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Guest Editors: Patricia S. Moyer-Packenham, Robert K. Yin, Kenneth K. Wong and Darnella Davis

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From the Guest Editors

In 2007, the National Academies released its landmark report: *Rising Above the Gathering Storm* (National Academy of Sciences, 2007). Like many reports that have come before it, the document, again, brought attention to the critical need for leaders and policy makers to focus on the United States' science, technology, engineering, and mathematics (STEM) infrastructure. As a call to action, the report made four recommendations and outlined twenty implementation actions necessary to meet the National Academy's goals. The Academy's top goals were to "Increase America's talent pool by vastly improving K-12 mathematics and science education," and "Develop, recruit and retain top students, scientists, and engineers from both the United States and abroad" (National Academy of Sciences, 2007).

The National Science Foundation's Math and Science Partnership (NSF MSP) Program was in place prior to the release of *Rising Above the Gathering Storm*. The NSF MSP Program continues the Foundation's many initiatives for improving STEM education. Presaging the National Academy of Science's (NAS) goals, the MSP aims, in part, to "improve student outcomes in high-quality mathematics and science for all students, at all pre-K-12 levels," while promoting research and development efforts in STEM (NSF, 2001). The recommendations of the NAS (2007) report describe implementation actions that parallel the work begun in many partnerships in the MSP Program. For example, the following implementation actions are recommended in the NAS report:

> Annually recruit 10,000 science and mathematics teachers by awarding 4-year scholarships and thereby educating 10 million minds. Our public education system must attract at least 10,000 of our best college graduates to the teaching profession each year (p. 115).
>
> Strengthen the skills of 250,000 teachers through training and education programs at summer institutes, in master's programs, and in Advanced Placement (AP) and International Baccalaureate (IB) training programs (p. 119).
>
> Enlarge the pipeline of students who are prepared to enter college and graduate with a degree in science, engineering, or mathematics by increasing the number of students who pass AP and IB science and mathematics courses (p. 129). (National Academy of Sciences, 2007).

Among the goals and implementation actions of many of the MSPs are actions that reflect attention to addressing the vision of the NAS report. The funded partnerships in the NSF MSP Program include STEM faculty in disciplinary departments at universities working in collaboration with faculty in colleges of education and K-12 school systems to improve mathematics and science teaching and learning. Essentially, the NAS report reaffirmed the work of grantees in the NSF MSP Program, and highlighted the continuing critical need for a mathematically, technologically and scientifically literate work force, through the improvement of mathematics and science education for teachers and students.

This special issue of the *Journal of Educational Research & Policy Studies* focuses on the work of partnerships in the NSF MSP Program to impact the quality of mathematics and science education. Since 2002, the MSP Program has awarded five cohorts of MSP grants. The 48 awards that were part of the first three cohorts comprise the database for the reviews that are presented in this special issue. While individual MSPs each have their own evaluations undertaken within the MSP, the reviews emanate from the Math and Science Partnership Program Evaluation (MSP-PE), a cross-site evaluation embracing the MSP Program as a whole entity. A collaborative group of education, disciplinary, and research professionals has been undertaking the MSP-PE. Based on the differing perspectives and backgrounds in research methodologies of members of the collaborative team, the papers in this journal issue reflect the divergence and convergence of the research undertaken in the cross-site evaluation. Included among these studies are investigations of the multi-faceted work being undertaken within the mathematics and science partnerships as examined by the diverse backgrounds and specialized expertise in a variety of areas that represent the make-up of the MSP-PE research team.

As an introduction to the volume, the first paper presents the complexity and diversity of the partnerships that exist within the MSP Program. In her examination, *Understanding the Role of Partnership Configuration in the NSF MSP Program*, Jennifer Scherer explores the configurations of partnerships and how they influence the types of partnering activities that are undertaken. The examination identifies a variety of influences on partnering activity including pre-existing partnerships, the number of Institutions of Higher Education (IHEs) involved in the partnership, the presence of a community college partner, and the number of school districts participating in partnership activities. Other factors considered explore how partnerships distribute their funds within the collaboration, types of dissemination activities, and ways partnerships communicate (because some are spread over entire states or several states). In the final section of this paper, Scherer presents the types of activities in which the partnerships are involved, using a topology to investigate the scope and depth of the activities.

At the core of the MSP Program's STEM-focused partnerships, are the members of the STEM faculty and their STEM departments collaborating with education. Kathleen Alligood, Patricia Moyer-Packenham, and Patricia Granfield examine the participation of one of these disciplinary groups with a focused lens, namely mathematics researchers. In the paper, *Research Mathematicians' Participation in the MSP Program*, the authors note the importance of changing departmental culture as an influence on increasing the participation of STEM researchers in education-related activity. By distinguishing between STEM faculty, as a general group, and mathematics researchers, more specifically, the authors highlight distinct characteristics of mathematics researchers in the MSP Program. The paper reveals the types of activities in which mathematics researchers are involved, and shows a unique case of a large group of 15 mathematics researchers in one mathematics department. The paper provides insights into the types of activities in which mathematics researchers might be more likely to participate.

A major focus of the NSF MSP Program is its emphasis on teacher quality, quantity and diversity. In particular, the NSF MSP Program "serves students and educators by emphasizing strong partnerships that tackle local needs and build grassroots support to increase the number, quality and diversity of mathematics and science teachers, especially in underserved areas" (National Science Foundation, 2007). Patricia Moyer-Packenham, Jana Parker, Anastasia Kitsantas, Johnna Bolyard, and Faye Huie provide the first examination of the MSP Program's progress toward increasing the diversity of mathematics and science teachers. The paper, *Increasing the Diversity of Teachers in Mathematics and Science Partnerships,* makes use of demographic teacher diversity data self-reported by the partnerships from the first two years of program implementation. While Moyer-Packenham et al. found no significant changes in teacher diversity for the MSP Program overall, there were significant changes in individual partnerships. Particularly useful in this paper is the authors' identification of a typology of specific strategies effective for influencing change in the diversity of mathematics and science teachers.

The second half of this special issue provides three different approaches to the examination of the MSP Program's progress toward improving the mathematics and science achievement of K-12 students. In each of the three articles, the authors delve into questions about the influence of MSP-related activities on student achievement by using different analytic approaches. In the first student achievement examination, Kenneth Wong, Megan Boben, Chisoo Kim, and Ted Socha employ a comparative approach to measuring student achievement by matching schools participating in the MSP Program with non-participating comparison schools from the same state. In the paper, *Comparison of MSP and Non-MSP Schools in Six States,* the authors discuss the systematic process they utilized for matching MSP schools in six states with their non-participating peers to examine student achievement patterns among the schools. The careful matching processes used by Wong et al. provides a useful analytic design for additional large-scale analyses of student achievement data by states.

Dimiter Dimitrov's paper is the second in the series of complementary examinations on student achievement. In *Intermediate Trends in Math and Science Partnership-Related Changes in Student Achievement with Management Information System Data*, Dimitrov utilizes extensive collections of school-level data submitted to the MSP Program's Management Information System (MSP-MIS) to analyze student achievement trends. The within-group design identifies changes in students' mathematics and science proficiency across three years (2003-04, 2004-05, and 2005-06). The paper considers important student achievement issues including: trends in mathematics and science proficiency across the three-year period, significant changes in student achievement and their effect sizes, growth trajectories for schools with and without a focus on mathematics and science, and relationships between teacher participation patterns and students' mathematics and science proficiency. Taken together, the findings from this examination provide interesting insights into student achievement trends in the MSP Program.

In the final paper focused on student achievement, Robert K. Yin synthesizes the student achievement findings provided in the self-reported data from individual partnerships in the paper, *Student Achievement Data and Findings, as Reported in MSPs' Annual and Evaluation Reports.* Each MSP has its own evaluation design, and a descriptive analysis of these designs is the focus of this paper. Yin categorizes the MSPs' evaluation designs along two dimensions: the evaluation framework used by the MSP, and the direction of findings on student achievement reported by the MSP. The paper provides readers with a glimpse at the types of research designs being employed in the MSP Program and highlights several specific examples of the reporting formats used in the self-reports from the partnerships. The examination provides useful suggestions to MSPs on ways to strengthen their analysis of student achievement findings.

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The MSP-PE is led by COSMOS Corporation. Robert K. Yin (COSMOS) serves as Principal Investigator (PI) and Jennifer Scherer (COSMOS) serves as one of three Co-Principal Investigators. Additional Co-Principal Investigators are Patricia Moyer-Packenham (Utah State University) and Kenneth Wong (Brown University).

Any opinions, findings, conclusions, and recommendations expressed in this Special Issue are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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Understanding the Role of Partnership Configuration in the NSF MSP Program

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The National Science Foundation's (NSF's) Math and Science Partnership Program (MSP) promotes the development, implementation, and sustainability of exemplary partnerships to produce high-quality math and science education at all K-12 levels. The MSP Program anticipates that the partnerships will be instrumental in improving student achievement, as well as reducing achievement gaps among student populations differentiated by race/ethnicity, socioeconomic status, gender, or disability, a strategy advocated by Haycock, Hart, and Irvine (1991). This paper explores how different configurations influence the types of partnering and educational activities undertaken by partnerships. It further provides illustrative examples of education partnerships from the National Science Foundation's (NSF's) Math and Science Partnership (MSP) Program, which calls for inter-institutional partnerships among institutions of higher education (IHEs), local education agencies (LEAs), state education agencies (SEAs), and other for-profit and nonprofit entities. The study examines partnerships awarded in three cohorts during FY2002, 2003, and 2004 in three categories: Comprehensive Partnerships, Targeted Partnerships, and Institute Partnerships (Teacher Institutes for the 21st Century). Data sources include interviews conducted with the MSPs, archival data submitted by the awardees as part of the MSP Program's Management Information System (MSP-MIS), available extant literature, awardees' annual reports, awardees' evaluation reports, documents available through the awardees' learning network (www.MSPnet.org), and Web site information reported by the individual partnerships in the MSP Program accessible through 2007. Preliminary results indicate that the particular type of configuration of the MSP partnership does not appear to significantly impact the quantity and types of activities the MSPs carry out and accomplish. Those partnerships configured with multiple IHEs did, in some instances, show an enhanced capacity to conduct a greater number and richer array of activities.

* Now with Danya International.

Introduction

Scant *empirical* evidence exists on how partnerships work and if they result in their intended outcomes (Clifford, Millar, Smith, Hora, & DeLima, 2007; Marra, 2004); however, there is evidence that partnerships create added value (Barnes, Carpenter, & Bailey, 2000). Interorganizational partnerships are an important component of research efforts that anticipate creating real-world applicability and relevance. Approaching research efforts individually, partners may not be able to accomplish what would otherwise be possible as a collective. Thus, the unified partnership entity may be able to generate more than the sum of its parts and has become an important component of the National Science Foundation's (NSF's) Math and Science Partnership Program (MSP) that requires a partnership between institutions of higher education (IHEs) and K-12 school districts.

Partnership Formation and Configuration

Partnerships form for many reasons that benefit the individual partners such as sharing information, building capacity, combining resources, bringing expertise and talent together to learn from each other and work toward a common goal (e.g., curriculum development), accessing previously unavailable networks or target groups, influencing policy and decision makers, and seeking new funding opportunities.

Often, partnerships are viewed as a single freestanding entity or concept, but partnerships in general are configured in a range of shapes, sizes, and arrangements for their overall governance. A partnership structured as a centralist model has a strong core group of partners that make all decisions centrally. A partnership structured as a hub and spoke model has a central leading partner and many subgroups or lesser partners. The central leading partner makes decisions coordinated through the hub, but all partners are not equally involved or have equal decision-making authority. Some partnerships operate somewhere between these two models.

Several factors guide the configuration of a partnership. First, when developing a partnership structure, the anticipated outcomes of the partnering endeavor and the urgency of these needs contribute to the resulting partnership configuration (Epanchin & Colucci, 2002). In education partnerships the outcomes may include an enhanced workforce (new teaching skills or increased content knowledge), curriculum revision (updated or aligned to new state standards), the creation of new teaching programs, courses, or certifications, vertical articulation, and the creation of learning networks or communities, just to name a few. These types of needs would require a partnership between an IHE and K-12 schools (districts) such as when an IHE serves as the supplier of services to fill the need of increased content and instruction and the K-12 teachers would be the recipients of the service.

Other factors guiding partnership configuration take into account inclusiveness (such as decisions about whom to include, or if power extremes are represented), having an equitable and shared responsibility as the reason they have come together for the partnership, a general consensus about priorities and best practices, approaching the partnership with the flexibility to be responsive to changing and dynamic situations, and having commitments to sustainability, if applicable.[1] Available, willing, and qualified leadership further contributes to partnership construction. For instance, when examining leadership in IHE and school partnership configurations, Firestone and Fisler (2002, p. 450) propose using a "micropolitical perspective" because of the sometimes conflicting agendas and special interests of the two groups. To address the conflict and bridge the span between IHEs and K-12 schools, the authors believe that "boundary spanners," (p. 450) rather than leaders isolated at IHEs or K-12 schools, are in a better position to lead the partnerships. The authors theorize that the partnership may best come together through the development of a professional community (with shared ideals of change). They found that while sharing elements may encourage improvement, only "subunits" of the partnership are most apt to become professional communities.

The Role of Pre-existing Relationships in Partnership Configuration

Pre-existing relationships also play a role in partnership configuration. When pre-existing partnerships or relationships exist, they can provide a foundation of familiarity, shared interest, mutual commitment, and trust, which may accelerate the rate of implementation of new grants while facilitating start-up and also the partnering process. In many instances, successful partnerships and relationships are sustained from grant to grant. In these cases, those lasting beyond the grant period usually have a combination of individual and institutional support focused on developing and sustaining the partnering relationship (Phillips, Rivo, & Talamonti, 2004).

The general consensus in the literature is that to be successful, partners should either have a pre-existing relationship or be able to devote time during the initial planning phases to get to know one another and build a relationship. However, sometimes the funding agency does not view this step as necessary or does not believe that a grant can allot the time to do so (Seifer & Krauel, 2003).

Alternatively, pre-existing partnerships or relationships may inhibit the pace of implementation due to previously established institutional patterns and behaviors. For example, a newly configured partnership consisting of members who collaborated previously may not agree or fully support new leadership, new operational components, new overall vision, or new direction. Further, partners may perceive that they are not being dealt with fairly or are not equally represented at the table, compared to their earlier roles. Partners also may feel strain with regard to their own internal economic and financial priorities that may not align with those of the overall partnership. Given these historically ingrained patterns and sentiments, the partnership may suffer because these issues carry forward to the new undertaking.

Partnering in Education Settings

The report, *A Nation at Risk* (National Commission on Excellence in Education, 1983), encouraged the initiation of K-12 and IHE partnerships, and some of these partnerships have been in existence for at least two decades (Catelli, Padovano, & Costello, 2000). For example, in an attempt to improve schools and renew teacher education, the National Network for Educational Renewal has been working with IHEs who are in partnership with schools to develop collaborative networks that include education faculty in colleges, schools, and departments of education. Goodlad (1993) maintains that for educational renewal to occur there must be a robust link between the reform of teacher education and school reform. For this to take place there must be strong and effective partnerships. Essex (2001) holds that partnerships between IHEs and schools are critical to renewal, but require support and commitment from top leadership at both institutions.

For K-16 public education, the main hypothesis is that partnerships are needed to coordinate and align the actions and policies leading to improved student achievement, starting with widespread agreement over the goals for student learning, based on rigorous content and performance standards (e.g., Raizen, McLeod, & Howe, 1997). Partnerships are needed to create coordination and alignment across these institutions, as well as within K-16 systems that traditionally have been "loosely-coupled" (Weick, 1976, p. 1). Partnerships also can provide continuity of focus, align curricula and assessments, create desired normative climates, and instill accountability (Elmore, 2000). For example, the Annenberg Foundation's "Challenge" gifts, which began in 1993, have helped build strong coalitions among businesses, foundations, universities, and grassroots community groups to generate greater public will and support for public school reform (The Annenberg Foundation, 2002).

At the same time, previous research suggests that collaborations between IHEs and local education agencies (LEAs), far from taking place within a congenial and enduring framework, may even evoke the clashing of two cultures (Committee on SMTP, 2001; Conference Board of the Mathematical Sciences, 2001; Goodlad, 1993; Goodlad & Sirotnik, 1988). Even IHE interdisciplinary collaborations faced institutional challenges (Bohen & Stiles, 1998). Some of the participating IHEs might even have grappled with tensions over the historic role of schools of education (Clifford & Guthrie, 1988; Tierney, 2001; Timpane & White, 1998) and the evolving role of professional development schools (Clark, 1999; Committee on SMTP, 2001; Holmes Group, 1990; Rice, 2002). Given the nuances of partnering amongst educational institutions and agencies, the importance of creating a collaborative partnership becomes evident.

Obstacles to creating and sustaining collaborative partnerships include a wide range of factors. Turnover of staff can cause difficulties in terms of continuity (of content or infrastructure support, etc.). Staff turnover may be disruptive to a partnership for reasons other than the departure of key leadership. Disruptions may result from the departure of faculty, administrators, or teachers. Another obstacle is size. Size can refer to geographic expanse between partners, the sheer number of participants, or the physical size of a facility. As an example of physical size, an IHE department or school could be so spatially large that communication and interaction become challenging and fragmentation occurs (Bullough & Kauchak, 1997).

Methodology

This study examines partnerships awarded in three cohorts during FY2002, 2003, and 2004 in three categories: 1) Comprehensive Partnerships, 2) Targeted Partnerships, and 3) Institute Partnerships (Teacher Institutes for the 21st Century). Comprehensive Partnerships are required to work across the K-12 continuum in mathematics, science, or both. Targeted Partnerships focus on a specific grade band or content domain (e.g., middle school mathematics). Institute Partnerships focus on the development of teacher intellectual leaders in mathematics or the sciences. Data sources included interviews with the MSPs, archival data submitted by the awardees as part of the MSP Program's management information system (MSP-MIS), available extant literature, awardees' annual reports, awardees' evaluation reports, documents available through the awardees' learning network (www.MSPnet.org), and Web site information reported by the individual partnerships in the MSP Program accessible through 2007.

Education Partnerships in the National Science Foundation's Math and Science Partnership Program

The NSF MSP Program promotes the development, implementation, and sustainability of exemplary partnerships to produce high-quality math and science education at all K-12 levels. The MSP Program anticipates that the partnerships will be instrumental in improving student achievement, as well as reducing achievement gaps among student populations differentiated by race/ethnicity, socioeconomic status, gender, or disability, a strategy advocated by Haycock et al. (1991).

A required partnership in the MSP Program is between an IHE or eligible nonprofit organization (or consortium of such institutions or organizations) and one or more local education agencies (LEAs) that may also include an SEA or one or more businesses (National Science Foundation Authorization Act, 2002). This type of partnership arrangement is vertical in nature in that LEAs are partnering with entities (e.g., IHEs) at later points along the pre-K-20 education continuum.[2] The theory is that this verticality may enable the LEAs to maximize their educational potential and establish student pathways (Howard Community College, 1999). The MSP Program also distinguishes between core and non-core partners. Core partners share responsibility and accountability for the MSP grant. All core partner organizations are required to provide evidence of their commitment to undergo the coordinated institutional change necessary to sustain the partnership effort beyond the funding period. A non-core or supporting partner is *not* required to commit to the institutional change necessary to sustain grant activities beyond the funding period, but is an important stakeholder in

K-12 math and science education.

The complexity of the MSP Program derives both from the nature of the individual grants and their collectivity. Individually, each of the grants is being conducted by a partnership and not a single entity, with a core set of partners deeply engaged in the effort at both institutional and individual levels – sharing goals, responsibilities, and accountability for the grant.[3] While certain partnering requirements apply to the MSP partnerships (as stated above), these partnerships have structured themselves in four basic configurations as shown in Table 1.[4]

Table 1

Type and Number of NSF-MSP Partnership Configurations

Type of Configuration	Number of MSP Partnerships with this Configuration
1. One IHE with one school district	3
2. One IHE with multiple school districts	13
3. Multiple IHEs with one school district	7
4. Multiple IHEs with multiple school districts	25
Total	48

Note. From MSP Annual Reports and MSP Evaluation Reports.

Specifically, with regard to how composition or configuration impacts the four types of MSP partnership configurations, the first partnership configuration, one IHE with one school district, could result in the partners working in sync together on agreed upon activities or it could result in the partners pursuing independent sets of activities in isolation. This would depend on the nature of the relationship between the two partners (equal partners, not equal partners, something different). The second partnership configuration, one IHE with multiple school districts, could have a dominant, strong IHE partner that mandates all of the partnership activities with little influence from the other partners. Alternatively, if the school district partners are not in unison they may all be pursuing different activities that may or may not be aligned with the goals of the partnership. Also, configuration may impact the types of activities the partnership pursues. For example, configuration with multiple school districts may lead to a focus on activities in the K-12 setting as opposed to IHE-level activities such as the development of a new master's program at an IHE partner institution. The third partnership configuration, multiple IHEs with one school district, could lead to the IHEs presuming they know what is needed at the district level with little input or influence from the district. The fourth partnership configuration, multiple IHEs with multiple schools districts, could potentially go in the same direction, but with the influence on several district partners it would be less likely to do so. Due to the number of IHEs and school districts, this type of configuration could possibly lead to the richest array of activities.

Engagement of Community Colleges, Vocational Technical Colleges, or Tribal Colleges

The composition or configuration of the partnership may predict or define the activities it undertakes. Those partnerships engaging community colleges, vocational technical colleges, or tribal colleges within their partnership may have the ability to utilize IHE faculty to a greater extent due to their more flexible teaching schedules and their non-tenure track positions that do not require extensive research and publication for professional advancement. Thirteen MSP partnerships include a community college, vocational technical college, or tribal college as partners (see Table 2). Three of these exist in the partnership configuration of multiple IHE partners with one school district, and the remaining ten exist in the partnerships configured as multiple IHEs with multiple districts. The MSP Partnerships have as few as one community college, vocational technical college, or tribal college associated with them and as many as four. These types of community college relationships may not exist in the first two types of partnership configurations because both are structured such that one IHE leads the effort with single or multiple districts as partners.

