 8 SOCIAL NETWORK PATTERNS FOR DIFFERENT MILWAUKEE SCHOOLS





Distance is important. Closer nodes are more tightly connected than nodes that are further apart.

Color is important. Individuals from the subject school are colored orange and those who are not at the school are blue. The MTL for each school is colored yellow.

Shape denotes role as follows:
Diamond = MTL
Overlapping Triangles = Principal
Up Triangle = Literacy Coach
Down Triangle = MTS
Square = Teacher
Circle = Other Role

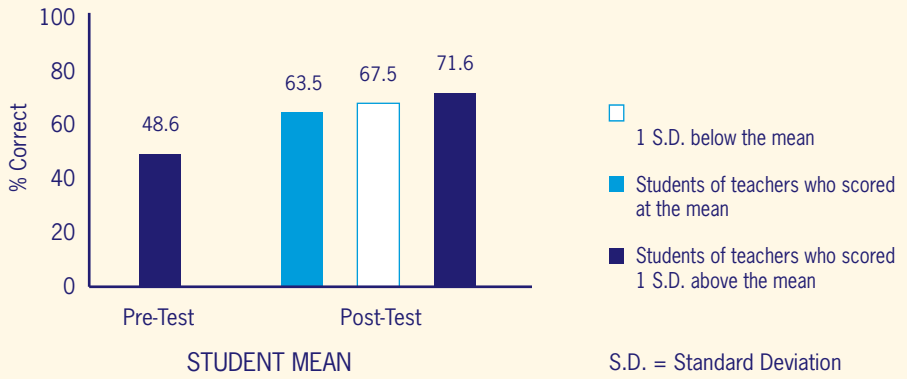
higher growth in student proficiency on state assessments of mathematics from 2005 to 2008 than schools with moderate, low, or no MMP involvement. This work demonstrates that the teacher leaders may be key actors within schools; the extent to which these individuals can inspire the development of distributed leadership is likely to be an important driver in helping their schools demonstrate improved results.

New tools and instruments, with documented reliability and validity, help professional developers accurately assess the content that teachers need to know for the teaching of mathematics and science.

Efforts to gauge the impacts of professional development have been constrained by a lack of instruments to measure teacher knowledge. Attempts to understand the relationship between teacher knowledge and student learning have been similarly limited. To address this need, the NSF's MSP program has funded projects that have produced measures that are being widely used in projects funded by NSF and the Department of Education, as well as in other contexts. Research projects at the University of Michigan,

the Harvard-Smithsonian Center for Astrophysics and Horizon Research, Inc. have developed instruments to assess growth through teacher professional development. By using the new instruments, validated on a national scale with strong attention to psychometric properties, it is expected that professional developers and their evaluators will be better able to assess impact of specific strategic implementations and thus how to improve teachers' mathematics and science knowledge for teaching.

FIGURE 9 STUDENT SCORES BY TEACHER CONTENT KNOWLEDGE AS MEASURED ON THE MKT



Several studies have found that higher scores on the teacher assessments are correlated with increases in student achievement. For example, The Learning Mathematics for Teaching (LMT) study conducted an effort to assess the relationship between teacher performance on its measure of mathematical knowledge for teaching (MKT) and classroom outcomes. The MKT instrument measures the mathematical knowledge and skills teachers possess for working with students in classrooms – for instance, solving the problems they are expected to teach students, sensibly representing mathematical ideas and procedures, and interpreting and understanding student mathematical productions. In a first effort, LMT researchers, through a partnership with other investigators, examined the relationship between performance on the MKT instrument and student achievement and uncovered a roughly .10 standard deviation effect of teacher knowledge on student achievement, controlling for prior student achievement levels and a variety of teacher and school characteristics (figure 9).

INSTITUTIONAL CHANGE AND SUSTAINABILITY

Revised tenure and promotion policies recognize faculty for scholarly contributions to the advancement of mathematics and science education.

A hallmark of the MSP program is its requirement that science, engineering and mathematics faculty from higher education partner organizations commit to working on issues of K–12 mathematics and science education. Some MSP projects have developed strategies to reduce barriers and motivate faculty to increase their time and effort on activities potentially critical to increasing K–12 student achievement. Work done in the Partnership for Reform in Science and Mathematics (PRISM) involved all levels of the University System of Georgia, from individual faculty members to departments to schools and colleges to the Board of Regents and resulted in a new advocacy policy that encourages and values joint higher education and K–12 work (Board of Regents Policy Manual, Section 803.17, Section 4.03.02: Faculty Work in the Schools). Faculty in the University System of Georgia can now be promoted based on Scholarship in Discovery, in Teaching and Learning and/or in Engagement.

New centers and institutes devoted to K–16 mathematics and science education facilitate interactions between higher education and K–12, offer professional development for STEM faculty, and advance the scholarship of teaching and learning.

The Appalachian Math and Science Partnership (AMSP) is a partnership of 56 Appalachian school districts and 10 institutions of higher educations. For the University of Kentucky, the Partnership's lead institution, it is the first formal program with a mission to build partnerships among higher education institutions, K–12 education and public and private stakeholders to improve teaching and student learning in prekindergarten–16 mathematics, science and technology education. The University of Kentucky has made two unique and strategic commitments to sustain AMSP practices in the future. The first was to create Outreach Professors in Mathematics and Science with continuing support from the University to achieve the AMSP's goals toward facilitation of K–12 and higher education partnerships. The second was to establish and support an institute that would utilize the capacity, capabilities and best practices created by the AMSP to continue to serve its goals for mathematics and science education reform. This Partnership Institute for Mathematics and Science Education Reform (PIMSER) was formally created by action of the University of Kentucky Board of Trustees in May 2005. The rationale for the institute derives from the recognition that the needs of STEM

education require an integrated collaboration of both content and pedagogical areas of expertise and for the need within the University for a hub to facilitate and manage the responses to these needs. These areas are both research-based and directly applicable to evidence-based and data-driven education reform practices in higher education and the schools.

