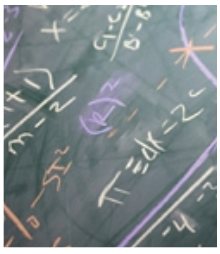
MSP Math and Science Partnership Program

NATIONAL IMPACT REPORT






Directorate for Education and Human Resources
National Science Foundation

Launched in 2002, the Math and Science Partnership (MSP) program at the National Science Foundation is a research and development (R&D) 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. MSP seeks to improve student outcomes in mathematics and science for all students, at all K-12 levels.

The MSP portfolio includes:

a) ***Comprehensive Partnerships*** that implement change across the K-12 continuum in mathematics and/or science;

b) ***Targeted Partnerships*** that focus on a narrower grade range or disciplinary focus in mathematics and/or science;

c) ***Institute Partnerships: Teacher Institutes for the 21st Century*** that support the development of school-based teacher intellectual leaders; and

d) ***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, strategic actions that extend beyond commonplace approaches to improve K-12 mathematics and science education.

The MSP program emphasizes:

a) partnerships between institutions of higher education—especially their disciplinary faculty in mathematics, science and/or engineering—and local school districts, business and industry, and other stakeholders;

b) teacher quality, quantity and diversity;

c) challenging courses and curricula at all educational levels;

d) evidence-based design and outcomes; and

e) institutional change in all core partners.

These constitute the MSP key features. Within the MSP portfolio of funded projects, evidence of accomplishments and progress abounds. Data and selected examples follow.

Partnership-Driven Work

52 Organizational Partnerships of Higher Education, K-12 Schools/Districts, Business/Industry and Others

- ***School districts***—Over **550 districts and 3300** schools: 29%, cities; 11%, large towns; 29%, small towns; and 18%, rural. Student demographics: 37%, White; 30.1%, Hispanic; 25.6%, Black; 6.7%, Asian/Pacific Islander; and 0.7%, Native American/Alaskan Native.
- ***Institutions of higher education (IHEs)***—Over **150 IHEs**: 37%, Research Universities; 26%, Master's Colleges/Universities; 20%, Baccalaureate Institutions; and 13%, Associate-granting Colleges.
- ***Business/Industry***—More than **70 business partners.**
- ***Other partners***—State Departments of Education, informal science organizations,

community-based organizations and others.

- ***Geographically dispersed***—In 30 states plus Puerto Rico.

Science, Technology, Engineering and Mathematics (STEM) Disciplinary Faculty

- ***Continuous growth in IHE faculty/administrator engagement***—To **1120** participants (most recent data): 61%, STEM faculty; 67%, tenured or on a tenure-track.
- ***Capacity-building among IHE faculty/administrators to work effectively in K-12 education***—Each year, roughly 30% of IHE faculty and administrators newly working in MSP report no prior experience in K-12 reform. As they gain experience in working productively on K-12 issues through their MSP work, they become a valuable human resource for K-12 in the future.
- ***Significant contributions of STEM faculty***—Include the delivery of content-focused professional development to K-12 teachers; review of K-12 course content and assistance in aligning K-12 courses to state standards and/or college expectations; leadership/participation in activities with K-12 students outside the classroom that motivate greater student participation in challenging mathematics/science courses; development of new courses, curricula and programs for preservice teacher education, and revision of existing courses, curricula and programs; and contributions to scholarship in the teaching and learning of mathematics and science.
- ***Professional/disciplinary societies***—As a potential model for engaging the national professional/disciplinary societies in IHE/K-12 work, MSP has made an award to a collaboration of the ***American Society of Human Genetics***, the ***National Association of Biology Teachers*** and the ***Smithsonian Institution*** to develop geneticist-educator alliances and study the role of a professional society-monitored, secondary science education outreach effort in the career development of junior and senior level faculty.