Partnering Activities

This section will examine partnering activities the MSP partnerships carried out, and the next section will examine education activities pursued by the MSP partnerships. This section is comprised of a set of illustrative partnering activities reported by the MSP partnerships including distributing or awarding funds, disseminating information and increasing awareness, partnering communications, evaluating the partnership and its activities, and enlisting external STEM professionals.

Distributing or Awarding Funds

The MSP partnerships distributed and awarded funds through mini-grants, grants, sub-grants, sub-awards, and general funds to further and advance the goals of the partnership. Other stated purposes of these awards included strengthening the partnership, fostering collaboration, generating awareness of the MSP's work at the local and regional level, conducting specific activities, purchasing supplies, and building the capacity of local or regional partners. Since the process of obtaining an award was competitive, some core partners provided technical assistance and training on proposal development and submission, which served as a learning experience to increase the partner's skills in grant writing techniques. The MSP partnerships also viewed the awards as a possible source for the partnership to achieve long lasting

Table 2
Presence of Community College Partner with Type of Partnership Configuration

	Type of Partner
Type of Configuration	Community College, Vocational Technical College, or Tribal College Partner
1. One IHE with one school district (*n* = 3)	0
2. One IHE with multiple school districts (*n* = 13)	0
3. Multiple IHEs with one school district (*n* = 7)	3
4. Multiple IHEs with multiple school districts (*n* = 25)	10
Total	13

Note. From MSP Annual Reports, MSP Evaluation Reports, Annual Survey of Partnership Projects (all years of data reported), and Annual IHE Participant Survey (all years of data reported).

benefits and effects on the partners. In other words, they could work through the partnership to bring about change at the local level.

Awards ranged in funding levels from approximately $1,000 to $80,000. A small amount of money is sometimes all that is required for an activity, and compared to the conventional grant-awarding process, mini-grants can be a way for the partner to obtain funds without a significant investment of time or resources. The MSP partnerships did show differences with respect to the requirements for application for funding in one critical area–the work proposed. Of the eight MSP partnerships that made sub-awards, five required that the partner propose work on a specific area as opposed to allowing the partner to determine how funds would be deployed after receiving the award. When the MSP partnership stipulates proposal criteria they exert more influence over the direction of the award and can make sure that the sponsored activity aligns with that of the partnership's goals. This becomes especially important when multiple school districts receive funding. Without guidance and encouragement on the use of the funding, school districts could potentially enact several disparate activities that do not further or augment the partnership's mission and goals.

Of eight MSP partnerships making awards, six fall into the configuration category of having multiple IHEs partnered with multiple school districts. The remaining two partnerships are configured as one IHE partnered with one school district and multiple IHEs partnered with one school district. Perhaps the sheer number of partners makes a difference. Partnerships with several partners need to find ways to keep the diversity of partners engaged and interested over the course of the long-term relationship. In addition, by dispersing several awards that serve the partnership's goal or mission the partnership is ideally creating coherence and cohesion among the partners and their activities. Finally, sometimes covering a large geographic expanse, the partnership is poised to communicate and disseminate its activities and goals to a broader audience at a local level, thus increasing the potential for impact.

Dissemination

The MSP-MIS and the MSPs' annual and evaluation reports show that the MSP partnerships are involved in a multitude of dissemination activities. The MSP partnerships produced and disseminated materials and findings about their partnerships to articulate the value-added of the partnership itself, its tools, and its strategies. To maximize the impact of dissemination, the MSP partnerships targeted different audiences including NSF, the research community, the education community, parents of students, and other community members interested in the improvement of K-20 educational practices.

Proportionate to their relative sizes, partnerships belonging to each of the four configurations types conducted approximately the same number of dissemination activities (approximately three activities per MSP). Among ten categories of activities, MSP partnerships participated most frequently in three: 1) developing Web sites; 2) producing, disseminating, and presenting materials and resources; and 3) holding parent/student math/science nights. Forty-six of the 48 MSP partnerships developed Web sites, 37 produced, disseminated, or presented written materials and resources, and 22 held parent/student mathematics/science nights. In the remaining categories of activities, 11 MSP partnerships produced and disseminated videotapes or DVDs. Seven opened resource centers for teachers, parents, or the community. Configuration of the partnership does not appear to impact the amount or particular type of dissemination activity.

Partner Communications through Meetings

The MSP partnerships reported that one of the key factors in maintaining their partnerships was communication and developing trust among the partners. Trust is one outcome of good communication behaviors, such as providing accurate information, giving explanations for decisions, and demonstrating sincere and appropriate openness. Roman, Moore, Jenkins, and Small (2002) find that partnerships are more likely to succeed if "partnership structures support multiple organizational contacts with clear lines of communication across organizations, as well as equal decision-making among community organizations and government agencies…Success appears likely to be achieved when both horizontal integration (among community organizations) and vertical integration (between community organizations and traditional power holders) are strong" (p. 70).

Leadership also plays a critical role in partnership communication. Leaders within the partnership initiate, guide, interpret, and monitor communication dialogues and identify communication needs and shortcomings. Even though partnerships are based on the notion of broad-based ownership and power sharing, several studies found that strong leadership is important to overall success (Birkby, 2003; Drug Strategies, 2001; Metzler et al. 2003). The nature of the pre-existing partnerships may further contribute to lines and modes of communication being more readily established since leadership may be in place and the modes of communication may already be in existence and routinized (Davis & McCullough, 2006).

Communication occurs through a range of activities, and as of the award period 2006-07, the MSP partnerships have been communicating through a variety of mechanisms. These include establishing advisory boards, steering committees, or advisory councils and convening regularly-scheduled meetings; convening regularly-scheduled meetings to discuss the partnership entity; convening regularly-scheduled meetings, conference calls, or electronic communications to maintain general communications or for general planning purposes; convening retreats; creating management and communication plans; and developing forms for information sharing (e.g., reporting forms, logs, etc.).

Of these types of communication activities, the MSP partnerships held regularly-scheduled meetings most frequently, and nearly all MSP partnerships in each of the four types of configurations reported holding such meetings. Both of the MSP partnerships configured with just one school district had 100 percent participation in holding regular meetings, perhaps because it is easier logistically to schedule these types of meetings since there is only one school district partner. The second most frequently occurring communication activity was convening meetings to discuss the partnership entity (as opposed to general discussions or planning meetings). Those MSP partnerships configured with multiple IHEs held this type of meeting frequently (i.e., proportionately speaking, at twice the rate of those MSP partnerships configured with one IHE). Overall, just under 40 percent of the MSP partnerships reported holding regularly-scheduled advisory board, steering committee, or other guidance board types of meetings. Finally, only those MSP partnerships configured as multiple IHEs with multiple districts reported holding significant retreats to discuss partnership issues. A retreat is one manner in which to more deeply engage a large number of partners for an extended period of time, supporting participation by all of the partners.

Evaluation

Evaluation is a critical component of a successful partnership (Gomez & de los Santos, 1993). Evaluation of the partnership assists partners in determining what works, what is effective, and what is not so effective with respect to the functioning of the partnership. Evaluation also can help demonstrate the effectiveness of programs the partnerships support. However, evaluation can be a major challenge for some partnerships given their many endeavors and management responsibilities.

The MSP partnerships drew upon an assortment of different methods of assessment and instruments to conduct evaluations (see Table 3). The methods employed include case studies, interviews, focus groups, surveys, secondary document analysis, and site visits.

The partnerships are measuring the effectiveness of their partnerships and are beginning to examine outcomes related to their activities. To attribute distal outcomes to the work of the partnership, it is important to have documented the partnership start-up process, identified key elements of the partnering relationship, and assessed the immediate effects of the partnership on major stakeholders: the members of the partnership, the partnership itself, and the targeted community.

Three MSP partnerships report that they are conducting a formal case study of the partnership. Seven partnerships say they are conducting formal studies about how their partnerships work, while eight partnerships report that they are using formal partnership assessment instruments. Fifteen partnerships include evaluation tools or methodologies embedded within annual or evaluation reports such as interview guidelines, site visit protocols, and other project documents. Seven partnerships mention that they are doing something in assessment but it is either in the preliminary stages, not reported well, or simply unclear as to what it is.

All three partnerships configured as one IHE with one school district are conducting some type of evaluation of their partnerships. The modest size and scale of these types of partnership configurations may contribute to their ability to conduct evaluations because it may be less costly and more manageable. Only four of the original 13 partnerships configured as one IHE with multiple school districts are conducting evaluations. In this instance, it may be that the IHEs do not think there is a need for an evaluation. Within this configuration category, three of the four partnerships are working on an embedded type of assessment.

Four of the seven partnerships configured as multiple IHEs with one school district conducted evaluations in at least one of each of the categories, except case study methodology. Eighteen of the 25 partnerships configured as multiple IHEs with multiple school districts conducted evaluations with the majority using an embedded assessment (n = 10) or doing a formal partnership assessment (n = 7). Of note, this is the only type of partnership configuration using a case study methodology. These two types of configurations have in common the participation of multiple IHEs (as opposed to one dominate entity).

Enlistment of External Support

As reported to the MSP-MIS and in the MSPs' annual and evaluation reports, the partnerships enlist support from STEM industry and business personnel who work in disciplinary fields. The more that links with business are created, the higher the

Table 3
Types of Evaluation Assessment by Type of Partnership Configuration

	Type of Evaluation Assessment					
Type of Configuration	Case Study Example: Triangulation of multiple data sources (interviews, focus groups)	MSP Study Example: Conducting the Building a Partnership Study	Formal Partnership Assessment Instrument Example: Administering formal assessment instruments	Embedded Example: Conducting interviews, site visits, etc.	Informal/Unclear Example: Distributing literature to read re effective partnerships	Total
1. One IHE with one school district (*n* = 3)	0	1	0	1	1	3
2. One IHE with multiple school districts (*n* = 4)	0	1	0	3	0	4
3. Multiple IHEs with one school district (*n* = 4)	0	2	1	1	1	5
4. Multiple IHEs with multiple school districts (*n* = 18)	3	3	7	10	5	28
Total	3	7	8	15	7	40

Note. From MSP Annual Reports and MSP Evaluation Reports.

likelihood of accessing additional resources and participating in joint ventures. Some of the partnerships maintain a large network of contacts to participate in MSP activities, such as experts from the field who mentor students. Using this network, the partnerships have generated awareness about potential career paths for students. Other partnerships are working to increase awareness among potential supporters such as university alumni, foundations, and for-profit entities. The partnerships have reported support in the form of office space, parking, materials, and monetary resources.

Of all the types of MSP partnership configurations, overall about 60 percent utilized STEM business professionals. Those partnerships configured as multiple IHEs with multiple districts engaged STEM professionals at the highest rate proportionately. The MSP partnership configured as one IHE with multiple districts had the lowest level of involvement by external STEM professionals.

Education Activities

A framework developed by Yin and Long (2007) will be used to examine how partnership configuration impacts education activities undertaken by the MSP partnerships. The framework arrays all of the education activities conducted by the MSP partnerships (as opposed to MSP partnering activities, which were described in the previous section). The framework (see Table 4) displays the education activities in a logic model format organized by the locus at which the activities occur: IHE, K-12, between these two, or in another venue. It further illustrates the interface or relationship of the education activities to each other and to student achievement.

At the K-12 level, MSP partnerships worked on activities in three broad education activity categories: 1) working with K-12 students, classroom, or curricula; 2) working with K-12 teachers, administrators, or staff; and 3) working with K-12 policies and institutional structure (see Table 5). Nearly three times the number of education activities occurred in the second category, working with K-12 teachers, administrators, or staff. Education activities in this category include providing in-service (professional development) to existing K-12 classroom teachers; training teacher leaders, coaches, and mentors to work with classroom teachers; and training school administrators or staff. On average, each of the types of partnership configurations conducted three activities with the partnerships configured as multiple IHEs with multiple school districts conducting an average of four activities per partnership. This higher level of activity within this partnership configuration may be due to the fact that this configuration simply has the greatest number of partners who both provide and receive professional development services.

The first K-12 education activity category, working with K-12 students, classroom, or curricula, showed the second highest number of activities. Education activities included supporting student enrichment activities and implementing new curricula, curriculum guides, or classroom technologies. With the exception of those partnerships configured as one IHE with one school district, on average the MSP partnerships

Table 4
MSP Activities Framework

Locus	Type of Activity	Type of Subactivities
K-12	Work with K-12 Students, Classrooms, or Curricula	1. Support student enrichment activities 2. Implement new curricula, curriculum guides, or classroom technologies
	Work with K-12 Teachers, Administrators, or Staff	1. Provide in-service (professional development) to existing K-12 classroom teachers 2. Train teacher leaders, coaches, mentors, etc., to work with classroom teachers 3. Train school administrators or staff
	Work with K-12 Policies and Institutional Structure	1. Define and implement new standards, curriculum frameworks, or educational policies 2. Develop new assessment or other tools
IHE (Undergraduate and Graduate)	Work with Undergraduate and Graduate Students, Classrooms, or Courses	1. Support student enrichment activities 2. Modify individual courses for existing undergraduates or graduates 3. Modify individual courses for existing K-12 teachers, administrators, or staff
	Work with Faculty, Administrators, or Staff	1. Provide professional development to existing IHE faculty 2. Train faculty leaders, coachers, mentors, etc., to work with IHE faculty 3. Train IHE administrators and staff
	Work with IHE Policies and Institutional Structure	1. Alter field of concentration or graduation requirements 2. Start or revise degree programs 3. Change IHE policies or encourage interorganizational collaboration
Families and Community and Commercial Organizations	Community Building	1. Organize family education or enrichment activities 2. Increase public awareness of mathematics and science education and its importance
Educational Activities with a Distinctive Interface Between:	K-12 and IHE Students, Classrooms, or Courses	For example, K-12 students working on a project with an IHE student
	K-12 and IHE Faculty, Administrators, or Staff	For example, teachers and faculty teaching a course together
	K-12 and IHE Policies and Institutional Structure	For example, work on vertical alignment issues

Note. From Yin & Long, 2007.

Table 5

Type of K-12 Education Activity by Type of Partnership Configuration

	Type of K-12 Education Activity			
Type of Configuration	Work with K-12 Students, Classroom, or Curricula	Work with K-12 Teachers, Administrators, or Staff	Work with K-12 Policies and Institutional Structure	Total
1. One IHE with one school district *n* = 3	2	9	2	13
2. One IHE with multiple school districts *n* = 13	15	36	11	62
3. Multiple IHEs with one school district *n* = 7	11	21	9	41
4. Multiple IHEs with multiple school districts *n* = 25	35	101	23	159
Total	63	167	45	275

Note. From Yin & Long, 2007.

participated in one to 1.5 activities. Proportionately speaking, the MSP partnerships configured with multiple IHEs conducted a slightly higher number of activities than the partnership configured with one IHE and multiple school districts. The partnership configured as one IHE and one school district performed on average less than one education activity per MSP.

The third K-12 education activity category, working with K-12 policies and institutional structure, had the fewest education activities and followed a similar trend of participation as the first education activity category. This category included such education activities as defining and implementing new standards and curriculum. The two partnership configurations that feature multiple IHEs participated in a slightly higher number of activities per MSP than those structured with single IHEs.

At the IHE level, MSP partnerships worked on activities in three broad education activity categories: 1) working with undergraduate and graduate students, classrooms, or courses; 2) working with faculty, administrators, or staff; and 3) working with IHE policies and institutional structure (see Table 6). Education activity categories one and three had a similar number and the highest total number of activities. The number of activities in these two categories accounts for 89 percent of all of the IHE education activities. These two categories focus on courses, programs, and policies, whereas

Table 6

Type of IHE Education Activity by Type of Partnership Configuration

	Type of IHE Education Activity			
Type of Configuration	Work with Undergraduate and Graduate Students, Classrooms, or Courses	Work with Faculty, Administrators, or Staff	Work with IHE Policies and Institutional Structure	Total
1. One IHE with one school district *n* = 3	4	1	3	8
2. One IHE with multiple school districts *n* = 13	13	3	13	29
3. Multiple IHEs with one school district *n* = 7	14	1	10	25
4. Multiple IHEs with multiple school districts *n* = 25	34	11	33	78
Total	65	16	59	140

Note. From Yin & Long, 2007.

the education activity category with the fewest activities focused on professional development and training at the IHE level. On average each MSP partnership participated in 3.1 activities, with those partnerships configured as multiple IHEs with one school district, performing slightly higher, averaging two activities in education activity category one and averaging 1.4 activities in education activity category three.

The two partnership configurations that feature multiple IHEs participated in a higher number of activities per MSP than those structured with single IHEs. For IHE-centered activities, those partnerships configured with multiple IHEs would likely accomplish a higher number of activities per MSP than those partnerships configured with only one IHE.

At the families and community and commercial organizations level, MSP partnerships worked on 27 activities in two broad education activity categories: 1) organizing family education or enrichment activities; and 2) increasing public awareness of mathematics and science education and its importance. Those partnerships configured with multiple IHEs and multiple districts conducted the highest number of education activities per MSP (approximately 0.8 activities per MSP) followed at a distance by partnerships configured with one IHE and multiple school districts (0.38), and partnerships configured with multiple IHEs and one school district (0.29). The partnership configuration of one IHE with one district showed no education activities in the community building category. Due to the low number of partners within this configuration, perhaps education activities in this category were not required or not a priority.

Some of the education activities pursued by the MSP partnerships happened within one of three distinctive interfaces. Yin and Long (2007) labeled these interfaces as: 1) K-12 and IHE students, classrooms, or courses; 2) K-12 and IHE faculty, administrators, or staff; and 3) K-12 and IHE policies and institutional structure. The highest number of education activities occurred at the second interface of K-12 and IHE faculty, administrators, or staff. This may be due to the basic composition of the MSP partnerships (which require IHE faculty, K-12 staff, etc.) rather than any particular partnership configuration. An example of an education activity occurring here would be a teacher and a faculty member teaching a course together. Those partnership configurations with multiple IHEs, had the greatest number of activities per MSP at this interface.

The second highest number of education activities occurred at the first interface of K-12 and IHE students, classrooms, or courses. The partnership configuration of multiple IHEs with multiple districts had approximately 0.56 of their activities at this interface. The remaining three partnership configurations ranged from 0.23 to 0.033 of their activities at this interface. The interface with the fewest number of educational activities was at the K-12 and IHE policies and institutional structure. Education activities that occur at this interface include working on vertical alignment issues. Again, those partnerships configured with multiple IHEs participated in the greatest number of education activities, averaging over 1.4 each.

Conclusion

This paper addresses how different types of partnership configurations may influence the types of partnering and educational activities undertaken by the partnerships. With regard to both partnering and education activities, the particular type of configuration of the MSP partnership does not appear to significantly impact the quantity and types of activities the MSPs carry out and accomplish. In some instances, those partnerships configured with multiple IHEs show a higher participation in activities, proportionately speaking.

Why is this so? One possibility is that a majority of the MSP partnerships configured with multiple IHEs formed as a result of pre-existing relationships (as compared to the other types of configuration). Pre-existing relationships provide an advanced starting point for the partnership in that relationships are formed, a sense of familiarity and trust exist, common goals and interests are in common, and operating mechanisms (including communication) have been established and refined. These aspects may help accelerate the rate of implementation. A pre-existing relationship further allows the partnership to have already formed a plan and process for dealing with a diverse set of partners. If a partnership is too diverse, there is potential for multiple mini-or sub-partnering arrangements occurring. For large partnerships such as those configured with multiple IHEs, a certain level of homogeneity is required. Also, because of the time spent in and effort given to pre-existing relationships, the partners may also have discovered the appropriate amount of alignment among partners. On the partnering continuum, the partnership should not have partners that are too distant or too closely aligned. A too distant partner would not make the contributions needed for a successful partnership; a too closely aligned partner may work to implement courses (as but one example) that would not serve a purpose beyond the grant period.

Second, size matters. Those MSP partnerships configured with multiple IHEs have access to a breadth and depth of resources the other configurations do not. These resources include an increased number of possible project participants, the amount of time project participants can contribute, facilities, existing knowledge about relevant topics, and other intangibles such as networking capabilities. These lead to an enhanced capacity to conduct a greater number and richer array of activities.

Third, the type of partners engaged in the partnership may impact its activities. As mentioned above, the partnerships configured with multiple IHEs have community colleges, vocational technical colleges, or tribal colleges within their partnership. In some cases, this provides the potential advantage of more IHE STEM faculty participation because of the different responsibilities of faculty positions at these types of institutions as opposed to universities and colleges.

How do those partnerships configured with one IHE differ? Those MSP partnerships configured with one IHE with one school district could result in the partners working in alignment with one another on agreed upon activities or it could result in the partners pursuing independent sets of activities in isolation. This would depend on the nature of the relationship between the two partners (equal, unequal, or some other relationship). The partnership configured as one IHE with multiple school districts, could have a dominant, strong IHE partner that mandates all of the partnership activities with little influence from the other partners. Alternatively, if the school district partners are not in unison they may all be pursuing different activities that may or may not be aligned with the goals of the partnership.

Endnotes

[1]See Scherer, 2006, *Partnership Implementation in the MSP Program* for further description of these factors.

[2]There is no intended value in the continuum (e.g., from good to bad or vice versa).

[3] At least one MSP awardee did not enact the partnership with the partners originally proposed. Instead, it added one district-level partner that was not proposed and dropped one district-level partner that was proposed.

[4]This table categorized comprehensives, targeted, and institute partnerships. RETA partnerships are not included.

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Research Mathematicians' Participation in the MSP Program

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The purpose of this study was to examine the involvement of higher education STEM faculty in disciplinary departments with pre-K-12 public schools. In particular, the study focused on 15 nationally funded awards, targeted at education in mathematics, in the National Science Foundation's Math and Science Partnership (NSF MSP) Program. One important goal of the MSP Program is to further cultural change in the STEM departments. Other studies have analyzed the effectiveness of efforts to engage STEM faculty in education activities; however, the groups studied previously included those faculty whose primary research field was STEM education. Taking the view that achieving cultural change in disciplinary departments may require an attitudinal shift among disciplinary research faculty, this analysis selected only the faculty group self-identified as "mathematics researchers" for study. Various research questions were pursued, including: How many mathematics researchers have participated in these projects; How many have worked directly with pre-K-12 teachers; How directed are they toward management activities; What is their tenure status; and, How have partnerships with a high rate of participation by mathematics researchers achieved this goal? The findings show that those projects with a high percentage of involved mathematics researchers are likely to be those with a large total number of participants. Results also indicated that mathematics researchers were more likely to be engaged directly in activities with pre-K-12 teachers, and less likely to be engaged in management activities, than other faculty participants in the projects.