Retention of AMSP practices and the K–12 district network as a vehicle of education reform is a defining characteristic of the institute. The institute itself has become a highly collaborative effort of the Colleges of Arts and Sciences, Education and Engineering.

Emerging from the Math Science Partnership of Greater Philadelphia (MSPGP), led by La Salle University but also including 12 other institutions of higher education and 46 school districts, is The 21st Century Partnership for STEM Education. This nonprofit corporation is operated exclusively for educational and research purposes, to promote public awareness, and to provide support for the improvement of student achievement in STEM. The Partnership aims to be a regional leader in data-based analysis, policy development, program planning, and the implementation of innovative curricula and professional development in K–12 and postsecondary institutions.

The Partnership builds on the institutional connections made through the MSPGP to expand connectivity with other institutions of higher education and school districts to jointly develop and carry out new large-scale research and development projects in STEM education. Included are a variety of custom-designed in-service interventions facilitated by university professors and master teachers. Partnership projects have already surpassed the original MSP investment.

Going to Scale and Collaboration

Partnership models are continually developed and refined.

Through multiple solicitations, the MSP program has continually developed and refined the key features and general characteristics of partnerships among K–12 school districts, institutions of higher education and other stakeholders that seek to improve student achievement in mathematics and sciences. The program's initial emphasis on Comprehensive and Targeted Partnerships and the response from the field has matured to include a rich portfolio of Institute Partnerships focused on training and supporting teacher leaders. MSP-Start and Phase II Partnerships were added to the program in 2008. MSP-Start Partnerships are designed to broaden the types of higher education institutions that participate in collaborations with K–12 school districts. Phase II Partnerships enable originally funded MSP projects to conduct targeted research on their key strategies and thus contribute to the STEM education literature.

MSP supports additional partnerships through the American Recovery and Reinvestment Act of 2009.

The MSP program was one of three educational programs at NSF to be appropriated additional funds through the American Recovery and Reinvestment Act (ARRA), the federal government's major effort to stimulate the nation's economy. By summer 2009, MSP had made awards for four Institute Partnerships, two Phase II Partnerships and three MSP-Start Partnerships for a total of $25 million committed to new partnership efforts. These awards span the nation – including projects in California, Illinois, Massachusetts, Missouri, New Mexico, and Virginia – and complement other new awards made through MSP's fiscal year 2009 appropriation from Congress.

ARRA-supported partnerships reach teachers in both urban and rural districts and students of all ethnic groups at all grade levels. The ARRA funding further expands the breadth and depth of the MSP program, and, among varied strategies, will result in extensive professional development for over 350 new teacher leaders.

The MSP programs of the NSF and the Department of Education collaborate and coordinate their efforts.

NSF's MSP program complements the MSP program at the U.S. Department of Education (ED), a program of formula-driven grants to the states. Together, NSF and ED have developed and refined the program linkages necessary to manage these investments of federal dollars in mathematics and science education to the greatest effectiveness. Highlights of these coordination efforts include:

- Research-based tools: Research-based instruments, developed through the

NSF-MSP funded program, have been disseminated to ED, the states and their funded MSP projects.

- Conferences: Annual MSP conferences, sponsored by both NSF and ED, are a vehicle for mutual exchange of strategies and knowledge among the projects. A 2007 STEM Summit brought together approximately 200 higher education faculty members from both NSF- and ED-funded projects to share what has been learned about the role of mathematicians, scientists, and engineers in teaching and learning, both at the K–12 and higher education levels.
- MSP-to-MSP connections: NSF- and ED-funded MSP projects in states or regions are working together at their own initiation based on capacity and areas of interest. Approximately 51% of all funded NSF MSP projects are working with ED-funded MSPs.

MSPnet promotes an electronic community of practice facilitating communication and collaboration among MSP participants.

MSPnet (*www.mspnet.org*) provides a vital link among active MSP projects. It facilitates dialogue among project participants for electronic sharing, professional examination and distribution of strategies and information in a real-time mode. The site also is an important vehicle for disseminating the work of the program to the public at large, as well as to the Mathematics and Science Partnerships community funded through the states by the U.S. Department of Education. Membership within MSPnet requires authorization by an administrator of one of the NSF MSP projects, and the ED MSP State Coordinators and approximately 800 representatives of ED MSP projects are members as well. At launch on January 28, 2004, MSPnet had pre-registered 351 members. As of August 2009, membership had grown to over 6,700 members. Working Groups provide members with the ability to form small or large groups that enable the sharing of files, calendar events and threaded discussions. A recent analysis found that there are 428 live Working Groups within MSPnet and participants within these groups have shared 6,917 files with each other. In addition to MSPnet members, the site is accessed by the public in increasing numbers. At the end of March 2005, the site had approximately 53,000 unique guests; by August 2009, the number of unique guests visiting the site had grown to over 890,000.

Since 2002, NSF's MSP program has fostered collaborations among educators in K-12 and higher education. With the development of new strategies and instruments to measure their impacts, MSP projects anticipate identifying additional outcomes from their work and thus will contribute to the decision making that all educators make in their efforts to improve teaching and, ultimately, learning.

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