Teacher Quality, Quantity and Diversity

Development of Critically Needed Tools that Address Teacher Quality

Such tools are transformative in fundamentally changing the way we think about and assess K-12 teachers' growth in content knowledge, both in mathematics and the sciences. They move away from locally developed tests of isolated mathematics/science content to nationally validated measures that address (1) the intellectual substance of school mathematics and science, and (2) the special nature of mathematics and the sciences needed for teaching. In mathematics, the *Design, Validation, and Dissemination of Measures of Content Knowledge for Teaching Mathematics project* at the University of Michigan has developed a bank of items to assess teachers' mathematical knowledge for teaching in the late elementary and middle school grades. Different from conventional measures of teachers' content knowledge in mathematics, these instruments—called the Learning Mathematics for Teaching (LMT) inventories—focus on teachers' mathematical knowledge as it is used within particular teaching/learning tasks. Partnership projects funded by NSF and the U. S. Department of Education have found this tool to be a valuable component of their work. Over time, the evidence gathered enables projects to investigate the effects of their professional development activities on teachers' growth in the knowledge of mathematics needed for teaching.

In science, Horizon Research, Inc., located in North Carolina, and the American Association for the Advancement of Science (AAAS) have partnered in the *Assessing Teacher Learning About Science Teaching (ATLAST)* project to develop instruments that assess change in middle school teachers' knowledge for teaching three important topics: force and motion, plate tectonics and flow of matter and energy. *MOSART: Misconception Oriented Standards-based Assessment Resource for Teachers,* a Research, Evaluation and Technical Assistance (RETA) project at Harvard University, is developing subject matter assessment tools that can function as diagnostic tools to identify teachers' strengths and weaknesses across grade levels. The assessment items measure the extent to which teachers and students have mastery of the K-12 National Research Council Content Standards and the AAAS Benchmarks in Physical Science and Earth and Space Science.

Substantial Professional Development for K-12 Teachers of Mathematics and the Sciences

MSP expected to directly impact over 141,500 teachers in *Comprehensive, Targeted* and *Institute Partnerships*. Research findings from the 1990s strongly indicate that for teacher professional development to be effective, the experiences need to be in-depth and of sufficient duration. Yet, actual practice in many school districts stands in direct contradiction to these findings, with professional development opportunities often planned in an episodic fashion, scattered through the academic calendar and emphasizing 'modularized'

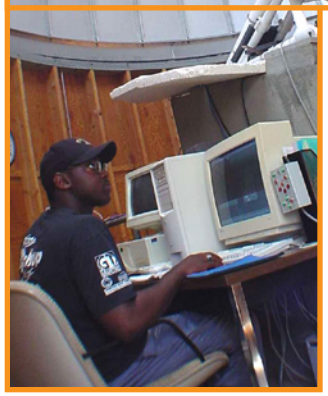
pedagogical approaches for classroom instruction. Opportunities for substantial, coherent, in-depth teacher professional development focused on helping teachers deepen their understanding of subject matter in mathematics and the sciences, are all too infrequent. To make these kinds of opportunities more widely available and to study the array of venues for their delivery, the MSP program has devoted an impressive portion of its portfolio to the Teacher Institute as an important model of professional development.

For *Comprehensive* and *Targeted Partnerships*, a common vehicle of choice is the Summer Teacher Institute. Significant gains in reasoning/problem solving and pedagogical content knowledge have been documented, for example, with in-service teachers from central Appalachia who participated in the innovative 2005 summer Algebra Institutes of the *Appalachian Mathematics and Science Partnership*. Pre- and post-test scores for middle and high school algebra teacher participants in the southwest Virginia summer institute showed gains of 24% and 18% for reasoning/problem solving and pedagogical content knowledge, respectively. In the Tennessee algebra institutes, participants showed gains of 20% and 13% in these same domains, respectively, while participants in the Whitesburg, Kentucky, algebra institutes showed gains of 13% and 23%.