Research Mathematicians' Participation in the MSP Program

The National Science Foundation Math and Science Partnership (NSF MSP) Program is a national research and development effort with awards funded for partnerships among pre-K-12 schools and Institutes of Higher Education (IHEs) to strengthen mathematics and science education. As a result of this programmatic emphasis, partnerships depend on higher education faculty in STEM (Science, Technology, Engineering, and Mathematics) disciplinary departments to conduct their collaborative work. The required pairing of STEM faculty in IHEs with the administration and teaching staff of public school systems is one of the innovative aspects of the NSF MSP program.

The traditional means by which STEM disciplinary faculty have been involved with pre-K-12 schools is in teaching pre-service and professional development courses at the IHE. Therefore, the collaboration of IHE STEM faculty, IHE Education faculty, and school teachers to improve pre-K-12 education presents a new challenge to many of the partnerships involved in the NSF MSP. Some of these challenges include problems in overcoming differences in culture, knowledge areas, and expectations. The NSF MSP Program Solicitation states that "…partnerships must include mathematics, science, and/or engineering faculty and their undergraduate, graduate and postdoctoral students, and should link to the work of education faculty and preservice teachers if available on partner campuses" (NSF, 2002, p. 8). How are the populations "mathematics, science, and engineering faculty" and "education faculty" defined in various program analyses? As the present report shows, there is not a uniform definition.

In addition to requiring that STEM faculty be engaged in the work of the NSF MSP, the NSF Program Solicitation (2002) states: In the MSP effort to improve teaching and learning in mathematics and science education, all comprehensive and targeted partnerships will:

> …further cultural change within the collaborations such that all partners, including higher education faculty among education, engineering, mathematics and science departments, make commitments to working together with pre-K-12 educators and are accountable for student performance… (p. 10).

In this statement, *cultural change* requires the participation of IHE STEM faculty in collaborations with K-12 education that impact K-12 student performance. If a cultural change is to be achieved within STEM disciplinary departments, many of these departments may require an attitudinal change among the research faculty, due to the value of research weighed against that of teaching and service/outreach in the tenure and promotion process. Perhaps just as important may be the role of research in the hiring process.

Some partnerships in the MSP Program rely on faculty members (perhaps members of STEM departments), whose primary research field is education, to conduct the work of the partnership. For example, mathematics departments may contain faculty who teach mathematics courses, but whose research field is mathematics education. In such cases, the individuals may be identified as STEM faculty in certain MSP databases, but viewed as education faculty by members of their disciplinary departments.

In a separate examination of the work of IHE STEM faculty in the MSP Program, researchers found that, when 14 provider groups (including IHE STEM faculty) were compared, the IHE STEM faculty participated more broadly in activities for teachers than any of the other groups across topics, grade levels, and teacher activity categories (Moyer-Packenham, Kitsantas, Bolyard, Huie, & Irby, 2009). The Moyer-Packenham et al. (2009) analysis focused on the participation of all IHE STEM faculty defined broadly, rather than focusing on any specific STEM faculty group. (For example, it did not focus specifically on mathematicians or on engineers as an individual group, and it included STEM faculty who teach in a STEM field but whose primary field of research might be education.) In contrast, the purpose of this examination is to analyze how mathematics faculty, who have defined themselves as *mathematics researchers*, are contributing to the partnerships in the MSP Program targeted at mathematics. In particular, the following research questions were pursued. 1) How many mathematics researchers have participated in partnerships targeted at mathematics? 2) How many of these mathematics researchers have worked directly with pre-K-12 teachers? 3) How have partnerships with a high rate of participation by mathematics researchers achieved this goal?

We chose to investigate the second question, not only because it represents a direct involvement on the part of the research discipline faculty with teachers (a priority of NSF), but also because it is an activity with which this group of faculty is not typically associated, as they are more commonly associated with mathematics course or program development and teaching pre-service courses in mathematics.

Background on STEM Faculty Engaged in Education Work

Considerable research has been applied to the subject of working in partnerships, including distinct ways of conceptualizing a partnership (Kingsley & Waschak, 2005), the importance of shared decision-making (Grobe, Curnan, & Melchior, 1990), and shared recognition, credit, and accountability (Winkler & Frechtling, 2005) in collaborative environments. But this general background on partnerships does not illuminate the specific instance of STEM disciplinary faculty in partnerships to conduct mathematics or science education work. In a study of 32 National Network for Educational Renewal (NNER) institutions (reported to be 44% research oriented and 56% teaching oriented), Ginsberg and Rhodes (2003) discuss faculty rewards, rank, and status in "University Faculty in Partner Schools." In this examination, they make the point that "faculty" involvement almost never means the involvement of STEM disciplinary faculty. They write:

We asked one [survey] question about the involvement of liberal arts and

> sciences faculty in partner schools. Their involvement remains minimal in teacher preparation with few actually engaged directly in partner schools… One administrator comment captured what we continually heard regarding this issue: 'Virtually all faculty involved in partner schools are education people…' (Ginsberg & Rhodes, 2003, p. 153).

Based on this observation, it would seem that the engagement of disciplinary faculty presents a unique challenge.

Historically, some eminent research mathematicians have been interested in K-12 mathematics education. Hyman Bass (2005) wrote about two such mathematicians, Felix Klein and Hans Freudenthal, in the *Bulletin of the American Mathematical Society*. Bass' analysis seeks to dispel the myth, common among mathematicians, that "attention to education is a kind of pasturage for mathematicians in scientific decline" (p. 418). Based on the writings of Bass, one might ask: Why should K-12 mathematics education be unappealing to so many research mathematicians? Perhaps part of the problem, as reported in the 1990 presidential retirement speech of Jean Pierre Kahane from ICMI (the International Commission on Mathematical Instruction), may be that "In no other discipline, however, is the distance between the taught and the new so large" (Bass, 2005, p. 417).

In recent years, Bass and other respected research mathematicians have addressed perceived problems in mathematics education (see, for example, Askey, 1999, n.d.; Koppes, 2003; Milgram, 2005; Roitman, 2000; Wu, 1999). Bass (2005) highlights the importance of research mathematicians developing an understanding of the work of K-12 mathematics so that they can see ways that their own mathematical knowledge can contribute to solutions for mathematics education problems. These examples demonstrate that the efforts of some respected research mathematicians have been effective historically, and in many cases, continue to be effective today.

The extent of participation of STEM faculty in activities designed for K-12 mathematics and science teachers in the NSF MSP Program has been of particular interest to researchers and educators. In one examination, researchers analyzed the work of IHE STEM faculty in the MSP Program by reviewing NSF MSP archival data on the participation of 14 different provider groups (e.g., IHE Administrators, Graduate Students, K-12 Instructional Coordinators and Supervisors, K-12 Teachers; Moyer-Packenham et al., 2009). STEM faculty participation with mathematics and science teachers was compared with the participation of other provider groups using three main variables: Participation by Topics (i.e., mathematics, science, technology), Participation by Levels (elementary school, middle school, high school), and Participation by Activity Categories (Pre-service Preparation – Developing Courses, In-Service Retention/Enhancement for STEM Teachers, New Policies in Pre-service). The results of this study indicated that, not only were the IHE STEM faculty in the MSP Program participating in activities for teachers, but they were participating in greater proportions than any of the other provider groups across all topics, levels, and activity categories. These findings demonstrate that the IHE STEM faculty in the MSP Program have gone beyond the traditional roles of STEM faculty in IHE disciplinary departments (i.e., teaching disciplinary courses at the IHE) and taken on new responsibilities by participating broadly in activities for teachers. For the Moyer-Packenham et al. (2009) study, however, the group of IHE STEM faculty considered included not only those whose primary field of research was in a STEM field, but also those IHE faculty whose primary field of teaching was in a STEM field, regardless of research field.

Other evaluations of the work of STEM faculty in the NSF MSP Program have begun elsewhere (Shapiro et al., 2006; Zhang et al., 2006, 2007). For example, the main focus of the report from the Change and Sustainability in Higher Education (CASHÉ) project (Shapiro et al., 2006) is the role of STEM higher education faculty in course and curricular changes in the IHEs under a collaborative MSP relationship. Results in this analysis indicated that the majority of changes that occurred were in certification and professional development programs for pre-service and in-service K-12 STEM teachers. One comment from the Shapiro et al. report is pertinent for our research:

> The data also suggest that these changes are occurring at the local level rather than at the institutional level, involving individual faculty members who are engaged in specific MSP-supported activities (as opposed to department-wide initiatives or collaborative teams) (p. 3).

CASHÉ plans a future examination of the extent to which STEM faculty are engaged in these curricular innovations. In fact, one of the guiding questions for the CASHÉ study was: "Who is responsible for these changes, and are they the result of the efforts of individuals or teams" (p. 6). In a discussion of this issue, Shapiro et al. (2006) report:

> In the vast majority of the 21 MSP projects that were studied, course development or redesign activities predominantly appeared to be the product of individual faculty members. However, from the data provided, it is difficult to know if this is indeed the case (p. 9).

Nonetheless, Shapiro et al. do give examples of partnerships that have used a team or consortium approach for course development, and future reports of case studies should be of interest.

A second year MSP Research, Evaluation, and Technical Assistance (RETA) study (Zhang et al., 2006) analyzed STEM faculty engagement in eight partnerships, chosen because of the potentially high level of STEM faculty involvement in each. That report addressed many important issues, including the types of involvement of STEM faculty, interim outcomes (in terms of student achievement), institutional support, STEM faculty collaboration with other participants, and other direct and indirect evidence from the eight case studies. Particularly interesting to our inquiry are comments included in the reports from these case studies. For example: "We found that most of the RETA Cohort I projects are still working with the same group of STEM faculty" (p. 15) and, "One project used specially selected teacher leaders to support IHE/K-12 exchange. The experience of jointly designing and delivering the curriculum 'converted' some people, and the PI [Principal Investigator] observed an 'attitudinal shift'" (p. 17). These quotations provide some insight into the individuals participating in the K-12 mathematics education work and the cultural shift within the departments examined in the study.

Tenure and reward policies in the same eight case studies are a main focus of a third year RETA study by this group (Zhang et al., 2007). These policies are studied at the university, department, and individual faculty levels. Typically, education outreach work in STEM departments (such as work in the NSF MSP Program) falls under the category of "service," or perhaps "teaching," as opposed to "research." In the case studies, Zhang et al. (2007) found little change in these areas at the university level over the last three years. They conclude:

> …the issue of incentives may be critical to further expansion of STEM faculty engagement, as the current IHE reward structure and tenure policies are not particularly conducive to MSP-like activities. If faculty are not intrinsically motivated to participate in this type of activity, nothing else will bring them in, because the system appears to be designed to keep them from taking part (p. 53).

An additional example from this study shows that, again, mathematics research faculty appear to present a special problem in at least one case study with a co-teaching model: "We noticed that the inclusion of education faculty in instructional teams seemed to work better with science faculty than with mathematics faculty" (Zhang et al., 2007, p. 56-57). On a more positive note, flexibility in addressing faculty needs may make a difference: in one case study the STEM faculty are intensely involved only in the year when their content area is featured in a summer institute (Zhang et al.).

As this previous research shows, when "IHE STEM faculty" are broadly defined, their engagement in MSP-like activities appears to be substantial; however, if we look more narrowly at the participation of mathematics research faculty, these partnerships are neither natural nor flourishing. There have been and continue to be important isolated efforts of collaboration. However, in the present report, we were particularly interested in group efforts of partnerships that demonstrated that they had achieved success in engaging significant numbers of mathematics researchers in order to make a cultural change in their departments.

Methods and Data Sources

Sources

In this evaluation we used qualitative and quantitative methods to examine archival data from the NSF MSP Program drawn from FY2002-04 partnership awards. Our basic approach in examining the qualitative data followed from background reading of Annual and Evaluation Report documents (written by the partnerships) and selected site visits. An illustrative MSP profile, in the final section, was taken from the Annual and Evaluation Reports of one partnership and a site visit to that partnership. The quantitative data were extracted from archival information gathered in the MSP Management Information System (MSP-MIS) (Westat, 2003). Data for all tables and figures came from the MSP-MIS (2004-05, Wave II) *Annual IHE Participant Survey* completed by 13 partnerships targeted at mathematics and 2 comprehensive partnerships which are mathematics projects. These 15 partnerships, which were the only 15 projects in the MSP Program to concentrate specifically on mathematics, were the focus of our analysis. The data that were analyzed during this examination were obtained between January 2005, and June 2007.

Analytic Approach

To examine our research questions, we used the Venn diagrams (see Figures 1(a) and (b) for numbers and percentages) to categorize the IHE STEM faculty, (STEM faculty *in general*) in the 15 mathematics-targeted partnerships. IHE STEM faculty participation is displayed in these figures in three categories: (1) field of research or teaching (a STEM field or not), (2) level of involvement by time (at least 160 hours per year or fewer than 160 hours per year); and, (3) level of involvement by activity (direct involvement with in-service teachers or not). (Note. Contact hours increments were determined by the designers of the MSP-MIS *IHE Participant Survey*.) Although other studies (Moyer-Packenham et al., 2009; Shapiro et al., 2006; Zhang et al., 2006) show that, taken together, STEM faculty are involved in virtually all aspects of MSP activity, we chose mathematics researchers' work with in-service teachers as a pivotal activity that represents direct involvement in the MSP collaboration. We selected this activity because it is one with which the population of mathematics researchers is not typically associated, as opposed to, for example, the training of pre-service secondary mathematics teachers in mathematics courses in the disciplinary department at the IHE. In Figures 2(a) and (b), we will later show analogous Venn diagrams for *mathematics researchers*.

Specifically, in Figure 1(a), the sum of the numbers inside the circle labeled S (for STEM faculty *in general*) in the Venn diagram is the number of IHE STEM faculty in the 15 mathematics-targeted partnerships who indicated that their primary field of *research or teaching* is a STEM field. The sum of the numbers inside the circle labeled H (for Hours) is the number of IHE faculty participants who indicated they spent at least 160 hours working on MSP activities. The sum of the numbers inside the circle labeled T (for Teachers) is the number of IHE faculty who indicated they worked on at least one of the following five activities with in-service teachers (as specified in the MSP-MIS *IHE Participant Survey*):

1. Conduct workshops/institutes/courses with K-12 teachers that increase general content and/or pedagogical knowledge (e.g., teach at a summer science institute;

conduct a workshop on cognitive science and its impact on instruction);
2. Conduct targeted workshops/institutes/courses with K-12 teachers (e.g., teach at a summer science institute that is specifically linked to the curriculum/text used at partner schools);
3. Remain "on call" for classroom teachers (e.g., communicate with K-12 teachers via email or telephone to clarify a concept or content issue);
4. Mentor a K-12 teacher in a shared discipline; and,
5. Establish/provide STEM learning communities/study groups (e.g., lesson study groups; discipline dialogues).

In Figure 2(a), we present analogous data, reorganizing the numbers in the figure using our definition of *mathematics researchers* (whom we refer to as MRs), rather than IHE STEM faculty in general, as was presented in Figures 1(a) and (b). In Figure 2(a) the sum of the numbers inside the circle labeled MR (for Mathematics Researchers) in the Venn diagram is the number of IHE STEM faculty in the mathematics-targeted partnerships who indicated that their *primary field of research is mathematics*. The circles labeled H and T have the same meaning as in Figure 1(a), although the distribution of faculty is necessarily different within these circles. If participants worked fewer than 40 hours, they did not have to indicate their specific activities, just whether or not they worked with in-service teachers. We counted these individuals in the T circle if they indicated they worked in any way with in-service teachers. Note that the number of hours represented in the Venn diagram does not necessarily mean hours spent working with K-12 teachers, even in the set $H \cap T$. This set counts participants who have worked at least 160 hours on any aspect of the project and have also worked with pre-service or in-service teachers.

Results

In our initial efforts to understand the role of STEM faculty in the MSP Program, we determined (primarily through our reading of Annual Reports) that some disciplinary departments had succeeded in involving disciplinary STEM faculty, while others depended more on IHE education faculty. Our results from reviews of the qualitative and quantitative data indicate that previous surveys and evaluations have not captured this important distinction. This distinction is important to research on the work of STEM disciplinary faculty because it requires that the specific population be defined before there can be any determination of meeting the goal of influencing cultural change in STEM departments. In addition, an NSF MSP Program goal is to involve both groups (STEM and Education faculty); therefore, without this clear distinction evaluators would be unable to determine whether or not mathematics researchers were truly involved in meaningful ways in MSP Program work. In the following sections we will highlight the mathematics education work of this specific group of mathematics researchers.

What do we contribute to the previous research on the MSP Program? Other researchers (Zhang et al., 2006, 2007) have used data from the NSF-MIS IHE participant and IHE institute surveys; however, their definition of "STEM faculty" has resulted in a larger set of faculty than we present in our findings. Previously, "STEM faculty" have been defined as those who either teach in a STEM field or whose research is in a STEM area. In this prior definition, IHE faculty whose research field is education or who are not academic researchers can be counted as STEM faculty. In the following results, we specifically focus on STEM faculty whose *research* field is a STEM field, and since we are studying mathematics-targeted awards, we restrict our analysis to those IHE STEM faculty whose (self-reported) research field is mathematics. We identify these individuals as *mathematics researchers* (or MRs).

Participation of Mathematics Researchers

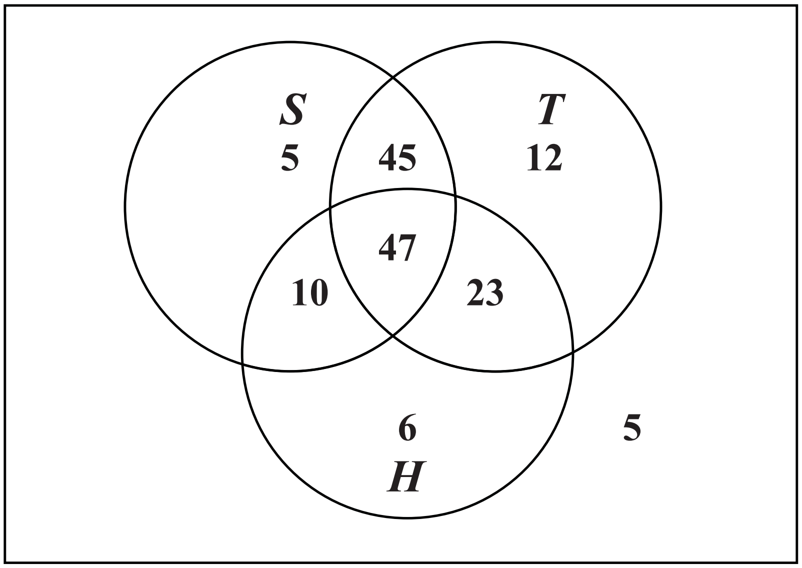
Figure 1(a) indicates how STEM faculty (as defined by Zhang et al., 2006, 2007) are engaged in K-12 teacher training activities based on a level of significant contribution to the partnership (160+ hours). The relationships are given as percentages of the total IHE faculty in the mathematics-targeted partnerships in Figure 1(b). Figure 2 shows analogous Venn diagrams for MR engagement. As these figures show, the total number of STEM faculty, in general, in these mathematics-targeted partnerships is 107, while the number for mathematics researchers is 63. The distribution of MRs and STEM faculty throughout the attributes represented in the Venn diagrams reflects the difference in the size of the two sets.

In comparing those defined as STEM faculty with those defined as MRs, approximately the same percentage (92 of 107 STEM, and 54 of 63 MRs, or 86%) are directly involved with in-service teacher activities. In general, of those STEM faculty or MRs who are involved in teacher activities, a smaller percentage of MRs (24 of 63, or 38%) than of STEM faculty (47 of 107, or 44%) is involved with grant activities at the level of 160+ hours per year.

Mathematics Researchers' Involvement in Activities

Table 1 shows selected means and standard deviations of reported numerical responses from the MSP-MIS *IHE Participant Survey*. There were a total of 153 faculty participants in the 15 mathematics-targeted partnerships included in this analysis. Of those faculty, 63 participants identified themselves as MRs. The set of MRs is a subset of the total STEM faculty (defined by Zhang et al., 2006), which number 107.