While knowledge of subject matter is one of the distinguishing characteristics of a quality teacher, the teacher's ability to translate that knowledge into an effective learning experience for students is critical. In the *Alliance for Improvement of Mathematics Skills, PreK-16*, a partnership among

the Hispanic-serving Del Mar (Community) College, Texas A&M University, Kingsville, and nine independent school districts in South Texas, approximately 250 teachers participated in over 30 hours of professional development per year for two years, most typically through mathematics-focused institute models. A pilot study over a three-year period, with observations of teachers who participated in this professional development, showed a 70% decrease in total "teacher-directed" instruction (lecture) and a 62.5% decrease from mostly "teacher-directed" instruction towards a more "student-centered" learning environment. Measures of student engagement showed an 80% increase, suggesting a trajectory towards a more "student-centered" classroom experience.

Another vehicle for professional development has been the ***Learning Community***, most often implemented as a school-based community of teachers with a common purpose of their professional development, but often also including higher education STEM and education faculty. Such learning communities embrace variants of the Japanese Lesson Study model, as well as other operational models in which teachers examine student data, strategically address their content and pedagogical needs, and devise new strategies to improve student achievement. Still ***other modes of teacher professional development*** within the MSP portfolio include externships for teachers at higher education and business sites, mentoring/cognitive coaching to develop and enhance peer-to-peer relationships (especially as a means of teacher retention), and a continuum of experiences that support teachers in increasing their uses of technology to innovatively demonstrate course content.



Teacher Intellectual Leadership Development

MSP's *Institute Partnerships: Teacher Institutes for the 21st Century* emphasize leadership development for teacher participants to learn how to become school- and district-based intellectual leaders in mathematics or the sciences. Many of these accomplished, experienced teachers will acquire a formal credential (e.g., a new certification or a master's degree) as a result of their completion of an institute, thus increasing their credibility in their new responsibilities. Further, their schools are required to make a commitment to work with each institute graduate in shaping and supporting his/her new leadership role. At Virginia Commonwealth University (VCU), for example, the MSP Teacher Institute is preparing the first elementary mathematics specialists for a newly approved licensure in the Commonwealth of Virginia. Graduates of the institute will receive a master's degree in a program that will be institutionalized at VCU, Norfolk State University, the University of Virginia and elsewhere in the Commonwealth. Each teacher participant has made a commitment to serve as a full-time school-based mathematics specialist upon successful completion of his/her three-year institute program. The eight partnering Virginia School systems have also made commitments to place and support these individuals in mathematics specialist positions.

In addition to the institute at VCU, other *Teacher Institutes for the 21st Century* are housed at William Marsh Rice University (TX), Florida Atlantic University (FL), University of Pennsylvania (PA), Tufts University (MA), University of Nebraska-Lincoln (NE), Oregon State University (OR), University of Illinois at Urbana-Champaign (IL), Washington University (MO), University of Arizona (AZ), Salish Kootenai College (MT) and at the Institute for Advanced Study/Park City Mathematics Institute (UT).

Increased Quantities of New Mathematics and Science Teachers

Many higher education partners have significantly increased efforts to recruit their students into preservice teacher education. During the most recent data-reporting year, nearly 7,500 IHE students were enrolled in preservice courses initiated or revised with MSP support. Moreover, MSP projects are investing in strategies for undergraduates to explore the teaching profession early in their college careers. Many projects, for example, have created pre-practicum experiences that enable freshmen and sophomores to have authentic experiences in K-12 classrooms through work with teachers and their young students. Some partnerships have initiated innovative, supporting structures for future teachers, such as the "Careers in Teaching" Theme House for undergraduates interested in becoming teachers in the *Faculty Outreach Collaborations Uniting Scientists, Students and Schools* (FOCUS) Comprehensive Partnership at the University of California – Irvine.