Our findings on the MRs indicate that, among faculty participants, the MRs have a *higher* tenure status than all other (non-MR) faculty participants (3.67 vs. 2.94). MRs also have a *higher* rate of participation in activities with in-service teachers than all other (non-MR) faculty participants (.86 vs. .82). This involvement is important because the MRs' participation in these activities with in-service teachers could strengthen the a.) Venn Diagram representation of IHE STEM faculty participation in the 15 mathematics-targeted partnerships. The numbers of IHE STEM faculty participants are shown in circle "S"; the numbers of IHE faculty participants involved in in-service teacher training activities, in circle "T"; and the numbers of IHE faculty participants spending more than 160 hours on grant-related activities, in circle "H" (n = 153).



b.) Venn diagram representation of IHE STEM faculty participation, as percentages of total IHE faculty participation in the 15 mathematics-targeted partnerships. The values given are those numbers in Figure 1(a), above, as percentages of the total IHE faculty participation (n = 153). *(Note: percentages may not total 100% due to rounding.)*

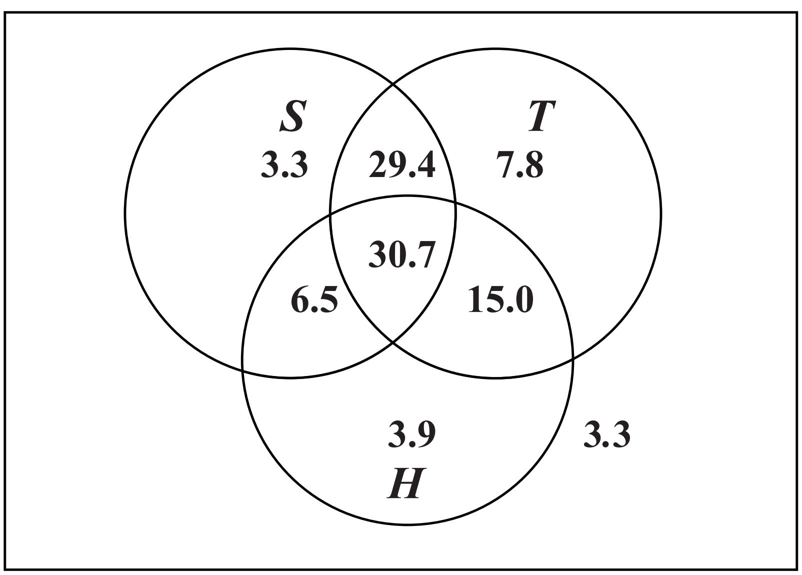
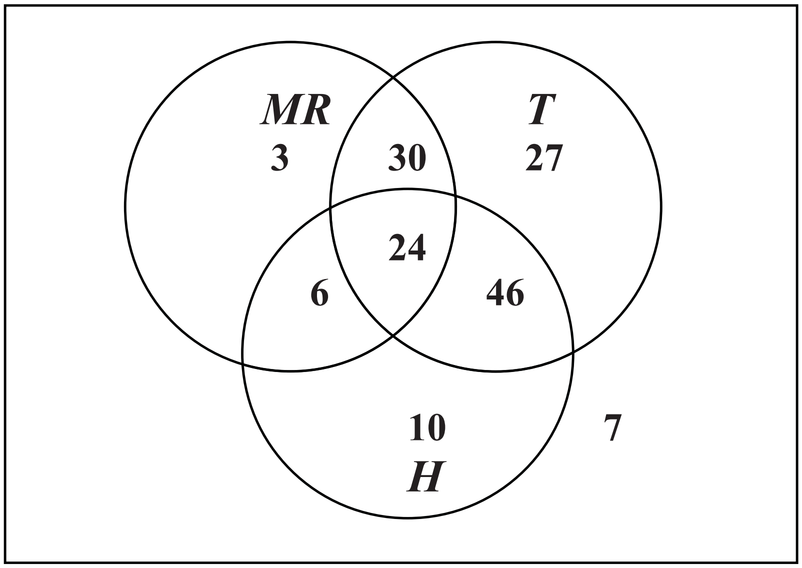


Figure 1. Faculty participation as defined by STEM researcher or STEM teacher (S).

a.) Venn Diagram representation of Mathematics Researchers' participation in the 15 mathematics-targeted partnerships. The numbers of Mathematics Researchers are shown in circle "MR"; the numbers of IHE faculty involved in in-service teacher training activities, in circle "T"; and the numbers of IHE faculty spending more than 160 hours on grant-related activities, in circle "H" (*n* = 153).



b.) Venn diagram representation of Mathematics Researchers' participation, as percentages of total IHE faculty participation in the 15 mathematics-targeted partnerships. The values given are those numbers in Figure 2a, above, as percentages of the total IHE faculty participation (*n* = 153). *(Note: percentages may not total 100% due to rounding.)*

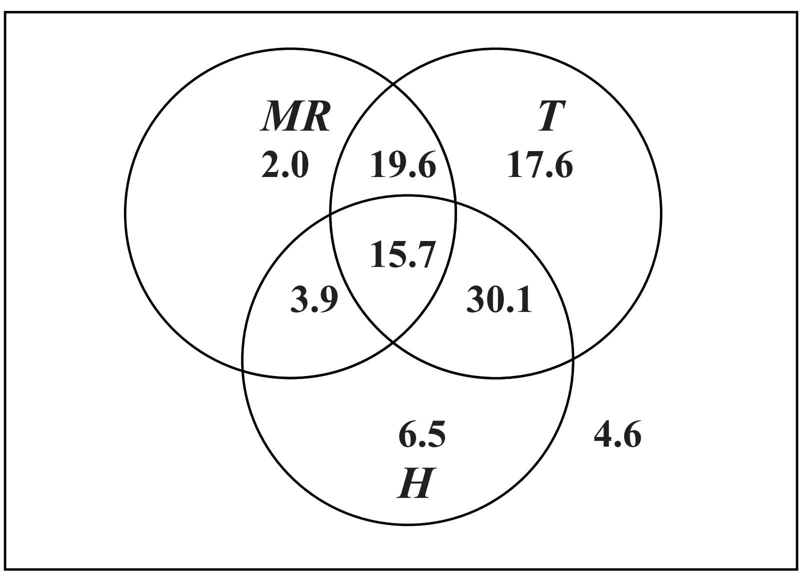


Figure 2. Faculty participation as defined by Mathematics Researcher (MR)..

mathematical content of the activities, and the MRs would be impacted by the teachers during this involvement. Finally, MRs have a *higher* rate of participation in activities with pre-service teachers (.51 vs. .47), a *lower* rate of participation in management activities (.38 vs. .60), and spend *fewer* hours participating in MSP activities than other (non-MR) faculty (4.38 vs. 4.72), all of which are consistent with historic notions of MR involvement with K-12 teachers. The means for the STEM faculty are between those of the MRs and the non-MRs. This is not surprising, since the set of STEM faculty intersects both the MR and the non-MR sets. We propose that these data, showing the activities of 63 mathematics researchers, serve as a more accurate indicator of cultural change within mathematics departments than those from the more broadly defined category of STEM faculty. The findings also indicate that MRs and STEM faculty are different groups from the point of view of the types of partnership activities in which they are engaged and the duration of their engagement. As these data indicate, although mathematics researchers spend less time involved in partnership activities, their time is focused more on pre-service and in-service teacher activities, rather than on the management of the partnership.

In Table 2 we present the results based on high contact K-12 teacher in-service activities for those IHE faculty reporting that they participated in 41 or more hours of partnership activities in general during the academic year. (Note. Contact hours increments were determined by the designers of the MSP-MIS *IHE Participant Survey*.) Table 2 shows the average participation of three groups (MRs, STEM and Other non-MR Faculty) in partnership activities with in-service teachers. The similarity of the averages indicates that the MRs are equally as involved as other faculty in MSP activities with teachers. Note that non-MR faculty are more likely to mentor a teacher than MRs, while MRs are more likely to remain "on call" for teachers than non-MR faculty.

The scatter plot in Figure 3 shows the percentage of MR involvement in individual partnerships plotted against the size of the partnership (i.e., the number of participants in the partnerships overall). While these data do not suggest that there is a causal relationship (the data set is too small), it does appear that partnerships with a large percentage of MR involvement tend to be larger partnerships. The converse is not necessarily true, as "outliers" (below the diagonal) with large values of n and a small percentage of MRs are also shown.

As expected, the percentage of mathematics research faculty involvement varies widely from partnership to partnership. Among the mathematics-targeted partnerships, we singled out one for special attention because it had the largest number (and percentage) of MRs. The following section is a profile of the activities of this partnership.

Profile of Mathematics Researchers in Schools

In this section we showcase a partnership which has 15 MRs (out of 17 total IHE faculty participants; as reported in MIS archival data) in the project. All 15 of these MRs indicated that they work with in-service teachers, with six of them spending at least 160 hours during academic year 2004-05 on partnership activities. The partnership,

Table 1
Faculty Tenure Status, Hours Spent on MSP during the Previous School Year, and Type of Activity Involvement

	Math Researcher (*n = 63)*		STEM Faculty (*n = 107)*		All Other (non-MR) Faculty (*n = 90)*	
	M	*SD*	*M*	*SD*	*M*	*SD*
Tenure Status[a]	3.67	0.78	3.44	1.04	2.94	1.27
Number of hours[b]	4.38	1.61	4.57	1.55	4.72	1.59
Type of Activity[c]						
Pre-Service Activity	.51	.50	.47	.50	.47	.50
In-Service Activity	.86	.35	.86	.35	.82	.38
Management Activity	.38	.49	.47	.50	.60	.49

Note. [a]1 = Not applicable to my position/at my institution, 2 = Not on tenure track , 3 = On tenure track, 4 = Tenured (scale reversed from MIS data). [b]1 = Less than 20 hours, 2 = 20-40 hours, 3 = 31-80 hours, 4 = 81-160 hours, 5 = 161-200 hours, 6 = More than 200 hours. [c] 0 = no; 1 = yes.

Table 2
Type of High Contact In-service Teacher Activity[a] Engaged in by IHE Faculty

	Math Research[b] (*n = 47)*	STEM Faculty[c] (*n = 81)*	All Other (non-MR) Faculty[d] (*n = 62)*
Conduct General Content Workshop	1.26	1.20	1.17
Conduct Targeted Workshops	1.60	1.57	1.50
Remain "on call" for teachers	1.36	1.36	1.73
Mentor a teacher	1.72	1.70	1.31
Establish study group	1.66	1.69	1.71

Note. [a]1 = yes, 2 = no. [b,c,d] Includes only respondents reporting 41 or more hours spent on the institution's MSP during the school year.

targeted at mathematics in grades 6-12, comprises three IHEs, an education institute, and five urban school districts. The lead institution is a large, urban university, Carnegie classification: Research University, Very High Research Activity (RU/VH), while the other IHEs are classified Doctoral/Research University (DRU) and Masters Colleges and Universities, Larger Programs (Master's L). *Mathematics researchers* are an integral part of this group, with 15 fully engaged in activities. All 15 are tenured at their IHEs, including nine who are tenured at the lead university and six at the other two IHEs. In this report, we do not examine how successful the partnership is in meeting its goals in student achievement or teacher production and professional development. Because very little is known about the participation of mathematics researchers in these partnerships, our focus is solely on understanding the partnership's success in attracting and retaining a large group of MRs. Once this relationship is further understood, future research could examine the link between their participation and student and teacher outcomes.

As an indication of their cooperative spirit, we quote the first few sentences in the section "(MSP) Mathematicians" from the Year 3 Evaluation Report:

> Over time, and continuing in Year 3, [MSP] mathematicians have been deepening their knowledge of schools, teachers, and to varying extents, students. Mathematicians have served [MSP's] overall program goal of strengthening teachers' [knowledge for teaching mathematics] by working with teachers in a variety of roles, while expanding their own knowledge of 5-12 education, the culture of school districts, and the challenges teachers face in doing their work. Instead of mathematicians presenting themselves as experts, they have been quick to 'dive in' to working with teachers in the study groups, summer

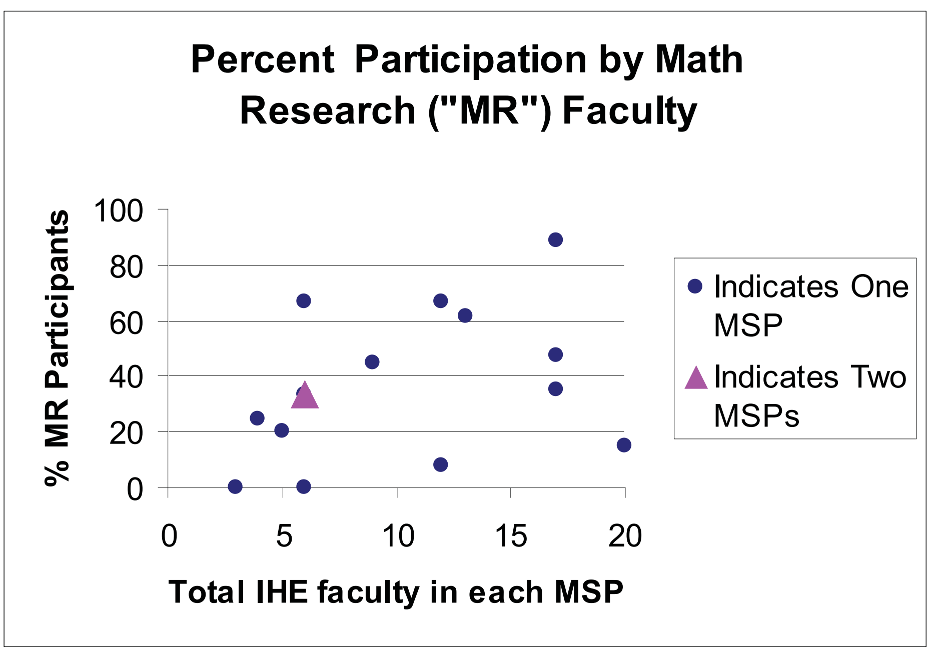


Figure 3. Participation by mathematics research faculty.

> institutes, seminars and other [MSP] activities, offering ideas for their work together initially, and encouraging teachers to take over shared leadership for the groups' learning over time. Mathematicians' enthusiasm in and commitment to the partnership have encouraged community building within their study groups and across the broader community of [MSP] participants (Year 3 Evaluation Report, p. 22).

There are numerous ways in which mathematicians have participated in this partnership. For example, 14 of 18 active mathematicians in this project returned their annual surveys. The 18 (as reported in the Year 3 Annual Report) include 15 MRs and three individuals identified as faculty from an education institute. It is unclear whether the 14 include some of these three. As evidence of the number of MRs involved in partnership work, we indicate activities which have engaged at least five MRs, followed in parentheses by the number of MRs participating in each of three successive years: colloquia (8, 8, 7), seminars (6, 9, 8), study groups with teachers (12, 14, 13), summer institutes (4, 4, 6), classroom visits (12, 8, 6), K-12 student research projects (3, 7, 5), presented ideas to students (4, 9, N/A), judged mathematics fairs (7, 10, N/A), attended mathematics expos (5, 8, N/A), worked with students (5, 8, 6), attended principal breakfasts (8, 11, 7), and attended executive council meetings (4, 5, 5). Each MR spends at least one day per month in the schools engaged in these school-based teacher and student activities. These numerous participation examples show, as Bass (2005) suggests, how mathematicians can find ways that their own mathematical knowledge can contribute to K-12 education.

During a site visit to the partnership, the MRs interviewed reported that their favorite activities were study groups with teachers and student mathematics fairs. Every K-12 teacher in the five school districts was invited to join a study group with a member of the IHE faculty. These study groups met in the schools. In the first year, some district leaders reported the IHE faculty did not understand schools and K-12 teaching. By year two, there were only accolades for the efforts of the mathematicians to learn about the districts and their work (Year 2 Evaluation Report). "Over time, the mathematicians have become markedly more comfortable working with teachers, and the teacher-mathematician interactions and collaborations within the study groups were cited as a key reason for mathematicians' continued commitment to the project, especially in Year 3" (Year 3 Evaluation Report, p. 25).

From the point of view of the partnership, the study groups were reserved for problem-solving activities, i.e., working as a group on engaging, accessible problems, usually brought in by the IHE faculty leader (a mathematician). The PIs of the partnership and the interviewed MRs discussed problems they faced in countering efforts on the part of the teachers and school administrators to turn the group sessions into "help sessions" for current course or exam material (either student or teacher assessments). In this case,

> … the PIs have treated the request as an opportunity to dig deeply into the mathematics *behind* questions and topics on the exam. Mathematicians also

identified important mathematics concepts on [the exam] and designed a study group to explore these concepts in depth (Year 3 Evaluation Report, p. 21).

The PIs, together with the MRs, had a single vision for the partnership which was directed toward what they saw as "doing real mathematics" together, to inspire teachers to become lifelong learners and instill in them an inquiring, discovery-based approach toward doing and teaching mathematics.

One of the goals of the partnership was to have middle and high school students participate in mathematics fairs at their schools by carrying out mathematics "research projects;" these schools do not have science fairs. In 2007, there were at least 2,545 students involved in over 1,536 projects. Some of the MRs served as advisors to the students, some as judges, and other judges were enlisted from nearby corporations and non-partner universities. The MRs interviewed during the site visit expressed that they loved the innocent enthusiasm of the students (even for "bad" projects) and preferred that the projects be voluntary. They thought that one of the biggest stumbling blocks was teachers' fears of starting projects where they did not have the final answer. Again, they wanted to see teachers develop a discovery-based approach.

The partnership has not neglected producing new teachers. The lead university has instituted a Master's degree in Mathematics for Teaching. This degree program has challenging mathematics content courses developed and taught by MRs, including courses designed to promote independent inquiry. There is also a graduate certificate program in Mathematics for Teaching (with somewhat fewer required hours) to accommodate teachers who already hold Master's degrees but wish to go through the program for their own professional development.

The following are examples of some of the many quotes from MRs in the Year 3 Evaluation Report, providing a perspective on the work of this group of mathematics researchers with teachers and schools:

- I have a much better appreciation of what teachers are up against in school. It is very easy to blame them for the poor preparation of students entering college, but this is clearly erroneous.
- The typical attitude of a mathematician regarding math education is that 8th grade math is easy; how can teaching it be an issue? I've come to appreciate [that] teaching math well at that level is difficult.
- [I have] more of an appreciation for all they have to deal with…the political stuff, its impact on daily life [of teachers] and the incredible pressure of NCLB and testing.
- [I enjoy] getting to know some of the [teacher leaders] well enough to talk about mathematics with them, talk about teaching with them, visit their classrooms, and watch as they use [the MSP] as an opportunity to think about their lives as teachers and learners.
- If I can draw a moral---just as I learned that there is a pool of talented, dedicated math teachers in the districts, there is a pool of talented, dedicated faculty in our, and I'll bet in most, research university math departments, who genuinely care about outreach. (Year 3 Evaluation Report)

Why are the mathematicians so enthusiastic about their work in this partnership? Two reasons were emphasized during the site visit: a) "[They] haven't asked us to do education things," where 'education things' had negative connotations; and, b) the PI and other colleagues in the program have active research careers, despite their participation in the education work. Participants in the interviews also reported that their Dean (who was also a mathematician) would only hire mathematics professors with teaching credentials. The education institute played a key role in this partnership by providing the structure and management, as MRs reported: "They got us into the schools." A synthesis of the MRs comments during the interviews indicated that when the education institute provided the structure and management for their activities, this allowed the MRs to do what they enjoy doing and were trained to do, which is mathematics research.

Discussion

This study investigated the activity of mathematics researchers in mathematics and science partnerships. We chose to focus on mathematics researchers because of the importance placed on research in IHE STEM departments and the influence this group has on departmental culture. As the results show, mathematics researchers are significantly involved with the professional development of K-12 teachers in some partnerships. Our findings showed that MRs were more likely to choose to be engaged in activities with K-12 teachers and less likely to be engaged in management activities than non-MRs. In partnerships with a small number of participants, MRs might be asked to take over more management duties than they would want.

Although mathematics researchers should not necessarily be expected to choose K-12 mathematics education work, their specialized knowledge of mathematics and insight as to where the field is heading are important for mathematics education. This knowledge can be tapped by a partnership that finds appropriate avenues for mathematics researchers' participation. For example, at least one of the case studies previously discussed (Zhang et al., 2007) has adopted a policy of having STEM faculty participate intensely only in years in which their specialty is taught during summer institutes. This type of organization requires the partnering of management persons or organizations. As our data show, among the mathematics-targeted partnerships, those with a high percentage of MRs are likely to have a large number of IHE participants. Thus the "intrinsic motivation" (Zhang et al., 2007) toward education work, when present, can be guided to useful purposes.

In the partnership profiled in this paper, the large number of MRs at the lead university served as a respected peer group in their department, in essence, a "club" that many wanted to join. All of these MRs are tenured faculty, and they set the tone for the work that is done by those in the department. (They would not ask untenured, tenure-track mathematics faculty to participate.) We believe that there were four main reasons for the success of this partnership in recruiting mathematics researchers:

- The leaders of the partnership involved the MRs in activities that were more like mathematics research than mathematics education.
- The participants saw other MRs in their department (including the PI)

continuing their research careers while participating in the NSF MSP activities.

- The lead university made interest and ability in teaching a priority in hiring MRs.
- The universities were partnered with an education institute which provided expertise in education, school relations, and the overall management of the partnership.

Two of the activities identified most frequently by MRs interviewed during the site visit as "favorites" of the MRs were the teacher study groups and the school mathematics fairs. These were also the activities viewed by the MRs as the most important to sustain. In each case, the activity points to a long-term program goal: The study groups, as implemented by this partnership, are designed to empower teachers as learners of mathematics, passing on productive habits of mind through these teachers to influence their school culture. The mathematics fairs, for students participating in projects, instill pride and the spirit of discovery in mathematics. Future studies by the partnership on the 2,545 middle and high school students who participated in the mathematics fairs may reveal whether or not these students go on to take more advanced mathematics courses or major in STEM fields in college.

In the NSF MSP Program Solicitation (NSF, 2002), the partnerships are charged to link STEM faculty with education faculty, if available, and teachers, and to "further cultural change within the collaborations…" (p. 10). We began this study with the idea that cultural change will only occur in mathematics departments if mathematics researchers are involved in the projects. We do not make assumptions as to which populations are more successful in their work with teachers. While the purpose of our project was not to link cultural change in the mathematics departments with student outcomes, future studies may wish to pursue this line of inquiry. Although there have been individual mathematics researchers who have served as important links with education and as role models for their colleagues, the population of MRs, in general, has not been associated with K-12 mathematics education. We hope to have shown, by example, that when the proper conditions are met, a mathematics department can produce an active group of mathematics researchers who become involved with K-12 education while continuing their research careers in mathematics. In particular, the partnerships need to find ways to engage mathematicians in ways that match their interests and talents.

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Increasing the Diversity of Teachers in Mathematics and Science Partnerships

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This study examines teacher diversity in a federally-funded mathematics and science partnership program. Each of the partnerships in the program provided preservice and/or inservice education for teachers in mathematics, science, or both. Researchers used qualitative and quantitative methods to examine the effect of strategies implemented by the partnerships to influence teacher diversity and the relationship of strategy implementation to changes in teacher diversity. There were no significant changes in teacher diversity for the program overall; however, there were significant changes in individual partnerships. Researchers identified categories of strategies for increasing teacher diversity among the partnerships and found that some partnerships employed numerous strategies in a comprehensive manner. While there were no significant relationships between strategies implemented and changes in teacher diversity, the findings suggest the potential for relationships to be revealed with further longitudinal study. Particularly useful among these findings is the identification of a typology of specific strategies known to influence changes in the diversity of mathematics and science teachers.

Mathematics and Science Partnership Initiatives

The performance of American students on international comparisons (e.g., TIMSS) of academic achievement has brought focus to the teaching and learning opportunities students experience in the nation's schools (Stigler & Hiebert, 1999; U.S. Department of Education, 2007). This focus has been particularly intense on the teaching and learning of mathematics and science because of their impact on a variety of fields (engineering, technology, medicine, space exploration) (National Academy of Sciences, 2007; U.S. Department of Education, 2002). In 1999 the Glenn Commission investigated the quality of mathematics and science teaching in the country and examined ways to increase the number and quality of mathematics and science teachers. The resulting report, *Before It's Too Late* (National Commission on Mathematics and Science Teaching for the 21st Century, 2000), highlighted the importance of quality mathematics and science education in preparing students to be competitive in an increasingly global society. High quality teachers and teaching do matter.

Ensuring teacher quality includes improving the characteristics of individual teachers and the characteristics of the teacher population. For example, improving a teacher's subject-specific knowledge in a discipline such as mathematics or science refers to the quality of *individual teachers*. Teacher turnover and a diverse teaching force refer to the quality of the *teacher population*, as a whole. In recent years, national initiatives have provided support for improving individual and population characteristics of the mathematics and science teaching force.

One current national initiative in mathematics and science is the National Science Foundation's Math and Science Partnership Program (NSF MSP). "MSP serves students and educators by emphasizing strong partnerships that tackle local needs and build grassroots support to increase the number, quality and diversity of mathematics and science teachers, especially in underserved areas" (National Science Foundation, 2007, p. 1). The present study was designed to examine, specifically, the efforts of NSF partnerships to increase the diversity of mathematics and science teachers. In particular, we sought to identify strategies supported through the Program to increase the diversity of teachers in partnership activities, and to determine changes in teacher diversity that resulted from those strategies, both in partnership activities and in the participating districts where partnerships operated. Promising findings, when employed on a larger scale, could have the potential to increase the diversity of mathematics and science teachers in the U.S.

In its broadest sense, the term *teacher diversity* may include characteristics such as race, ethnicity, gender, age, experience, and disability. Because the partnerships in this program focused their efforts to increase teacher diversity on race and ethnicity, our analyses were confined to these characteristics. In the present study, teacher diversity was measured by the proportion of minority teachers participating in NSF MSP partnership activities. One focus of our inquiry was to identify partnerships where teacher diversity changed over a two-year period. A second focus was to examine whether the implementation of specific strategies produced significant changes in the diversity of the partnerships' teacher participants.

Research on Teacher Diversity

The issues that surround teacher diversity described in the literature include: the demographic composition of the teaching force, the importance of having a diverse teaching force, barriers to increasing teacher diversity, and methods and strategies for improving teacher diversity.

The Demographic Composition of the Teaching Force

The student population in America's schools is increasing in diversity. However, the diversity of the country's teacher population has not followed this trend (Dandy, 1998; Newby, Swift, & Newby, 2000; Shen, Wegenke, & Cooley, 2003; Torres, Santos, Peck, & Cortes, 2004). Data from a nationally representative sample of public school teachers indicate that schools made slight increases in the racial and ethnic diversity of the teaching force in the years between 1987-1988 and 1999-2000; however, during this time, the number of male teachers decreased (Shen et al., 2003). Although there appear to be greater improvements in the numbers of diverse teachers in the new teacher population, retention of new teachers could prevent these gains from having a significant impact on the teaching population over time (Darling-Hammond, Dilworth, & Bullmaster, 1996; Kirby, Berends & Naftel, 1999; Shen et al., 2003).

In stark contrast to a student population that is rapidly becoming more culturally and linguistically diverse, many researchers argue that the teaching force is not keeping pace with the diversity of the student population (Branch, 2001; Ladson-Billings, 2005; Tyler, Yzquierdo, Lopezo-Reyna, & Flippin, 2004). Tyler et al. (2004) report that, "As recently as 1996, over 40% of the nation's schools had no teachers from underrepresented groups on their faculties" (p. 23).

The Importance of a Diverse Teaching Force

There are several arguments on the importance of increasing the diversity of the teaching force. One perspective is that a culturally diverse and culturally responsive learning community is necessary in order to reduce gaps in achievement among groups from different backgrounds (Darling-Hammond et al., 1996). Other arguments focus on the need and importance of role models and teachers who can relate to students' backgrounds and experiences (Branch, 2001; Loving & Marshall, 1997; Riley, 1998). Teachers from underrepresented ethnic groups can serve as bridges between schools, families, and communities (Ladson-Billings, 2005).

Further, there are pedagogical benefits of a diverse teaching force. Teachers of color may have advantages in successfully building relationships and relating to students from minority groups because of their personal experiences and may be able to use those experiences in their practice to connect with learners (Clewell & Villegas, 1998; Darling-Hammond et al., 1996). In a review of literature, Torres et al. (2004) found that there were a limited number of large-scale studies on the relationship between same-race teachers and minority (compared with general) student achievement. Results presented in the available literature indicate mixed evidence of a direct correlation between teacher diversity and student academic performance.

Barriers to Increasing Teacher Diversity

The stages along the path to America's mathematics and science teaching force are often referred to as the teacher "pipeline." Stages in the teacher pipeline include high school graduation, matriculation to an institution of higher education (IHE), achievement of a college degree, fulfillment of teacher certification requirements, and induction into teaching (Torres et al., 2004). Individuals interested in pursuing mathematics and science teaching careers can do so at any of these stages. Alternative certification programs allow individuals with college degrees to be inducted into teaching by working to fulfill teacher certification requirements. Professional development courses allow current teachers to fulfill certification requirements that qualify them to teach mathematics and science without having to be re-inducted into teaching. However, there are barriers that impact the diversity of the teaching force at all of these stages.

The available research on barriers to increasing teacher diversity shows several areas of the pipeline where there are gaps. Some of these gaps include too few minority students prepared for post-secondary education as a result of inadequate K-12 education (Gordon, 2005); limited career counseling provided to minority students (Quiocho & Rios, 2000); and financial and economic considerations (Clewell & Villegas, 1998). Another barrier cited is competency testing (either as part of the requirements for a teacher education program or for licensure) for which research indicates higher failure rates for minority students than for White students (Bennett, McWhorter, & Kuykendall, 2006; Darling-Hammond et al., 1996; Kirby et al., 1999; Latham, Gitomer & Zimonek, 1999). As a result of these and other barriers, smaller numbers of minority students enroll in and complete teacher education programs.

Barriers occur at other stages in the teacher pipeline as well. Once teachers are admitted to teacher education programs, they must complete certification requirements and accept a teaching position to impact the teaching force. Minority students who enroll in college are vulnerable to attrition (Nuby & Doebler, 2000; Tyler et al. 2004). Students of color often feel marginalized and socially isolated at majority white institutions, and are taught a curriculum that is not culturally relevant (Quiocho & Rios, 2000; Tyler et al., 2004; Villegas & Lucas, 2004). Villegas and Lucas (2004) report that multicultural education courses generally offer little in the way of preparing minorities to use their strengths in the classroom, focusing instead on “strategies for helping White preservice teachers to see student diversity as a positive situation” (p. 90).

Teacher turnover is an additional barrier to diversity efforts. The attrition rate is greater for minority inservice teachers than for White teachers (Villegas & Lucas, 2004). One possible reason is that minority teachers are more likely to be placed in low-performing, high-poverty urban schools. In addition to the challenges associated with teaching in urban schools, teachers in these schools receive less support and have less autonomy. Minority teachers also experience unpleasant conditions in non-urban schools with a shortage of minority teachers, such as isolation and increased scrutiny (Mabokela & Madsen, 2003; Quiocho & Rios, 2000).

Methods and Strategies for Improving Teacher Diversity

While there are barriers to increasing the diversity of the mathematics and science teaching force, research has shown several strategies that can be effective in overcoming these obstacles. These strategies focus on targeting efforts for minority groups and focusing on gaps in the teacher pipeline, and include: a) targeting high-minority populations for inclusion, b) recruiting, c) supporting licensure, d) induction into teaching, and e) retention of diverse teachers.

Targeting high-minority populations for inclusion. One of the first methods for increasing the diversity of the mathematics and science teaching force is identifying diverse individuals for inclusion at various stages along the teacher pipeline, including recruiting, licensure, induction and retention. Middle and high schools with high-minority populations must be engaged in rigorous academic activity that prepares students for college matriculation, and tutoring opportunities that expose students to careers in teaching. The nation’s colleges and universities play an important role at the stage of recruiting and licensure. Enhancing teacher education programs at minority serving institutions, such as historically black colleges and universities, and providing additional resources for recruiting diverse students through minority organizations on majority White campuses can be an effective means of reaching additional students of color. Accomplishing the goal of diversifying the mathematics and science teaching force requires coordinated, systematic, and comprehensive efforts and resources aimed at high-minority populations.

Recruiting. One recommended strategy is recruiting activities at various stages along the teacher pipeline. Recruiting strategies might include targeting students in middle school and high school, exposing college students to careers in education, and recruiting adult career changers. Early identification programs expose qualified high school or middle school students to teaching through cadet or tutoring programs. These efforts raise awareness of and interest in teaching as a profession and support and encourage students to prepare for and enter the profession (Loving & Marshall, 1997; Newby et al., 2000). Research shows that college students are inspired by their work as tutors, and that opportunities to tutor high school or fellow college students often sparks their interest in teaching (Quiocho & Rios, 2000). Programs designed to recruit paraprofessionals to become teachers have also been found to play a role in diversifying the teaching force (Haselkorn & Fideler, 1996). There is evidence that these programs have higher retention rates than many traditional teacher education programs (Dandy, 1998; Haselkorn & Fideler, 1996).

Supporting licensure. The research reveals three types of support that are successful for retaining minorities during the licensure process in teacher certification programs: academic, financial, and social. Academic support is necessary to overcome obstacles created by ineffective K-12 education and testing requirements, both of which negatively impact minority teacher candidates disproportionately (Bennett et al., 2006; Quiocho & Rios, 2000). Academic support takes the form of tutoring for coursework and/or in preparation for teacher-certification tests. Providing financial assistance, including grants and scholarships, is another strategy considered essential for supporting minorities in teacher education programs (Quiocho & Rios, 2000; Tyler et al., 2004). Minority preservice teachers, particularly those enrolled in predominantly white institutions, also cite interpersonal support in the form of mentoring or cohort structures as an important component of effective teacher education programs (Holloway, 2002; Nuby & Doebler, 2000; Torres et al., 2004; Tyler et al., 2004). Delpit (2006) notes that minority teachers who have negative experiences in their preservice education, may choose not to enter teaching, despite being certified. These individuals equate the lack of academic and social support with the field of education and decide not to become a member of the teaching profession.

An additional form of support during licensure is through alternative certification programs which allow candidates to enter the teaching profession by alternative means. Although there is evidence that alternative certification programs serve as a source for recruiting minority teachers (Kirby et al., 1999; Shen, 1998), conclusions are mixed. Findings indicate that alternatively certified teachers are more likely to be female and teaching in elementary schools and express less desire to continue teaching in the long term (Shen, 1998). Therefore, while alternative certification might contribute to diversity in terms of race and ethnicity, it does not in terms of gender (Shen, 1998). While alternatively certified teachers are more likely to teach mathematics and science, alternatively certified minority teachers are less likely to hold a bachelor's degree in mathematics, science, or engineering than alternatively certified White teachers (Shen, 1998).

Induction into teaching. A variety of methods of induction have been instituted to support the transition into the beginning years of teaching. A successful strategy employed during the induction phase is mentoring (Holloway, 2002). Souto-Manning and Dice (2007) describe a mentoring initiative in which two university professors partnered with a Latina first-year elementary school teacher to conduct action research and develop reflective teaching for all three. Souto-Manning and Dice described the partnership as invaluable to the Latina teacher because the teacher reported that her team members helped her to integrate her intuitive respect for diversity with state and national standards to meet the needs of her students. Souto-Manning and Dice reported that oftentimes minority teachers are not taught how to use their strengths in teaching and may become frustrated or give in to pressures to conform to non-minority cultural norms and expectations.

Retention of diverse teachers. One way for educators and policymakers to support the diversification of the mathematics and science teaching force is to recognize the importance of retaining inservice teachers of color. Research has shown over time that about 15% of America's three million teachers leave their schools or leave teaching each year, and by the end of five years of teaching, 46% of teachers leave the teaching profession (Ingersoll, 2006a, 2006b). According to Grant and Gillette (2006), the percentage of the teaching force that leaves the profession is greater than that of any other professional workforce. Schools searching for mathematics and science teachers already know how difficult it is to find replacements, with turnover rates for mathematics and science teachers at about 16% and 15%, respectively, compared to 9% for social studies and 12% for English (Ingersoll, 2006b).

A closer examination of mathematics and science teacher turnover shows reasons for leaving teaching include pursuing other jobs (28%) and retiring (11%). While 40% of mathematics and science teachers leave teaching because of dissatisfaction, only 29% of all teachers leave because of dissatisfaction. For mathematics and science teachers, dissatisfaction frequently includes poor salary, poor administrative support, poor student motivation, and student discipline problems (Elfers, Plecki, & Knapp, 2006; Ingersoll, 2006a).

> Personal reasons, such as departures for pregnancy, child rearing, health problems and family moves are far more often given as reasons for turnover than are either retirement or staffing actions (38 percent for all teachers and 44 percent for mathematics/science). (Ingersoll, 2006b, p.204)

Therefore, retention strategies for mathematics and science teachers must include efforts to improve conditions such as school climate, professional growth opportunities, and access to resources. Research shows that minority teachers are more likely to remain in schools that demonstrate respect for diversity (Jorgenson, 2001).

Summary of the Issue

Educators agree that there is a need to increase the diversity of the nation's mathematics and science teaching force, and that targeted strategies can be effective in addressing this need. The causes of low numbers of minority mathematics and science teachers include substandard K-12 preparation for minority populations, low minority enrollment in teacher credentialing programs, barriers to certification of minority preservice teachers, minorities' decision not to join the teaching force after achieving certification, and attrition of novice and mid-career minority teachers. Studies reveal that minorities are more likely to pursue teaching career tracks, join the teaching force, and remain in the classroom when strategies aimed at minorities demonstrate that diversity is valued.

In the present analysis, we anticipated that a variety of efforts were being undertaken by the NSF partnerships to increase teacher diversity. This assumption was based on Moyer-Packenham, Bolyard, Oh, Kridler, and Salkind's (2006) finding that about half of the partnerships in the program reported *increasing teacher diversity* as a goal, and identified *recruiting* minority teachers and implementing *social support structures* for minority teachers as elements in their partnership activities. We were particularly interested in efforts to bring about changes in numbers of minority teacher participants in the partnerships, with the goal that identifying these effective efforts might be useful on a larger scale.

The following research questions guided this analysis: a) What strategies are being implemented by the partnerships to influence teacher diversity? b) How are diversity strategies implemented within partnerships in terms of length of time, number of strategies, and comprehensiveness? c) How is teacher diversity among the partnerships changing from year to year? d) Does the number of strategies employed vary by baseline teacher demographics (high-minority, low-minority)? e) Are partnerships offering the resources of the MSP Program to schools and/or districts with high-minority populations? f) Are the changes in teacher diversity obscured by reporting trends? and g) Are changes in teacher diversity related to strategies being implemented to influence those changes?

Methods

The present evaluation used qualitative and quantitative methods to examine archival data on teacher diversity from the National Science Foundation's Math and Science Partnership (NSF MSP) Program. Qualitative and quantitative data were gathered from 48 NSF MSP partnerships. The qualitative data were obtained from secondary sources and included Annual and Evaluation Reports prepared by representatives of the partnerships. The quantitative data were extracted from archival information gathered in the NSF Management Information System (MIS). MIS surveys requested that the Project Investigator (PI) (or a representative) submit specific demographic information on all teacher participants in the MSP project activities.

Qualitative Measures

The qualitative data were the partnerships' Annual and Evaluation Reports submitted to the NSF in the form of written narratives and prepared by the Project Investigator or another representative of the MSP. Because the partnerships were in the midst of five-year awards during our analyses, they had submitted one, two, or three reports. Therefore, the number of documents available from each partnership varied. Researchers analyzed a total of 90 reports written by the 48 partnerships, with the partnership as the unit of analysis. The analytic method used with the qualitative data was a document analysis of secondary sources (Miles & Huberman, 1994; Patton, 2002). Because of the complex nature of the reports, the research team used hand coding (rather than electronic software) to better preserve the context and content of the information contained in the reports. These data sources were used to identify diversity strategies used by the partnerships.

During the first phase of the analysis, researchers reviewed the written reports of the 48 partnerships for information on teacher diversity. The written reports provided a variety of descriptions of teacher diversity which were the impetus for designing a framework to categorize actionable strategies used by partnerships. During the second phase of the analysis, researchers reread the documents with a specific focus on identifying partnerships that described *actionable* strategies. This phase was guided by the question: What are the strategies that directly describe an *action* being taken by the partnership to influence teacher diversity? This targeted reading resulted in the identification of a framework of major categories of actionable strategies. Subsequent readings winnowed out rhetoric that went beyond the mere description of teacher diversity strategies to the identification of specific actions being carried out by the partnerships.

After determining the major categories of diversity strategies in use among the partnerships, we further determined three dimensions of strategy implementation to identify *high intensity partnerships*. The first dimension was the *length of time* that the strategies were implemented within the partnership. This was determined by identifying the number of years in which diversity strategies were employed. The second dimension was the *number of strategies* that were used over the course of the entire partnership. In some cases, this included the use of multiple strategies within the same year. The third dimension was the *comprehensiveness of the strategies,* defined as strategies that focused on various stages along the teacher pipeline. To provide illustrative insights into the partnerships' work, we used the following selection criteria to identify one exemplary partnership to profile: a) the partnership's demographic data showed an increase in teacher diversity, b) it was a high intensity partnership, and c) it was a high-minority population partnership, in terms of its participating teachers.

Quantitative Measures

The quantitative data were excel files in numerical form extracted from survey items reported in the NSF MIS. Thirty-four partnerships completed the first round of MIS surveys (this MIS administration was referred to as Wave I) and 48 partnerships completed the second round (this MIS administration was referred to as Wave II). Wave II data included the original 34 partnerships and an additional 14 partnerships from subsequent awards in the MSP Program.

We utilized data from three items in two MIS survey tools: *Annual K-12 District Survey for Comprehensive and Targeted MSPs* (for data on inservice teachers) and

Annual Institution of Higher Education (IHE) Survey (for data on preservice teachers). The first inservice teacher item reported demographic information on the *total number of teachers* in participating schools during the given school year, and the second item reported demographic information on the *participating teachers* that actively participated in the MSP during the given school year. Survey items did not request cumulative information on teachers, but rather the items asked partnerships to report teacher information for the given year only. The MIS definition for "participating teachers" was defined on the MIS tool as: "Those teachers who have participated in 30 or more hours of MSP-sponsored activities during a given school year" (Silverstein, Bell, Frechtling, & Miyaoka, 2005, p. 11). The preservice teacher survey item reported demographic information on the participants in each preservice university course or seminar offered during a given school year. Quantitative data were used to identify changes in the diversity of teachers in each partnership.

In the first quantitative analysis, we identified partnerships with teacher demographic data from both administrations of the MIS tools (Wave I and Wave II) to examine changes in teacher diversity between the two administrations. There were 34 partnerships providing data for the Wave I and Wave II administrations. Using these 34 partnerships, the first metric examined the *representation of minority groups* among teachers participating in the partnerships. High representation was defined as minority teachers composing 25% or greater of the participating teachers in the partnership, based on the U.S. population in general, and based on current teacher population demographics (U.S. Census Bureau, 2005). We compiled district demographic data for participating districts and participant demographic data for partnerships. Therefore, we were able to compare the representation of minorities among teachers *eligible* to participate in MSP activities and the representation of minorities among actual MSP participants.

The second metric examined *changes in teacher diversity*. Changes were defined as increases or decreases in the proportion of minority teachers participating in partnership activities, whether it was individual teacher or school participation that influenced those changes. Because of the limitations in the reported data, demographic data were compiled and analyzed in three categories – minority (Nonwhite and individuals of more than one race), White, and race not reported. The number of teachers in each category was computed as a proportion of all participants. This analysis was conducted at the partnership level. After examining changes in teacher diversity, we examined the relationship of strategy implementation with those changes by comparing partnerships that implemented strategies with those partnerships that did not implement strategies.

Results

The results that follow are presented in three major sections. The first section provides descriptive information on categories of diversity strategies implemented by the partnerships and highlights high intensity partnerships. The second section presents statistical and numerical changes in diversity in the MSP Program overall. The third section examines relationships between strategy implementation and changes in the diversity of participating teachers.

Categories of Teacher Diversity Strategies

The first research question asked: What strategies are being implemented by the partnerships to influence teacher diversity? Of the original 48 partnerships, 42 wrote about teacher diversity, but only 21 provided descriptive information on actionable diversity strategies in use by the partnerships. The others included general statements such as, "teacher diversity is one of the project's key features" or "increasing diversity is an important goal." Among the 21 partnerships we identified the following five main categories of diversity strategies in their order of frequency: a) recruitment, b) supporting licensure, c) induction into teaching, d) retention of diverse teachers, and e) targeting high-minority populations for inclusion. These categories, with actionable strategies and specific examples, are presented in Table 1 and described below.

Recruitment. The most common category of strategies was recruitment. This category focused on recruiting diverse high school or college students and partnering with existing organizations. Partnerships included minority faculty as members of the recruiting teams to help recruit minority students. Other recruitment practices included collaborating with staff at community colleges, creating tutoring positions that could be used as a recruiting tool for minority STEM majors to pique their interest in mathematics and science teaching careers, exposing high school and college students to careers in teaching, and designing recruitment materials to target diverse populations.

Supporting licensure. The second most common category of strategies was supporting licensure aimed at individuals already enrolled in teacher education programs. Strategies in this category were designed to help preservice teachers overcome academic or financial obstacles often reported in research as hindering the certification of diverse teaching candidates (Clewell & Villegas, 1998; Darling-Hammond et al., 1996; Kirby et al., 1999; Latham et al., 1999; Torres et al., 2004). Partnerships provided tutoring, either in coursework or as preparation for certification exams. They created support networks for preservice teachers by partnering students with mentors or placing students in cohorts. Partnerships also designed financial supports that assisted with obtaining financial aid for college or offered scholarships to students of color.