Greater Diversity of the Teaching Force than the Nation as a Whole

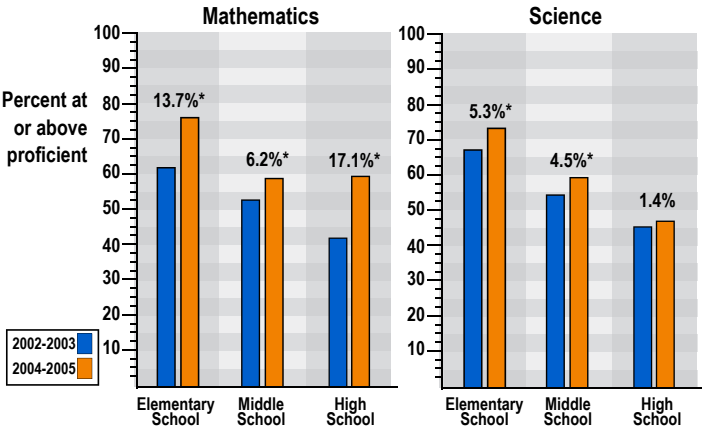
Diversity of MSP participating teachers (those who have received 30 or more hours of MSP professional development in a year) reported in 2004-05: 58%, White; 11%, Black; 28%, Hispanic; 3%, other. These percentages suggest a teaching force in MSP that is more diverse overall than the nation (as reported by the National Center for Educational Statistics) and more diverse than in such bell-weather states as Florida, Texas and California. California data (2003), for example, document a teaching force that is 63%, White; 7%, Black; 18%, Hispanic; 9%, other.

Challenging Courses and Curriculum

Positive Student Outcomes

Schools participating in NSF's MSP continued to show improvement in student mathematics and science proficiency over the three-year time period from 2002-03 to 2004-05. In an analysis of 123 schools that started their participation during the MSP program's first year (2002-2003) and that have continued to report student performance data over the three-year time frame, students in elementary, middle and high school showed significant improvements in mathematics proficiency for the three-year period. Over the same period of time, scores in science also showed gains from the first to third years at all grade spans.

Updating the first report of the MSP Program's first two years, this three-year analysis also documented the extent that year-to-year improvements have persisted. The most dramatic increases were documented by elementary grade students in mathematics where 7.2 percent more students achieved or exceeded proficiency from 2002-03 to 2003-04, followed by an increase of another 6.5 percent from 2003-04 to 2004-05, with both increases statistically significant. High school mathematics students showed the greatest percentage gain from 2002-03 to 2004-05.



The "" denotes a statistically significant change at the 0.05 level (i.e., 1 in 20 chance the change results from random chance).*

Development of Novel Curriculum Models in K-12

In the *System-Wide Change for All Learners and Educators* (SCALE) Comprehensive Partnership at the University of Wisconsin – Madison, interdisciplinary teams of university STEM faculty, learning scientists, school district curricular coordinators and teachers have developed, tested and implemented *Immersion Units* designed to sustain students' enthusiasm as they learn rigorous science content aligned with district standards. Using Immersion Units, students learn academic content by working like scientists: making observations, asking ques-

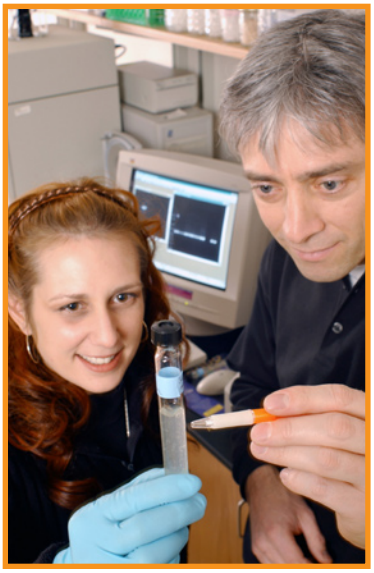
tions, doing further investigations to explore and explain natural phenomena and communicating their results based on evidence. Immersion Units focus on standards and concepts where students typically need focused support, or on highlighted concepts that merit deeper exploration than what is currently supported by the existing instructional materials.

In a paired experimental/contrast study comparing an Immersion Unit developed to teach electricity concepts against a commonly used curriculum unit in eighth grade science, students in the Immersion Unit approach showed greater knowledge-gain achievements in core science concepts, engagement and retention. Overall, the experimental group achieved twice the pre-post gains in science knowledge content as the contrast group of peers, but the largest impact on learning was with low-achieving black students who demonstrated science knowledge gains eight times higher than the contrast group.