Induction into teaching. A third category of strategies supported minority teachers during their first years of induction into teaching. One strategy employed was to provide mentors to new minority mathematics and science teachers. One partnership reported an effort to train minorities and women as mentors and coaches in mathematics to support minority inductees. One partnership reported, "It is not clear that an eye towards increased diversity within the scholarship program and a mentoring program

Table 1
Categories of Diversity Strategies Implemented by Partnerships

Categories	*General Strategies*	*Specific Examples*
Recruiting	Target community college students	Align university curriculum and local community college curriculum; Recruit from area community colleges; Collaborate with staff at community colleges
	Partner with minority organizations and/or minority leaders	Partner with minority student STEM organizations; Include minority faculty members; Partner with existing minority-teacher recruitment programs
	Target high school and middle school students	Connect with area high school guidance counselors; Partner with high school future teacher organizations; Expose high school students to teaching careers
	Expose college students to careers in teaching	Send college students to diverse public schools to spark interest in teaching; Use high performing and diverse STEM students as college level tutors; Sponsor/develop workshops or conferences on teaching
	Design recruitment materials for underrepresented minorities	Create recruitment brochures with pictures of diverse future teachers
Supporting Licensure	Individualize education program for participating students	Pair education students with mentors; Train faculty on how to motivate and support students; Solicit feedback from minority student participants
	Provide social support structures	Place student interns together in cohorts at cluster schools; Establish (future) teacher support groups at high minority colleges and universities
	Provide academic support	Tutor students in math; Prepare students for certification exams, i.e. PRAXIS, CBEST
	Provide financial aid	Establish minority scholarship funds; Offer scholarships or tuition waivers; Assist minorities in applying for financial aid
	Provide positive experiences for pre-service teachers	Place pre-service teachers in schools that will likely have openings; Employ teacher leaders as mentors/coaches for practicum students and student teachers

Table 1 (continued)

Categories	*General Strategies*	*Specific Examples*
Induction	Provide high quality mentoring to new teachers	Train teachers as mentors
	Provide minority role models to serve as mentors, coaches	Train minorities and women who can provide support to minority inductees
Retention	Provide support for K-12 teachers	Use STEM students as teacher assistants
	Create opportunities for teachers to advance	Train minority teachers to be mentors/coaches/ teacher leaders; Link to or create continuing education/graduate programs in the area
Inclusion of High Minority Populations	Provide professional development to urban schools/districts Provide professional development to high minority schools/ districts Partner high-risk and low-risk schools together	

for induction teachers will yield significant results in these areas." This quote shows that, although partnerships were aware of strategies described in the teacher diversity research literature, it was still a challenge for them to implement these strategies effectively.

Retention of diverse teachers. A fourth category of strategies focused on retaining veteran mathematics and science teachers from diverse racial and ethnic groups. One strategy employed was to create pathways for teachers' professional growth. Two of these pathways included opportunities to obtain advanced degrees in mathematics and/or science education and training to become a teacher leader. Teacher leadership provided opportunities for diverse teachers to interact with other leaders at the district, state or national levels. Teacher leaders also received support from college STEM students volunteering in their classrooms. By creating professional growth opportunities, offering professional development in mathematics and science, and providing other benefits associated with participation in an MSP, partnerships improved working conditions in schools and districts as recommended in the teacher diversity literature.

Targeting high-minority populations for inclusion. The final category of strategies included actions for targeting high minority teacher populations in high minority schools/districts. Some partnerships recruited high minority schools and/or districts to be involved in their activities. This was an actionable strategy that included additional minority teachers in MSP activities and gave minority teachers access to MSP resources. Some demographic changes within partnerships were influenced by adding high minority schools to the partnership. When the schools added to the partnership included high minority student populations, their inclusion often increased the diversity of the mathematics and science teachers. This was true because schools with high minority student populations often had a more diverse teaching force than schools with low minority enrollment. This strategy was linked to minority teacher retention because the introduction of MSP resources into high minority school settings had the potential to increase job satisfaction by improving access to resources and opportunities for teachers' professional growth in underserved schools.

High Intensity Partnerships

The second research question asked: How are diversity strategies implemented within partnerships in terms of length of time, number of strategies, and comprehensiveness? In terms of the *length of time* that partnerships had implemented diversity strategies, there was no conclusive evidence from the reports on the length of the implementation of various strategies. For example, when partnerships indicated a diversity strategy in two separate reports (e.g., Year 1 and Year 2), researchers could not determine if the strategy was ongoing across the two years, or if the strategy was planned in the first year and implemented in the second year.

In terms of the *number of strategies*, the 21 partnerships that provided descriptive information on actionable diversity strategies implemented an average of about three strategies per partnership, with a range from one to seven strategies. (See Figure 1.) Five partnerships addressed diversity using only one strategy, while 16 implemented multiple strategies. The six partnerships that implemented four to seven strategies were viewed as high intensity partnerships because they employed multiple strategies to impact teacher diversity. For example, some partnerships employed a collection of recruitment strategies aimed at community college students, high school students, and university students not currently enrolled in teacher education programs to increase the scope and intensity of their recruitment efforts. Other partnerships coordinated strategies for minority students enrolled in licensure programs to provide a combination of academic, financial, and social supports. These partnerships supported minority students enrolled in teacher education programs by creating support groups or cohorts for students, providing financial aid at the university, pairing minority students with mentors, and offering tutoring services to support students' performance in licensure courses.

In terms of the *comprehensiveness of the strategies*, partnerships provided support structures for minority teachers at various stages along the teacher pipeline from high school, through teacher training, and into the teaching profession. The most common category implemented by partnerships was recruitment for candidates not yet enrolled in a licensure program. In addition to recruitment strategies, some partnerships employed additional induction strategies, acknowledging that recruiting diverse candidates into teacher certification programs does not ensure that these candidates enter the teaching force. Other partnerships implemented recruitment strategies along with strategies to support candidates while they were enrolled in teacher education programs and seeking licensure. A few partnerships worked to improve the retention

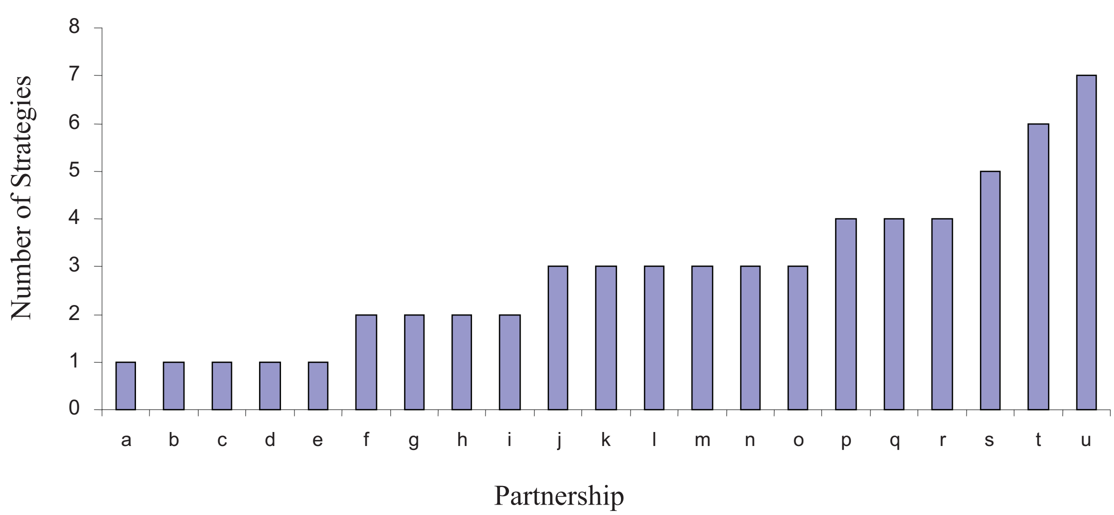

Figure 1. Range and distribution of diversity strategies by partnership.

of inservice teachers along with their recruitment activities. Additional partnerships targeted teachers in urban and high minority school districts for professional development. One partnership coordinated their efforts by supporting candidates enrolled in a certification program, beginning teachers through induction, and inservice teachers through professional development. These examples demonstrate coordinated implementation plans to address critical points along the teacher pipeline for minority candidates.

One Exemplary Partnership

One of the partnerships was notable among the others along several dimensions. First, the partnership made increasing teacher diversity a clear priority, and it showed a statistically significant increase in the diversity of its teachers. This partnership demonstrated how to "be purposeful and deliberate in how they increase diversity" (Torres et al., 2004, p. 18). It was one of the few partnerships that reported diversity data in its annual reports, in addition to providing this information for the MIS. It analyzed changes in the demographics of teacher candidates: "Particularly notable is the 111% increase in Chicano/Latino/Latino American participation for Year 2 (up to 19 in Year 2 from 9 in Year 1) and the 65% increase in the number of female participants (up to 43 in Year 2 from 26 in Year 1)" (Year 2 Annual Report). Tracking these data allowed the partnership to examine the effects of its strategies on increasing teacher diversity. The partnership began with large minority representation and increased this representation over time.

This partnership employed multiple strategies to address diversity comprehensively. For example, it partnered with local community colleges and STEM departments to recruit future teachers, sought a grant to provide scholarships to students, and offered teacher certification test preparation workshops. The partnership sought alternative means of supporting preservice teachers: "…With significant support from [MSP] PI's, [a] director worked closely with other campus units to get approval for a proposed Careers in Teaching Theme House for undergraduates, …with dorm space for 24 future teachers" (Year 3 Annual Report). While this campus housing may not have been approved specifically for minority students, teacher diversity research identifies cohort models as beneficial to minorities, in particular, crediting their success as a result of close professional relationships with mentors and cohort members (Torres et al., 2004). There were also workshops for English Language Learners and assistance in preparing scholarship applications. These services were not limited to minority preservice teachers in the partnership, but addressed obstacles that have been reported to disproportionately hinder minorities from entering the teaching profession (Darling-Hammond et al., 1996; Torres et al., 2004).

The partnership demonstrated awareness of potential obstacles to increasing diversity and worked towards overcoming those obstacles. For example, in one report they described the challenge of recruiting minority students into mathematics and science teacher education. "It continues to be a challenge to recruit underrepresented students into the [teacher pipeline] at [the University] due to relatively low numbers of Latino and African American students on campus in general. In Year 2, direct action was taken to recruit underrepresented students such as recruiting through campus cultural and political organizations" (Year 2 Annual Report). The partnership's actionable strategies for addressing challenges demonstrated a commitment to increasing the diversity of its teachers.

Statistical and Numerical Changes in Teacher Diversity

The next set of research questions focused on a statistical examination of the MIS data on teacher diversity. This analysis was separate and distinct from our analysis of strategy implementation. Of the 34 partnerships involved in the Wave I and II administration of the MIS tools, 24 partnerships reported usable data on teacher demographics in both waves. These 24 partnerships, representing 50% of the original 48 partnerships in the MSP Program, were the subjects of our statistical analysis.

Changes in teacher diversity. Research question three focused on identifying changes in teacher diversity from year to year. This analysis included 24 partnerships that reported data on teacher demographics for Wave I and II of the MIS. We compared the proportion of participating minority teachers with the number of eligible teacher participants in schools. The proportions analysis revealed that there were no significant differences in teacher diversity for the overall program; however, there were significant differences in minority teacher participation between Waves I and II in seven partnerships, $p < .05$. In three of the partnerships, minority teacher participation increased significantly; in four partnerships, minority teacher participation decreased significantly. Of the three partnerships with increases, one implemented teacher diversity strategies. Of the four that decreased significantly, none implemented actionable strategies to influence teacher diversity.

Large minority populations and strategy implementation. Our fourth research question asked whether the number of strategies employed varied according to the baseline teacher demographics of the partnerships. We considered whether partnerships with high percentages of minority teacher participants tended to implement more actionable strategies to increase diversity. To establish guidelines for determining "large minority populations," we used demographic data from the U.S. Census Bureau's 2005 American Community Survey (U.S. Census Bureau, 2005). According to the Census data, Nonwhites make up 25.3 percent of the U.S. population. Therefore we defined "large percentages of minority teacher populations" to be above 25 percent of the total population of teacher participants. Of the 24 partnerships, seven reported minority representation to be above 25 percent in both Waves I and II. For example, one partnership reported that 44.7 percent of its teacher participants were Nonwhites, with the largest racial group being African Americans; while another partnership reported minority participation to be at 51.6 percent, with Latinos as the largest ethnic minority group in this partnership. Of the seven partnerships with large minority populations, four reported implementing diversity strategies (57.1%). Of the 17 partnerships *without* large minority populations, only three partnerships implemented diversity strategies (17.6%).

Representation of minority teachers in participating districts. Our fifth research question was: Are partnerships offering the resources of the MSP Program to schools and/or districts with high-minority populations? To examine whether partnerships were including districts with more diverse teacher populations, we again examined demographic data from the 24 partnerships that reported in both Waves I and II. We compared the percentage of minority teachers in the *districts served by* the partnerships, the percentage of teachers in the district who participated in partnership activities, and the percentage of *minority teachers in the district* who participated in partnership activities. The purpose of this examination was to make comparisons between district demographics in Waves I and II and rates of participation for minority and non-minority teachers. In 12 of the 24 partnerships, the percentage of minority teachers in participating districts increased. However, overall, the percentage of minorities in the participating districts decreased between Wave I and Wave II. In Wave I, there were 13,240 teachers in the districts targeted by the 24 partnerships. Minority teachers represented 33.6% of this teacher pool. In Wave II, there were 17,350 teachers in the 24 partnerships. The population of minority teachers decreased to 26.9% of the teacher pool. While the total number of teachers in the participating districts increased, the percent of minority teachers in the districts decreased. This indicates that more teachers and schools, in general, were involved in MSP-supported activities, but that those teachers and schools had smaller proportions of minority teachers during Wave II.

Given the low numbers of minorities in the teaching force in general, minority teachers must participate in mathematics and science activities at higher rates than Whites for diversity to increase among mathematics and science educators. During Wave I, while an average of 43.4 percent of all teachers and 39.7 percent of eligible White teachers in the targeted districts took part in partnership activities, an average of 50.6 percent of the *eligible minority teachers* in those districts participated. Similarly, in Wave II, the average percentage of teachers in targeted districts who participated in partnership activities was 33.7 percent for all teachers and 30.1 percent for White teachers, while it was 43.4 percent for the eligible minority teachers in the districts. Therefore, in both Waves I and II, a larger portion of the eligible minority teachers participated in partnership activities than the eligible White teachers, indicating that eligible minority teachers in these 24 partnerships are participating at higher proportions than eligible White teachers.

Our sixth research question asked if the changes in teacher diversity were obscured by reporting trends. One limitation of the available data was large increases in numbers of teachers *not reporting* their race or ethnicity in Wave II. Variance in the results, in terms of percentages of minority and White participants, is due, in part, to changes in the percentage of participants for whom race was not reported. We analyzed the incidence of this reporting trend by computing the proportion of participating teachers whose race was not reported to determine if there were significant differences between Wave I and Wave II. When the proportions were compared and confidence intervals were computed using SPSS software, changes in the proportion of teachers for whom race was *not reported* was present between Waves for 12 of the 24 partnerships, with 8 partnerships showing significant increases in not reporting and 4 partnerships showing significant decreases in not reporting. For example, in two partnerships, the percentages of participants *not reporting* their race jumped from 8.7% to 100% and from 0% to 95.1%. The majority of partnerships in which the incidence of not reporting race increased were partnerships where no diversity strategies were implemented. The two partnerships that implemented the most strategies (six and seven strategies) significantly decreased their *not reported* category, and thereby increased the number of teacher participants for whom race *was* reported.

Differences between Strategy Implementation and Changes in Teacher Diversity

The final research question assessed any differences between the two Waves and the absence or presence of actionable diversity strategies. To conduct this analysis, we compared partnerships with actionable strategies to those without actionable strategies among the 24 partnerships that reported demographic data in both Wave I and II of the MIS. Among the 24 partnerships, there were seven with actionable diversity strategies (determined from the qualitative reports) and 17 without actionable strategies. We examined whether changes in teacher diversity were related to the implementation of diversity strategies (absence or presence) and different years of implementation (Wave I vs. Wave II). Specifically, we performed a 2x2 factorial ANOVA where factor 1 was Wave (which indicates Years 1 and 2 of the data collected from the partnership) which had two levels (Wave I and II). The second factor was strategy implementation which also had two levels (actionable versus non-actionable strategies). The dependent variable was the number of minorities who participated in the study. Therefore, the number of minorities was treated as a continuous variable. It was found that there was no main effect for strategy $F(1, 44) = 0.65$, $p = .43$, Wave $F(1, 44) = 0.01$, $p = .94$, or interaction, $F(1, 44) = 0.22$, $p = .64$. The means show that in Wave I there were 122 minority participants in partnerships without actionable strategies and 26 minority participants in partnerships with actionable strategies. In Wave II, there were 92 minority participants in partnerships without actionable strategies and 67 minority participants in partnerships with actionable strategies. This indicates that there was a numeric increase in the number of minority participants in partnerships that implemented strategies; however, there was not a statistical main effect for strategy implementation.

Although no statistically significant relationship was found due to the small sample size, we chose to examine the subset of seven partnerships more closely because they were essentially the only partnerships with a comprehensive set of data on teacher diversity. A detailed examination of the strategies implemented by these seven partnerships is presented in Table 2. Five of the seven partnerships fit our definition of "high intensity partnerships" because they implemented four or more actionable strategies. The demographic data from these seven partnerships are presented in Table 3. As this table shows, the overall number and proportion of minority teachers increased for these partnerships. One of these partnerships was one of the three partnerships previously reported to show a statistically significant increase in minority teacher participation. In these seven partnerships where actionable strategies were implemented, the *number* of minority teachers increased in five of seven partnerships, and the *proportion* of minority teachers increased in four of seven partnerships (71 percent and 57 percent, respectively). In comparison, for the 17 partnerships reporting demographic data in both Wave I and II with no actionable strategies, the *number* of minority teachers increased in 5 of 17 partnerships, and the *proportion* of minority teachers increased in 6 of 17 partnerships (29 percent and 35 percent, respectively). Though not statistically significant, these findings provide early evidence of the potential for relationships to be revealed with further longitudinal study.

Limitations

Due to large proportions of missing MIS data and incomplete descriptive information, our findings are limited. Both the quantitative and qualitative data were self-reported and there was no system to determine whether or not these data were complete and reliable. In some instances, MIS information did not add up and data disaggregated by gender did not match data disaggregated by race and ethnicity. For example, one project reported that 19 Native American teachers from one school district participated in MSP activities. Yet, the same school district reported having no Native American teachers. Other data were incomplete for all years the partnership received NSF funding, and there were great fluctuations in participant numbers. To address these limitations, we analyzed the program overall and individual partnerships in an attempt to provide the reader with several views of the data that were available.

In addition to missing data, the data were also limited in their scope. For example, the definition for "participating teachers" included only "Those teachers who have participated in 30 or more hours of MSP-sponsored activities during a given school year" (Silverstein et al., 2005, p. 11). This definition of participating teachers could have significantly impacted the reporting of all teacher participants. The available data reported only inservice teacher demographics and omitted preservice teachers. The data available for preservice teachers reported only on course enrollment, and information for large portions of the preservice teacher population was missing; therefore, we determined that these data were unreliable. Other investigators who have analyzed this data set have reported that gender was not reported for thirty-two percent of the preservice teachers and race/ethnicity was not reported for thirty-seven percent

Table 2
Actionable Strategies Implemented in Seven Partnerships with Demographic Data

MSP	*Category of Strategies*	*Actionable Strategies Implemented*
A	Recruitment	Target community college students
	Recruitment	Target high school students
	Recruitment	Partner with minority organizations and/or minority leaders
	Recruitment	Expose college students to careers in teaching
	Preservice – Supporting Licensure	Diminish academic obstacles
	Preservice – Supporting Licensure	Provide financial aid
	Inclusion of High Minority Populations	Provide professional development to schools/ districts with high minority student populations
B	Recruitment	Target community college students
	Recruitment	Target high school students
	Recruitment	Expose college students to careers in teaching
	Preservice – Supporting Licensure	Individualize education program for participating students
	Preservice – Supporting Licensure	Diminish academic obstacles
	Retention	Create opportunities for teachers to advance
C	Recruitment	Target high school students
	Recruitment	Partner with minority organizations and/or minority leaders
	Preservice – Supporting Licensure	Provide financial aid
	Induction	Increase positive experiences during induction

Table 2 (continued)

MSP	*Category of Strategies*	*Actionable Strategies Implemented*
D	Recruitment	Target community college students
	Preservice – Supporting Licensure	Individualize education program for participating students
	Preservice – Supporting Licensure	Create support groups/cohorts
	Preservice – Supporting Licensure	Provide financial aid
E	Recruitment	Expose college students to careers in teaching
	Recruitment	Send diverse STEM students into K-12 classrooms as teacher assistants
	Inclusion of High Minority Populations	Provide professional development to urban schools/districts
	Inclusion of High Minority Populations	Provide professional development to schools/districts with high minority student populations
F	Recruitment	Target high school students
	Recruitment	Tailor recruitment efforts to underrepresented students
G	Preservice – Supporting Licensure	Create support groups/cohorts
	Preservice – Supporting Licensure	Provide financial aid

(Silverstein et al., 2005). Therefore, it was not possible to track changes in diversity among preservice teachers with any certainty.

Discussion

This investigation examined the efforts of partnerships in the NSF MSP Program to increase the diversity of mathematics and science teachers in their partnership activities. Here we discuss the strategies implemented by the partnerships, changes in the diversity of mathematics and science teachers in the partnerships, and the implications of these findings for increasing the diversity of mathematics and science teachers in the U.S. population.