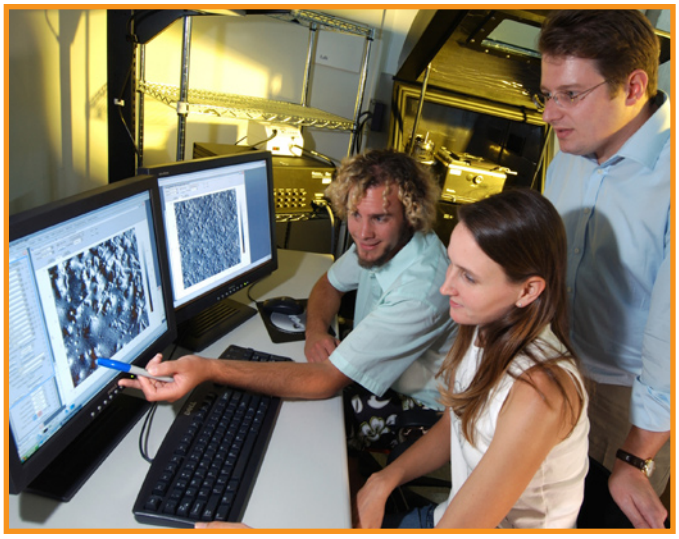
New Graduate Opportunities for Teachers

MSP has supported educational transformation through new graduate programs and courses inaugurated for teachers of K-12 mathematics/science. Such programs and courses deliver high quality content and pedagogy through a variety of innovative venues accessible to those who work full-time.

In a first sample of 10 partnerships, over one-hundred courses were identified as having been redesigned or newly developed with MSP support. Most are aligned with state standards and external disciplinary recommendations. Every partnership in the sample has developed new programs, certificate pathways or degrees as a result of MSP funding.



Three cohorts of teachers, for example, have participated in the master's degree program developed through the *Texas Middle and Secondary Mathematics Project*, a Targeted Partnership at Stephen F. Austin State University. Twenty-eight



teachers of grades 4 to 8 formed the first cohort to complete the program, with each teacher receiving a *Master of Science Degree in School Mathematics: Middle Level Teaching*. Degree requirements included 27 credit hours of graduate coursework in mathematics and an additional 9 credit hours of coursework in educational leadership, mentoring and assessment. Project-developed pre- and post-tests measured mathematical content knowledge, with a paired t-test on pre- and post-test means. With a pre-test mean score of 28.313 (SD = 11.443) and a post-test mean of 53.261 (SD = 12.793), a two-tailed $\rho < 0.0001$ was significant ($t = 9.862$, $df = 22$), and the magnitude of teacher growth in mathematical content knowledge became an important indicator of the efficacy of the graduate program.

Distance learning opportunities, as well as combinations of on-line and face-to-face courses, are demonstrating that the needs of those who teach full time can be met well through nontraditional venues. *The Fulcrum Institute for Education in Science*, a Teacher Institute at Tufts University, for example, is developing a graduate program for producing leaders in science education. Using both on-line and face-to-face courses, the project is recruiting accomplished teachers, substantially deepening their subject matter knowledge and teaching skills and helping them assume leadership positions in their classrooms, schools and professional communities. The institute is introducing a radical restructuring in the way preservice students are inducted into schools and supervised by mentoring teachers. The economies of online course delivery bode well for sustainability.

Evidence-based Design and Outcomes

Scholarship in MSP Projects

As part of a large research and development effort, all MSP projects are expected to collect appropriate data to both document their work and inform their future directions. The quality of scholarship should be commensurate with findings/results that are potentially publishable in appropriate and respected peer-reviewed journals. The development of any tools should be accompanied by sufficient piloting, revision and field-testing.

Project-Level Evaluation as Catalyst for Building Human Evaluation Capacity

Every Partnership is required to have an independent evaluator who provides formative and summative feedback on the project's work. The *Building Evaluation Capacity of STEM Projects* at Utah State University and *Adding Value to the Mathematics and Science Partnerships Evaluation* at the University of Wisconsin – Madison have established collaborations that develop and test more sophisticated evaluation models and that regularly work with MSP evaluators on evaluation challenges and the use of appropriate analytic tools and techniques for studying the impacts of MSPs. They have brought the MSP evaluation community together in two National Evaluation Summits during which project-specific work, methods and outcomes have been shared. Pre-publication papers generated for the summits are available at http://www.mspnet.org

Increasing Effectiveness of Project-Level Evaluation

In 2004, the program convened a workshop of principal investigators and evaluators of MSP projects to formulate ***a statement that would guide effective project-level evaluation*** in the context of a national R&D effort, such as the MSP. In recognition of evaluation as an area of expertise and scholarship, the program convened the community of evaluators and principal investigators who were experienced in the work of MSP, as well as other experts representing a range of perspectives on evaluation. A major theme of discussion was the need for a common language—a language well known to evaluators, but also familiar to STEM faculty and other professionals involved in planning, implementing and evaluating MSP projects. Ultimately, this community produced the document ***Evidence: An Essential Tool—Planning for and Gathering Evidence using the Design-Implementation-Outcomes (DIO) Cycle of Evidence (NSF 05-31),*** which both addresses the need for a common language and provides a framework for considering projects and project activities at multiple levels, from the global "big picture" view of projects to the most detailed perspective of project activities designed to produce specific outcomes.

Institutional Change

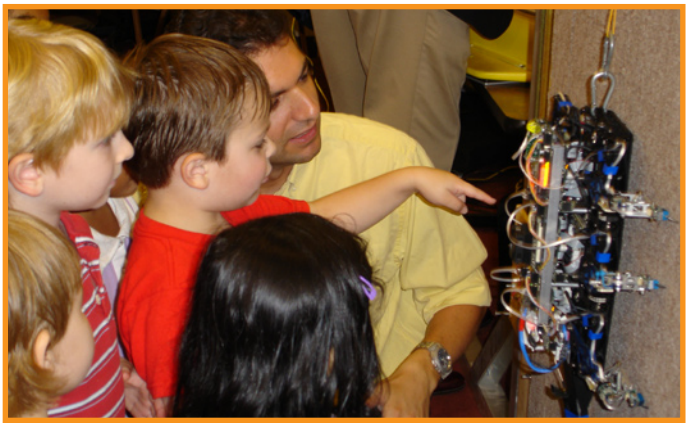
K-16 Alignment as an Important Construct

While the MSP program requires partnerships between higher education and K-12 organizations, some partnerships go beyond the required collaboration and articulate explicit goals to align the sectors. A strong example is *The El Paso Math and Science Partnership Program* at the University of Texas at El Paso, which seeks to prepare students for success in rigorous college courses by aligning their high school mathematics and science courses with those of partner universities, thus addressing state and national standards, as well as college/university expectations and assessments. Mathematics and science curricula in grades K-8 are then aligned with the newly designed high school courses. Finally, MSP further aligns the K-12 mathematics and science courses with the content and pedagogical approaches in the university/college teacher preparation programs, so that the university partners produce new teachers prepared to be more immediately effective in classrooms. For students, this alignment results in coherence among an often-disjointed series of assessments and requirements, with state assessments, high

school graduation requirements, college admission requirements, placement into entry-level college mathematics courses, and college and university graduation requirements becoming a single continuum.

Changing Faculty Reward Structures

While many IHE faculty and administrators have shown a strong desire to work on K-12 issues, a RETA project on *The Effect of STEM Faculty Engagement in MSP: A Longitudinal Perspective* at Westat, Inc., notes that "traditional reward structures and faculty perceptions about the status associated with different types of engagement are still considered major barriers for faculty in most MSP-like endeavors. While the majority of the IHEs recognized service or outreach, such activities are generally considered to be a distant third in priority as compared to research and teaching. This presents a serious institutional problem and a major roadblock to involving faculty in the STEM disciplines." Some partnerships, however, have been notable in incorporating strategies that motivate faculty to increase their time and effort in ways that are potentially critical for increasing K-12 student achievement. *The Partnership for Reform in Science and Mathematics* (PRISM), for example, has engaged all levels of the University System of Georgia, from individual faculty members, to departments, to schools and colleges, to the board of regents, in developing new policies and strengthening cultures that encourage and value joint higher education/K-12 work. As a result, faculty throughout the state are now considering for promotion and tenure decisions, broader definitions of scholarship that include the Scholarship of Teaching and Learning, as well as the Scholarship of Engagement and the Scholarship of Discovery.