Table 3
Demographic Data in Seven Partnerships with Actionable Strategies

MSP	Total Participants		Minority				White/Caucasian				Not Reported				Number of strategies implemented
	WI	WII	WI		WII		WI		WII		WI		WII		
	N	*N*	*N*	(%)	*N*	(%)	*N*	(%)	*N*	(%)	*N*	(%)	*N*	(%)	
I	42	25	12	(28.6)	7	(28.0)	30	(71.4)	18	(72.0)	0	(0.0)	0	(0.0)	4
II	3	35	0	(0.0)	9	(25.8)	3	(100.0)	26	(74.3)	0	(0.0)	0	(0.0)	4
III	76	342	34	(44.7)	215	(62.9)	8	(10.5)	72	(21.1)	34	(44.7)	55	(16.1)	7
IV	97	53	38	(39.2)	15	(28.3)	59	(60.8)	37	(69.8)	0	(0.0)	1	(1.9)	2
V	293	545	69	(23.5)	136	(24.9)	211	(72.0)	360	(66.1)	13	(4.4)	49	(9.0)	2
VI	164	169	6	(03.7)	7	(04.1)	153	(93.3)	147	(87.0)	5	(3.0)	15	(8.9)	4
VII	62	287	20	(32.3)	77	(26.8)	39	(62.9)	209	(72.8)	3	(4.8)	1	(0.3)	6
Total	737	1,456	179	(24.3)	466	(32.0)	503	(68.2)	869	(59.7)	55	(7.5)	121	(8.3)	

Strategies Implemented by the Partnerships

Five categories of strategies were identified in use among these partnerships, with *recruiting* most common among the strategies, followed by supporting licensure. The major focus of recruiting was on high school and college students to draw more minorities into teacher certification programs. A second strategy that was common among the partnerships was support for teacher licensure. Partnerships implemented social and financial supports for teacher licensure students. According to Villegas and Lucas (2004), “Recruitment efforts, although essential, will not result in a more diverse teaching workforce unless issues of preparation and retention receive greater attention” (p. 96). Although recruiting is one effective strategy for increasing teacher diversity, more comprehensive and long term solutions are needed that focus on other parts of the teacher pipeline to have lasting effects. In addition, changes in the diversity of mathematics and science teachers as a result of these partnerships’ recruitment strategies will likely not be noticeable until years after partnerships have completed their funded work. Therefore, it will be challenging to connect these efforts to changes in the diversity of the U.S. teacher population.

Partnerships have the potential to impact diversity all along the teacher pipeline; however, most efforts in these partnerships neglect the induction and retention years of teaching. Because research indicates that lack of support influences minority preservice teachers’ decision not to enter teaching even after obtaining certification (Delpit, 2006), financial, academic, and social supports play an important role in encouraging preservice teachers to complete certification requirements *and* enter teaching. Research on high attrition rates of teachers, particularly minority teachers and new teachers, are cause for concern (Ingersoll, 2006a, 2006b; National Commission on Teaching and America’s Future, 2003). Providing mentoring programs and minority role models for new teachers may help prepare novices to use their diversity as a strength in the classroom (Holloway, 2002). However, few partnerships reported induction strategies and opportunities for professional growth as a way of improving minority teacher retention.

An additional strategy for increasing minority recruitment and retention is the inclusion of high-minority populations to improve access to resources and teacher development opportunities, such as the NSF MSP Program. High minority schools are often underserved, low-performing schools where the attrition rate for teachers is understandably greater. However, as these results showed, the percentage of minority teachers in participating districts decreased over time. When partnerships include high minority schools in their activities, they bring resources and professional development that otherwise might not be available to minority teachers. Adding high minority schools to the partnership increases the likelihood that minority teachers have opportunities to participate in mathematics and science professional development, such as additional certification and leadership training. By providing high minority schools and districts with access to resources and certification in STEM fields, federally-funded programs have the potential to increase the number of minority teachers entering and remaining in the teaching profession.

Results indicated that there were a handful of high intensity partnerships. Some high intensity partnerships used a number of different strategies to target one population in the teacher pipeline; while, others showed comprehensiveness in their strategies, that is, they used strategies to influence different populations along the teacher pipeline. As the exemplary partnership showed, they employed numerous strategies, teacher diversity increased significantly, efforts were coordinated along the teacher pipeline, and they devised innovative methods for influencing change.

Changes in the Diversity of Mathematics and Science Teachers in the Partnerships

Our findings indicate that there were no statistically significant changes in teacher diversity for the overall MSP Program based on these data; however, there were significant changes in seven individual partnerships (with three increasing in diversity and four decreasing). These findings are not surprising, as changing a population characteristic like teacher diversity takes time, and these data were collected over a relatively short time span.

When comparing partnerships with high-minority populations to those where there was not a high-minority population, a larger percentage of the high-minority population partnerships implemented actionable strategies for increasing teacher diversity. This indicates that when there were more minority teachers, actionable strategies were more likely; and when there were fewer minority teachers, actionable strategies for increasing teacher diversity were less likely. Preliminary findings based on the strategies employed by demographics of teacher participants (high-minority, low-minority) warrant further study. These results suggest that partnerships with diverse teacher participants may be more likely to implement actionable strategies for increasing teacher diversity.

The findings revealed that the overall percentage of eligible minority teachers in the participating districts decreased between Wave I and II as schools were added to the partnership activities, indicating that partnerships did not show increases in targeting high-minority populations for inclusion. However, while overall results show a percentage decrease in eligible minority teachers, 12 of the 24 partnerships did increase the percent of eligible minority teachers in their participating districts.

To increase the diversity of the teaching force, minority teachers must participate in recruitment, licensure, induction and retention efforts and enter and stay in teaching at higher rates than White teachers. One result is promising in this regard. In Waves I and II, the eligible minority teachers in the districts participated at higher rates than the eligible White teachers in the districts. This indicates that, although the number and proportion of minority teachers in participating schools did not increase in these partnerships, the eligible minority teachers in the participating schools were involved in MSP activities at higher rates than White teachers.

When we compared partnerships that implemented actionable strategies with partnerships with no actionable strategies, we found no statistical relationships to changes in teacher diversity. However, there were numerical differences in teacher diversity between the partnerships with actionable strategies and those with no actionable strategies. These initial patterns warrant further longitudinal study.

Implications for Increasing the Diversity of the Teacher Population

Are partnerships truly invested in the NSF MSP Program goal of increasing teacher diversity? From this evaluation, it appears that some partnerships are and some are not. Based on these findings, there have been no significant increases in teacher diversity for the program participants, and there is no evidence that partnership activities have yet influenced an increase in the diversity of mathematics and science teachers in the U.S. population. Changing a population characteristic, like teacher diversity, takes time. The impact of current efforts by these partnerships could take many years to come to fruition.

There are several implications of these results for increasing the diversity of the teacher population. More attention and focus needs to be shifted to areas of the pipeline that go beyond simply recruiting more teachers (Ingersoll, 2006a, 2006b). As indicated previously in this report, minority teachers have a higher rate of attrition than non-minority teachers. Efforts aimed at induction and retention of minority mathematics and science teachers should be complementary to efforts aimed at recruiting teachers into the teaching force. Coordinated retention strategies that support teachers and improve working conditions can change the perception that mathematics and science education are fields that isolate and do not support teachers of color. As the results show, there are signs that actionable strategies can have positive influences on teacher diversity. Plans to increase teacher diversity require coordinated efforts, and these efforts are enhanced when partnerships employ numerous strategies in a comprehensive manner that influences various points along the teacher pipeline.

While some of the partnerships in the MSP Program do provide exemplars for implementing diversity strategies, in other partnerships, when there were fewer minority teachers, the partnerships were less likely to implement actionable strategies. Eligible minorities must participate at higher rates than eligible Whites to increase the diversity of the teaching force. A true effort to change the diversity of the mathematics and science teacher population will require actionable plans that incorporate state and national agencies, federal policies, financial incentives, educational leadership, and a serious commitment to this work.

Conclusion

This study considered strategies used by partnerships in the NSF MSP Program to increase the diversity of its participating teachers and demographic changes in minority teacher participation in relation to those strategies. While there were no significant increases in the diversity of teachers in the program overall, there were significant increases and decreases in minority teacher participation for individual partnerships. The results showed that individual partnerships made progress in terms of the inclusion of minority teachers and high-minority populations, the use of comprehensive strategies aimed at various stages along the continuum of the teacher pipeline, and providing increased access to partnership resources and activities for minority teachers. However, these strategies and changes in teacher diversity were only evident in a small number of partnerships.

Perhaps most important among these results are the categories of actionable strategies being implemented to increase teacher diversity across multiple stages of the teacher pipeline. It is the balanced focus on these categories (recruitment, supporting licensure, induction into teaching, retention of diverse teachers, and targeting high-minority populations for inclusion) that has the potential to produce meaningful effects on the diversity of the mathematics and science teacher population.

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Comparison of MSP and Non-MSP Schools in Six States

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This pilot study proposes a set of analytical steps for comparing schools that participate in the National Science Foundation's Math and Science Partnership (MSP) Program and their intrastate non-participating peers. This pilot is part of a larger effort to evaluate the MSP Program's role in student achievement, along with two companion analyses. While our pilot study uses a comparative approach, the paper by Dimiter Dimitrov (this volume) follows a within-group design. The third analysis by Robert K. Yin (this volume) covers the varied designs used by the MSPs themselves in their own evaluations. As this pilot study has progressed, there has emerged three distinct phases of analysis. Phase I focused on the participating schools within four Math and Science Partnerships (MSPs) located in three states. Phase II expanded Phase I to focus on three more MSPs in three additional states. The Phase III study was conducted using six cohort I MSPs in four states, and will eventually include the nine cohort I MSPs in all six states from Phase I and Phase II. For each phase, the MSP participating schools were carefully matched with the non-participating schools on eight demographic variables to form a comparison group. This paper offers detailed documentation on how we operationalize matching methods for comparative purposes. We conclude that carefully executed matching methods are promising for large-scale comparative analysis on the effects of the MSP Program across all involved states. The study draws on publicly accessible school-level standardized test data from six states and from data available at the National Center for Education Statistics' Common Core of Data (NCES CCD). In addition, the study uses documents available via MSPnet, and Web site information reported by the individual MSPs in the MSP Program accessible through the school year 2005-06.

The purpose of this pilot study is to propose a set of analytical steps for comparing schools that participate in the National Science Foundation's Math and Science Partnership (MSP) Program and their non-participating peers in their respective states.

This pilot is part of a larger effort, along with two companion analyses, to evaluate the MSP Program's role in student achievement. While our pilot study uses a comparative approach, the paper by Dimiter Dimitrov follows a within-group design. The third analysis by Robert K. Yin covers the varied designs used by the MSPs themselves in their own evaluations. The overall objective of this larger effort is to examine whether the Math and Science Partnership (MSP) Program is associated with student academic performance.

As there is increasing national concern about student performance, especially in the areas of mathematics and science, it becomes more important for policymakers and certification agencies to pay attention to programs that achieve results. One area of focus of educational reform has been on ways to improve teacher quality and teacher leadership (Sherrill, 1999). While there has been much research about teacher quality and its impact on student achievement, identifying the components of teacher quality that have the most influence on student achievement has been difficult to establish and measure. Teacher leadership has also been difficult to both define and measure (York-Barr & Duke, 2004). However, there have been several studies that strongly link teacher quality with high student achievement. Rockoff, for example, found that teaching experience is significantly correlated with an increase in test scores (Rockoff, 2004).

Professional development for teachers and in-service training have also been well-researched issues. Professional development has been a main focus of reform initiatives and many states require ongoing professional development for teachers (Garet et al., 2001). While some studies have found little or no impact on student achievement by in-staff development (Jacob & Lefgren, 2004), others have found promising results such as Angrist and Lavy's study (2001) on schools in Jerusalem.

In moving toward a comprehensive analysis of the outcomes associated with the MSP Program, we use state standardized test scores as a measure of student performance due to their public accessibility and prominence as accountability indicators. Ultimately, any conclusions drawn about the relationship between the MSP Program and student achievement will be based on the convergence of all three analyses (ours, Dimitrov's, and Yin's).

The purpose of the analysis is to examine whether MSP-participating schools compared to non-MSP schools are associated with different achievement trends. Because MSP activities primarily involve teacher training and professional development in multiple grade levels, we examine school-level achievement. We address the question: When schools in a state participate in the MSP Program, do their students perform better than they would have if they had not participated in the MSP Program?

In placing the MSP-participating schools in a comparative context, this pilot study uses social science methodologies that account for many confounding conditions, thereby making as fair a comparison as possible. Throughout the analysis, student achievement has been measured in terms of performance on state-administered assessments in mathematics and science for specific grades in the sampled schools. Generally, we assume the individual states' classification systems of "proficiency" and greater.

Central to addressing the issue of school performance is accounting for a school's previous level of achievement. A simple comparison of MSP-participating to non-MSP schools in a given year does not tell us about the potential association with the MSP engagement because it does not account for how those MSP participating and non-MSP schools were performing before the program began. Therefore, our statistical model account for the prior level of achievement. We also consider factors such as student poverty levels and student family background, due to their documented association with student achievement outcomes.

Three distinct phases of analysis emerged during the pilot study. Phase I focused on the participating schools within four MSPs located in three states. Phase II expanded Phase I to focus on three more MSPs in three additional states. The Phase III study was conducted using six cohort I MSPs in four states, and will eventually include the nine cohort I MSPs in all six states from Phase I and Phase II. For each phase, the MSP-participating schools were carefully matched with the non-participating schools on eight demographic variables to form a comparison group.

Even though we have made a strong attempt to match demographically and academically similar MSP and non-MSP schools, the nature of any MSP-like activities in the non-MSP entities is still unknown. Because the MSP Program was not organized to follow a "treatment" and "no treatment" design, many of the non-MSP schools may very well be undertaking MSP-like activities, using other sources of funding. In fact, the MSP entities in our study are limited to those funded by NSF, and the present analysis has not yet had an opportunity to remove from the non-MSP group those districts and schools that might have received funding from the U.S. Department of Education as part of a counterpart MSP Program supported by that agency.

Future analyses will attempt to further define the non-MSP group more precisely. To the extent that data are available, our next step will differentiate within the non-MSP group those districts and schools known to have some MSP-like activities. Nevertheless, even though such sorting has not yet been possible because of a lack of needed data, the present pilot analysis provides an opportunity for testing the pertinent statistical methods on an otherwise appropriate array of information.

It should also be noted that this study has not made an attempt to research the alignment between any of the MSPs' programs and the resident states' standardized tests. For the purpose of this study we are assuming that the content of each MSP's program is aligned with the standardized test. Additional caveats surrounding the analysis are stated throughout the rest of this paper.

Analytic Design in School Matching

The MSP Program can be seen as an investment toward building the capacity of partnering schools and districts to improve teaching and learning in mathematics and science. The MSP Program has provided for the opportunity to expand the capacity of schools and districts by bringing resources and commitment from institutions of higher education (IHEs) to support mathematics and/or science curricula, teacher professional development, and increases in the supply of highly qualified teachers. Equally important, the Program is designed to build sustainable relationships between these K-12 school systems and other key institutions, including: business and industry, professional organizations, state education agencies, and others with a stake in educational improvement (National Science Foundation, 2005). This pilot study focuses on the relationship between the MSP Program and one set of outcome measures, namely standardized test scores.

Research Model Structure

As emphasized by King, Keohane, and Verba (1994), the goal of social science research is inference. In the present study, we wish to make inferences about the relationship between the MSP Program and concurrent student achievement trends in mathematics and science. Theoretically, we want to look at the performance of an MSP-participating school, and compare it to the counterfactual: 'How would the school have performed without MSP participation?' We cannot observe the counterfactual directly, but we use statistical methods designed to estimate the differences associated with MSP participation.

Our analysis includes MSP-participating schools and matched non-MSP schools within the states in which the individual MSPs are located. We match on student background and socioeconomic status variables. Overlooking variables such as these (known as *omitted variable bias*) can lead to incomplete conclusions about the marginal differences associated with the MSP Program. Our study includes a measure of previous school achievement. Including baseline measures of achievement is critical for understanding the incremental difference associated with the MSP Program. It is not sufficient to know how an MSP-participating school is doing this year; we want to know how it is doing this year relative to previous baseline and programmatic years. Finally, our methods attempt to specify the uncertainty surrounding our estimates. Determining statistical significance is important for understanding how strong any MSP and non-MSP differences might be.

Applying Mahalanobis Distance Matching

To control for a number of demographic variables, we employ the Mahalanobis distance matching to define an appropriate comparison school group before analysis

(Gu and Rosenbaum, 1993). We first characterize each MSP school using a set of eight variables and then use the Mahalanobis distance function to locate a "matching" school within the particular state.

The estimated statistical distance between the two N dimensional points is scaled by the statistical variation in each component of the point. For example, if $\vec{x}$ and $\vec{y}$ are two points from the same distribution that has covariance matrix C, then the Mahalanobis distance is given by: $((\vec{x}-\vec{y})' C^{-1}(\vec{x}-\vec{y}))^{\frac{1}{2}}$ (Takeshita, Nozawa, & Kimura, 1993). The resulting group of statistically "close" non-MSP schools is used as our comparison group for regression analysis. Though Mahalanobis distance matching is widely used in computer and spectrometry science, it is only beginning to be used in education policy studies (Good, Burross, & McCaslin, 2005).

Ordinary Least Squares (OLS) Regression

Once the distance matching score is computed, the pilot study employs Ordinary Least Squares (OLS) regression. OLS regressions have, for many years, been the standard statistical technique for evaluation in the field of educational policy (Hanushek, 1979). Along the lines of Hanushek (1986), we assume an education production function. In this model, the outputs of school mathematics and science achievement are seen as the function of a series of inputs. One of the inputs that some schools have is MSP participation, while others do not. Our goal is to see if MSP participation is related to the outputs of mathematics and science student achievement. The general form of the relationship is specified as:

[1] $\boldsymbol{O_{it}} = \boldsymbol{f(M_{it})}$

where outcomes $(\boldsymbol{O_{it}})$ in school $\boldsymbol{i}$ in year $\boldsymbol{t}$ are understood to be a function of the vector of MSP Program activity $(\boldsymbol{M_{it}})$. We assume a linear form of the production function (Hanushek, Rivkin, & Taylor, 1996). Our linear estimation initially takes the following form:

[2] $\boldsymbol{O_{it}} = \beta_o + \beta \boldsymbol{M_{it}} + \varepsilon_{it}$

Considering the MSP Participation's Scope and Intensity

Thus far, we have only referred generally to a school's participation in an MSP. In our quantitative analysis, it is necessary to construct measures of MSP Program participation. We considered both the scope and intensity of the MSP participation. First, we used data from the MSP-MIS (Management Information System) to identify the scope of each MSP. By scope, we mean both the subject (mathematics and/or science), as well as the grade levels targeted. In many cases, an MSP's scope does not align precisely with the grades and subjects tested by state assessments. This can be best seen at the beginning of the MSP Program where many states were in the process of implementing No Child Left Behind (NCLB). At the beginning of the millennium, right after the NCLB Act had been passed, many states only administered their standardized test to a few grades, but added more grades as the years went on, according to NCLB requirements. Also, while many states had a standardized test for mathematics, most states did not test for science since it was not required under NCLB until 2006. Therefore, using the elementary grade span in state E as an example, in school years 2002-03, 2003-04, and 2004-05 we were only able to collect test scores for mathematics in the 4th grade whereas in school years 2005-06 and 2006-07 we could analyze test scores for both mathematics and science in grades 3-5. Similar situations occurred in many of the states we used for our pilot study. This may have an effect on our regression results in that we may not be able to fully capture the effect of the MSP Program in the early years. However, given our method in Phase III to combine several MSPs from different states, along with the fact that some of the states in our analysis do have complete scores for all the years we are looking at, we believe that our results will only be minimally affected.

In addition to scope, we also looked at the intensity of the MSP participation. It should be noted that this pilot study focused on a small set of MSP-MIS data to define the notion of intensity.

These data identified whether or not schools had met one of the following three conditions during school years 2002-03, 2003-04, 2004-05 or 2005-06:

- MSP-MIS item 'q5Bald': Whether 30 percent or more of targeted teachers participated in 30 or more hours of MSP-sponsored activities.
- MSP-MIS item 'q5Bbld': Whether 30 percent or more of targeted students engaged in a challenging mathematics or science curriculum that was initiated or revised with MSP support.
- MSP-MIS item 'q5Bdld': Whether 30 percent or more of targeted students participated in an MSP-supported academic enrichment activity.

For the purposes of this pilot study, if at least one of the three conditions was met for any given year, the school was classified as a 'Participating' MSP school. All other schools that are part of the MSP Program were categorized as 'Partnership' MSP schools. Based on these definitions, the same schools were classified as Participating or Partnership each year, which makes it possible to observe trends in our analysis.[1]

The criteria for being classified as a Participating school may seem a little light. The 30 percent targets were chosen as a cut-off point because that was the only participation threshold that was identified in the MSP-MIS data. Currently, we do not have a way of establishing a higher criterion for participation. It may also be argued that we have further increased the looseness our criteria by only requiring Participating schools to meet the 30 percent mark for one category in one year. We classified Participating schools the way we did in order to increase the sample size so we could do a regression analysis. Increasing the years that a school has to meet the 30 percent mark or the number of categories per year is something we will consider in the future. We focused only on Participating schools for Phases I and II and included Partnership schools in Phase III.

Variables for Statistical Matching

In addition to MSP participation, other school-level conditions are likely to be associated with student achievement. To address alternative explanations, we use relevant and available school-level control variables, as provided by state departments of education and the U.S. Department of Education's National Center for Education Statistics' Common Core of Data (NCES CCD) for the most recent school year available.

Our first control variable is the size of the school, measured as the total enrollment found in the NCES CCD data for the 2005-06 school year. Larger schools operate under different conditions than smaller schools, and in turn, potentially influence student achievement outcomes. Use of "size" as a control variable reduces, if not eliminates, any contaminating effect.

The makeup of the school's student body is likely connected to student performance, which the following five variables seek to address. Schools/campuses serving larger percentages of Black and/or Latino students may experience lower overall achievement as they address the racial disparity that pervades American public education (Jencks & Phillips, 1998), therefore we included a variable for the percentage of population of the student body that is Black and another variable for the percentage of population that is Latino. Another important control is for the percentage of students with disabilities in the school. Larger percentages of students with disabilities may reduce the overall level of school achievement, as those students may face additional educational challenges, so a control variable was included to account for the percentage of the student body with disabilities.

We also included two measures for the percentage of students in the school/campus who are eligible for free and reduced-price lunch, and Title I eligibility. Since the Coleman Report in 1966, a consistent finding in the social science literature on education is a strong relationship between family background and student success. The percentage of free and reduced-price lunch eligible students serves as a proxy for the students' family background, as does the percentage of those eligible for Title I.[2]

The seventh control variable takes into account the number of pupils per teacher in a given school. Education research suggests that class size reduction can benefit certain populations of students (Rivkin, Hanushek, & Kain, 2005).