Oversight and Management/Stewardship

Beyond the funding and oversight of a substantial portfolio of partnerships and RETA projects, the program itself has matured into a learning organization within NSF, thus contributing to the further effectiveness of future federal investments in mathematics and science education.

Continual Development and Refinement of Partnership Models

Through multiple solicitations, the program has continually developed and refined the Key Features and general characteristics of partnerships among K-12 schools districts, IHEs, business/industry and other stakeholders that seek to improve student achievement in mathematics and the sciences. Through intense and coherent work over a number of years and consultation with the field, a set of ***five Key Features*** identified in the first year of the MSP program has been made more precise. The program's initial emphasis on ***Comprehensive and Targeted Partnerships*** and the response from the field matured into Solicitations for ***Institute Partnerships: Teacher Institutes for the 21st Century*** and, most recently, projects that engage the ***national professional and disciplinary societies***.

A Research, Evaluation and Technical Assistance (RETA) Component

A novel component of the MSP portfolio is the collection of over 30 RETA projects that develop tools to assess the partnerships' progress and make their work more strategic, build evaluation capacity, and conduct focused research. In addition to RETA projects cited earlier, other examples are:

- ***Research on MSP Teacher Recruitment, Induction, Retention*** at WestEd (CA), which seeks to better understand impacts on novice teachers entering the profession.
- ***Distributed Leadership for Middle School Mathematics Education: Content Area Leadership Expertise in Practice*** at Northwestern University, which is developing, testing and validating instruments that measure content leadership practice and knowledge and studying how content leadership affects how teachers teach.
- ***MSP Motivation Assessment Program*** at the University of Michigan, a project in

which investigators are developing new tools for assessing student motivation and making these available to the partnerships to increase teachers' knowledge about how students' motivation, self-efficiency, self-regulation strategies and beliefs impact learning.

- ***Leadership Content Knowledge and Mathematics Instructional Quality in the MSPs: A Study of Elementary and Middle School Principals*** at the Education Development Center (MA), a large scale, research and technical assistance project that investigates the nature of elementary and middle school principals' knowledge of mathematics and beliefs about mathematics teaching and learning through the construct of Leadership Content Knowledge and its effect on their practices of classroom observation and teacher supervision.

MSP Management Information System (MSP-MIS)

As the primary data collection system for the program, the MSP-MIS collects common, required data from all partnerships and enables the aggregation of quantitative and qualitative data on students, teachers, schools, districts, STEM disciplinary faculty and others. This system is a source of information for an overall MSP Program Evaluation and for MSP Knowledge Management and Dissemination projects.

MSP Program Evaluation (MSP-PE)

An extensive, overall, independent program evaluation responds to both a ***context of justification*** and a ***context of discovery*** that are sensitive to the R&D nature of the program. Through a series of substudies, the MSP-PE is expected to address evaluation questions about not only what impacts the MSPs might have produced on student achievement and in other domains, but also about what contributions they may have made to advancing knowledge in mathematics and science education.

MSPnet: An Electronic Community of Practice Facilitating Communication and Collaboration

Created as the primary link among active MSP projects for electronic sharing, professional examination and distribution of strategies and information in a "real time" mode. MSPnet is an important vehicle for disseminating the work of the program to the public at large, as well as to the Mathematics and Science Partnership community funded through the states by the U.S. Department of Education.

MSP Knowledge Management and Dissemination

Projects designed to synthesize findings from MSP work and integrate them into the larger knowledge base for educational reform, thus strengthening the potential bonds between educational research and practice and contributing to the nation's capacity to understand and engage in large-scale education innovation. These projects also disseminate key findings and promising policies and practices derived from MSP work and evaluation.

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