Finally, we match on the locale of the school. We believe that the size and classification of the municipality where a school is located has a strong effect on how a school system operates and is structured. This can be directly linked to student achievement. Also, we posit that the type of neighborhood setting where students live has an influence on student achievement. The NCES CCD's categorical Locale Code variable was used to match non-MSP schools to the average MSP-participating school. The NCES CCD Glossary defines Locale as: "...the school is situated in a particular location relative to populous areas, based on the school's address." The possible categories are "Large City," "Mid-Size City," "Urban Fringe of Large City," "Urban Fringe of Mid-Size City," "Large Town," "Small Town," "Rural, outside [Core Based Statistical Area]," and "Rural, inside [Core Based Statistical Area]."[3]

This pilot study decided not to include student mobility rates as a control variable due to missing data from schools in the Phase I states. In fact, most states do not publish student mobility data. However, it is probable that this variable is highly correlated to the other eight variables already being used and therefore the characteristic does not need to be accounted for separately.

Measuring Achievement Gains

This study assumes that a connection exists between increasing teaching capacity in mathematics and science and improvement in student performance. We measured improvement in student performance by looking at state-specific standardized tests scores at the school level. These test scores are publicly accessible and allow us to collect multiple points of data over time to monitor trends regarding different schools. Both the direction and the magnitude of student achievement in specific subject areas and by grade levels can be informed by our preliminary analysis. It should be noted that some states will publish preliminary test scores on their Web site before the final scores are ready. In order to ensure the accuracy of our analysis, we only extracted final test scores from each state's Web site and data that were downloaded from the U.S. Department of Education's National Center for Education Statistics' Common Core of Data (NCES CCD) for the purposes of matching MSP schools to non-MSP schools, and all data were accessed at the same time for each phase. That being said, data accuracy is still dependent on each state department of education and the NCES CCD.

In conducting our analysis, we measure the achievement gains from (or value-added by) MSP participation. In the literature that examines the effects of school funding on achievement, this is typically accomplished by modeling, either by generating a dependent variable that measures "change in performance from year t-1 to year t" or by using performance in year t-1 as a statistical control variable on the right-hand side of the equation (Burtless, 1996). We adopt the second approach, including lagged achievement as a statistical control variable. This lagged achievement variable captures the MSP schools' performance in the previous year, relative to the matched non-MSP schools'. One of the reasons we do not calculate a direct change-in-performance variable is that the test instrument in states may have changed over the time period of interest.

Introducing this notion of value-added through the use of a lagged achievement control variable enables us to better estimate the trends associated with the MSP Program, distinct from influences such as unobserved family background influences (e.g., parental commitment to education). For instance, the assumption holds that if parental involvement is roughly the same year-to-year (e.g., active parents in year t-1 are still active in year t and vice versa), then those parental involvement factors will be captured by the lagged achievement variable. However, if parental involvement also changes from year-to-year (but such data are not available) and systematically with achievement, adjusting for such a contamination would be outside of our model's capability. Overall, given the limitations of the available data, we believe this is the most complete model we can develop.

School Level OLS Model

To perform our ordinary least squares (OLS) analysis, we employ STATA's reg command which regresses a variable on a single predictor (Hamilton, 2006). Our school-level statistical OLS regression model takes the basic form:

$$[3] \quad \boldsymbol{ACHIEVE}_{jt} = \beta_o + \beta_1 \boldsymbol{ACHIEVE}_{jt-1} + \beta_2 \boldsymbol{MSP}_{jt} + \varepsilon_{jt}$$

where $\boldsymbol{ACHIEVE}_{jt}$ is the mathematics or science student achievement score for school ***j*** in year ***t***; $\boldsymbol{ACHIEVE}_{jt-1}$ is the school's previous achievement level; $\boldsymbol{MSP}_{jt}$ is a dichotomous (dummy) variable indicating whether or not this is an MSP participating school (after accounting for MSP participation scope and intensity [discussed earlier]); and ε_{jt} is the error term. We use this base model for our school-level analysis and can apply this to all grade levels where we have such data.

When performing the regression, the schools are entered as a group (MSP schools or non-MSP schools) and not as paired matches. We did this in order to have a large sample size to perform a meaningful regression analysis.

Combining MSPs Across States

In order to perform a meaningful OLS analysis, there needs to be a large enough sample size. There are not enough schools in each state at each grade-span taking part in the MSP Program to make this possible, so we had to combine MSPs across state lines. Since test scores vary from state to state, this meant we had to find a way to make test scores across many states comparable to each other. We accomplished this by standardizing the test results using *Z*-scores, which is a common practice. *Z*-scores are useful for standardizing across states because they measure the number of standard deviations each school is above or below their state mean. The formula for finding a *Z*-score for each school is as follows:

[4] $Z_{score} = (X - \mu/\sigma)$

where X is the percent of students scoring at or above proficiency on the state test for the school; μ is the mean percent of students scoring at or above proficiency on the state test for the state; and σ is the state standard deviation within the population of all schools within the state.

Brief Explanation of Three Phases of Analysis

Phase I

For the first part of this pilot study, which occurred during 2007, we focused on four MSPs within three randomly chosen states (states A-C). The original analysis matched a group of ten non-MSP schools to an "average" MSP school. The thought behind this was that if we found significant effects we could double-check to ensure that other external conditions were not causing any portion of the observed effect. Also, aggregating up to the "average" MSP school would blunt the role of any possible conditions outside of the MSP school observations. Unfortunately, this method reduced the sample size, and although we did run several regression analyses, we did not feel that the results were as meaningful as they could be with a larger sample size. Therefore the method of matching ten schools to an average MSP school was discontinued in favor of one-on-one matching for each MSP school in Phases II and III.

Phase II

The second phase of this study started at the beginning of 2008 and added three MSPs in three states, which were also randomly chosen (states D-F). Phase II matched each MSP school individually to a non-MSP school and so provided us with an increased sample size. Unfortunately, in many cases, the sample size was still not large enough to do a regression. For example, state D has 91 participating schools, but 85 of them are elementary schools, while only 4 are middle schools and 2 are high schools. This discrepancy in sample size led us to perform two different types of analyses: a regression analysis for the groups that had a large sample size, like the elementary schools in state D, and a "trend analysis" for the groups of schools that had a small sample size, like the middle and high schools in state D. The trend analysis simply looked at each individual MSP school compared to its matching non-MSP school to determine if any trend was visible. We did not think it was appropriate to combine grade spans since each grade span is very distinct.

Due to the fact that we had to use different types of analyses depending on sample size, we decided to use only states D-F for this phase in order to determine whether it was worth expanding our analyses to states A-C. Because both our regression and trend analysis results were inconclusive, we moved on to Phase III without analyzing states A-C in the same manner.

Phase III

In Phase III, we decided to combine the standardized test results from multiple states to increase our sample size sufficiently to be able to perform a meaningful regression analysis for all three grade spans. We combined test results across states C through F by standardizing all the results using *Z*-scores. We still kept each grade span separate and combined MSP scores within each grade span. In some cases, the same grade could be included in different grade spans. For example, depending on the district, grade 6 can either be included in elementary school or in middle school. Since the way 6th grade is taught can be vastly different if it's part of an elementary school as opposed to a middle school, we decided just to keep each school in the grade span the state defined it to be in. This means that sometimes grade 6 is included in the elementary school results and sometimes it's included in the middle school results. This also occurred for grade 5, and for grade 9, which is sometimes taught in middle school.

Matching of Comparison Schools with MSP-Participating Schools

The Phase III study was first conducted using six cohort I MSPs in four states, and will eventually include the nine cohort I MSPs in all six states. The states were chosen at random and analyzed in various combinations depending on the phase of the analysis. Table 1 shows which states were included in each phase.

Table 1
States Included in Each Phase

	Phase I	Phase II	Phase III
State A	X		
State B	X		
State C	X		X
State D		X	X
State E		X	X
State F		X	X

In sorting out the MSPs for Phase I, we looked at each MSP in each state to see if the MSPs were part of Cohort I (awarded in 2002-03) and contained Participating schools (state C was also analyzed in Phase III). State A has multiple operating MSPs (three in its case). One of the three MSPs located within the state is a Cohort II grantee (awarded in 2003-04), so it was dropped from the analysis because it is desirable to have at least three years of student achievement data to analyze: one year as a baseline and two subsequent project years. State B has one operating MSP that focuses on mathematics instruction improvement at all levels of compulsory schooling. State C has three operating Cohort I MSPs with one focusing on mathematics instruction at all levels of compulsory schooling, one focusing on both mathematics and science instruction at all levels of schooling and, one targeting mathematics middle and high school teacher development.

The same categorization of MSPs was done for the second group of states analyzed in Phases II & III. State D has one operating MSP that is a targeted mathematics initiative. State E has one operating MSP that only focuses on mathematics instruction improvement at the elementary and middle school levels. State F has two operating MSPs, but one is a Cohort II grantee so it was dropped. Also, due to some issues, the Cohort I grantee was dropped after the 2005-06 school year. Since we randomly chose the states we decided to keep the state as part of the study.

According to the MSP-MIS data, and using the definition of "intensity" of MSP participation as previously discussed, the following table, Table 2, shows the break down of Participating (schools that meet at least one of the three 30% criteria for

Table 2
Number of Participating and Partnership Schools in Each MSP

Summary of MSPs Included in Pilot Study					
ID	**Total # Schools**	**# Participating Schools**	**% Participating Schools**	**# Partnership Schools**	**% Partnership Schools**
State A: MSP (1)	40	30	76.6	10	23.4
State A: MSP (2)	81	0	2.4	81	97.6
State B: MSP (3)	24	23	89.3	1	10.7
State C: MSP (4)	50	39	79.2	11	20.8
State C: MSP (5)	73	11	15.1	62	84.9
State C: MSP (6)	224	72	31.9	152	68.1
State D: MSP (7)	124	90	71.4	34	28.6
State E: MSP (8)	39	12	30.8	26	69.2
State F: MSP (9)	112	109	97.6	3	2.4
Pilot Study Total	**770**	**390**	**50.6**	**380**	**49.4**
Program Total	**6,020**	**3,181**	**52.8**	**2,839**	**47.2**

any given year) and Partnership schools (all other schools that are a part of the MSP program) in each of the MSPs in our study.

Once the states were selected and the Participating schools were sorted from the Partnership schools, the following characteristics listed in Table 3 were used to match MSP schools to non-MSP schools:

Table 3
Mahalanobis Matching Variables

Matching Variables		
Variable	**Source**	**Abbreviation**
Total Enrollment	NCES CCD	ENROLL
Percent Black/ African-American Students	NCES CCD*	PCT_BLK
Percent Latino Students	NCES CCD*	PCT_LATN
Percent Students with Disabilities**	State Data	PCT_SWD
School Title I Eligibility	NCES CCD	TITLE1
% Students Free/ Reduced Lunch Eligible	NCES CCD*	PCT_LUNCH
Students to Teacher Ratio	NCES CCD	PPT
Locale of School	NCES CCD	LOCALE

*Percent calculated from a raw number

**Not available in states B or C

Once the characteristics have been collected, we match the entire universe of each state's traditional public non-MSP schools to the MSP schools using Mahalanobis distance matching. This methodology calculates a distance between each MSP school and non-MSP school signifying how well the non-MSP school matches the MSP school profile. It short, the Mahalanobis method does this by determining the range between the minimum and maximum values for each variable and then summing-up all of those values. That number becomes the maximum distance value. So, a perfect match would have a distance value of 0 and the farthest observation from the average MSP school profile would have a distance value equal to the maximum distance value.

Results

Originally for States A-C in Phase I, we performed a regression analysis for each grade level for each MSP in spite of the small sample size. For the analyses, we used school year 2002-03 as the baseline and tracked student performance on mathematics and science state standardized tests through school year 2005-06. A total of 73 comparative regressions were run and out of all the comparisons, only two demonstrated statistically significant results. The findings are presented in Table 4.

Table 4

Phase I Results (Participating Schools)

Phase I						
School Year	**State A**		**State B**		**State C**	
	Mathematics	**Science**	**Mathematics**	**Science**	**Mathematics**	**Science**
2003-2004	**8.00%** change (99% CI) # students proficient in grade 11	n.s.	n.s.	n.s.	n.s.	n.s.
2004-2005	n.s.	n.s.	n.s.	n.s.	˜ **19.06%** change (95% CI) # students proficient in grade 5	n.s.
2005-2006	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

The table shows two statistically significant differences and no clear trend over time. Given the large number of regressions that were run, we consider these two as being chance occurrences, especially because one result was positive and the other was negative.

For Phase II, we looked to increase the sample size by matching each MSP school to a non-MSP school instead of matching an "average" MSP school to ten non-MSP schools as in Phase I. We also looked at grade spans (elementary, middle, and high school) instead of the individual grade levels. For each of the grade spans, we only considered those in which the MSP activities were concentrated. Unfortunately, we still encountered many instances where the sample size was too small. For example, there are only 4 participating middle schools and 2 participating high schools in State D, and in State E there are only 10 participating schools total – 5 at the elementary school level and 5 at the middle school level. Given the situation, we decided to only perform regression analyses for the MSP groups that had a large enough sample size and do a trend analysis for the MSP groups that had a smaller sample size.

Following this plan, we did a regression analysis on the elementary schools in State D (85 schools) and the elementary schools in State F (74 schools). Like Phase I, for these analyses we used school year 2002-03 as the baseline. However, because Phase II occurred many months after Phase I, we were able to include an additional year of test scores and tracked student performance on mathematics and science state standardized tests through school year 2006-07. We used the Mahalanobis analysis to find the best match for each MSP school on the eight variables that were discussed earlier in the paper and then all the MSP schools were regressed against their matching non-MSP schools. The results from this analysis in most cases were not statistically significant, and the ones that were statistically significant showed very little effect from the MSP treatment. Table 5 documents the findings.

Table 5

Phase II Results (Participating Schools)

Phase II				
School Year	**State D**		**State F**	
	Mathematics	**Science**	**Mathematics**	**Science**
	Elementary		Elementary	
2003-2004	n.s.	n.s.	n.s.	n.s.
2004-2005	**2.584** (SD = 1.255, $p < .05$)	n.s.	n.s.	n.s.
2005-2006	n.s.	n.s.	n.s.	n.s.
2006-2007	n.s.	n.s.	n.s.	n.s.

The above results again do not show any meaningful results, even though one of the comparisons was statistically significant.

We conjectured that one of the reasons that most of the results did not show an effect may be because we were matching on too many variables. Some of the variables are often highly correlated and may be interfering with the results. In order to test this theory, we redid the Mahalanobis matching for the elementary schools in State D and only matched on two variables: free- or reduced-price lunch and locale. The results from this analysis showed no significant results. Therefore, we put aside this line of thinking and went back to matching on all eight variables.

For the MSP groups that have a small sample size we did a trend analysis comparing MSP schools to the best-matched non-MSP school. The following table shows this analysis for State E.

The trend analysis was not conclusive either, in any state or grade span. We do not show the results from the other trend analyses since they are fairly similar to what is shown above for state E.

In an effort to have a large enough sample size to be able to do a regression analysis for each grade-span, we normalized the percent of students scoring at or above proficient across States C-F, using a *Z*-score. We felt it was necessary to keep the grade-spans separated (elementary, middle and high school) not only because of the differences of the grade-spans but also because of the differences of program implementation at each grade-span.

Table 6

One-on-one Matching Trend Analysis Results for State E

		Percent of Students Scoring At or Above Proficient						
School	**Grade**	**2002**	**2003**	**2004**	**2005**	**2006***	**2007***	**Match Score**
MSP Primary School A	4	N/A	N/A	N/A	43.6	37.8	43.8	4.722
Match Primary School A	4	N/A	N/A	N/A	27.5	37.8	21.5	
MSP Primary School B	4	33.9	62.5	41.5	58.0	6.0	21.4	0.304
Match Primary School B	4	16.7	35.3	36.5	25.5	16.8	25.8	
MSP Primary School C	4	43.9	47.8	43.4	54.3	46.0	59.2	2.211
Match Primary School C	4	60.0	56.3	59.6	82.9	84.6	79.5	
MSP Primary School D	4	33.3	33.8	49.2	45.7	60.9	43.6	0.888
Match Primary School D	4	23.3	25.0	21.3	36.7	23.5	29.7	
MSP Primary School E	4	25.8	23.3	48.3	44.2	19.5	27.7	2.16
Match Primary School E	4	7.8	5.4	19.1	18.2	15.3	14.9	
MSP Middle School A	8	1.6	3.4	1.9	0.5	5.5	11.2	11.809
Match MiddleSchool A	8	36.1	4.0	13.6	28.6	11.5	8.7	
MSP Middle School B	8	3.0	7.5	3.5	7.7	14.8	23.3	9.415
Match Middle School B	8	25.7	19.6	22.6	33.7	60.8	67.2	
MSP Middle School C	8	26.1	39.0	34.9	32.9	58.6	60.8	0.799
Match Middle School C	8	28.0	20.1	27.1	24.7	60.7	65.5	
MSP Middle School D	8	7.7	3.0	3.3	4.9	22.5	22.9	10.016
Match Middle School D	8	12.8	12.1	5.9	12.9	29.2	38.1	
MSP Middle School E	6	N/A	N/A	N/A	N/A	65.6	65.0	5.304
Match Middle School E	6	N/A	N/A	N/A	N/A	25.0	23.9	

Note. *Test changed in 2005-06 School Year so scores are not comparable to previous years.

Another change we made in Phase III was to examine Partnership schools along with Participating schools. Currently, as a trial, we have only looked at Partnership schools in States C and E. We are in the process of adding Partnership schools in States D and F to our analysis. We looked at both Partnership and Participating schools by themselves when compared to their matched non-MSP schools, as well as Partnership and Participating schools combined, labeled as "MSP" schools.

Tables 7.1, 7.2, and 7.3 show the results from the combined analysis. Looking at the following three tables (7.1-7.3), you will notice that we did not analyze science test scores when we combined just States C and E. This is because State C did not start testing for science until the 2006-07 school year, which means we did not have a previous year's score to include in our regression. Also, as mentioned above, State E only has a few Participating and Partnership schools involved in the MSP program, so the sample size is not big enough, not to mention that they did not start testing for science until the 2005-06 school year, which, even if there were enough schools to perform a regression, would only give us one year of data. The lack of science assessment has to do with the fact that under No Child Left Behind (NCLB), science assessments did not have to be developed until the 2005-06 school year and states were not required to use the assessments until the 2007-08 school year. This is not to say that this analysis is part of the No Child Left Behind Act, but that our access to test scores is linked to NCLB because of the mandate in the Act for states to perform assessments.

For the high school, since we only used States C and E when examining Partnership schools, we were unfortunately not able to get any results. This is due to the fact that in State C, there are only two Partnership schools and State E did not start standardized testing in mathematics until the 2006-07 school year, which means we did not have a previous year's scores to use in our regression analysis.

Looking over the results, Tables 7.1-7.3 again show no particular differences between the MSP and non-MSP schools. There are no statistically significant differences at the elementary and high school levels, and only one significant difference at the middle school level. Furthermore, the single significant difference occurs in an early year of the MSP program. One possibility for this single difference is that schools struggling with mathematics or science may have been chosen to be part of the program in order to give those schools increased assistance to catch-up to the state standard, and the early year still showed this lagging baseline condition.

Overall, and across all three Phases, the absence of nearly any differences between the MSP and non-MSP schools may be a reflection of three conditions that defined the current research design. First, the extent of MSP intervention in the MSP schools was only weakly defined, and the non-MSP schools may have been equally or even more engaged in MSP-like activities, but not funded by the MSP Program. For instance, the "Participating" schools only had to meet one of three "30 percent" criteria, and for only one of the four monitored years in Tables 7.1-7.3.

Table 7.1
Results for Phase III – Elementary Schools

School Year	Combined States C, D, E & F		Combined States C & E		
	Mathematics	**Science**	**Mathematics**		
	Particip	Particip	Partner	Particip	MSP
2003-2004	0.392 (*SD* = 0.396)	N/A	0.174 (*SD* = 0.192)	0.392 (*SD* = 0.396)	0.211 (*SD* = 0.179)
2004-2005	0.023 (*SD* = 0.055)	-0.046 (*SD* = 0.114)	-0.313 (*SD* = 0.222)	-0.09 (*SD* = 0.425)	-0.241 (*SD* = 0.199)
2005-2006	0.041 (*SD* = 0.059)	0.125 (*SD* = 0.079)	-0.011 (*SD* = 0.183)	-0.506 (*SD* = 0.529)	-0.078 (*SD* = 0.170)
2006-2007	0.035 (*SD* = 0.062)	-0.09 (*SD* = 0.104)	0.015 (*SD* = 0.085)	-0.238 (*SD* = 0.312)	-0.022 (*SD* = 0.084)
	N = 199	*N* = 199	*N* = 192	*N* = 32	*N* = 224

Note. "Particip" is the effect of Participating Schools compared to non-MSP Schools; "Partner" is the effect of Partnering Schools compared to non-MSP Schools; "MSP" is the effect of MSP Schools (Partnering combined with Participating) compared to non-MSP Schools.

Second, the comparisons were made as a series of annual comparisons, rather than calculating a single multi-year trend for each school and then comparing the two groups of schools. Such multi-year trends may yet reveal differences between the two groups, and therefore the estimation of such trends is among our ongoing research priorities.

Third, the "light" participation definition and the series of annual comparisons has a potential and undesirable interaction: the year of comparison between a school and its matched counterpart may have been a year in which the MSP school did not achieve even the 30 percent criterion. As more states and MSPs are added to the Phase III analysis, the sample sizes will increase so that this interaction can be avoided in the future. For instance, the criterion for a "participating" school might be made more stringent so that a school has to show 30 percent participation in at least two if not all of the monitored years in order to be defined as a participating school.

Table 7.2
Results for Phase III – Middle Schools

School Year	Combined States C, D, E & F		Combined States C & E		
	Mathematics	Science	Mathematics		
	Particip	Particip	Partner	Particip	MSP
2003-2004	-0.234 (*SD* = 0.117)	N/A	-0.194 (*SD* = 0.936)	-0.234 (*SD* = 0.117)	-0.291 (*SD* = 0.113, $p < 5\%$)
2004-2005	0.044 (*SD* = 0.121)	-0.045 (*SD* = 0.138)	-1.612 (*SD* = 1.323)	-0.186 (*SD* = 0.117)	-0.092 (*SD* = 0.149)
2005-2006	0.058 (*SD* = 0.140)	0.11 (*SD* = 0.114)	0.516 (*SD* = 0.300)	0.006 (*SD* = 0.158)	0.113 (*SD* = 0.135)
2006-2007	-0.161 (*SD* = 0.087)	-0.323 (*SD* = 0.161)	-0.063 (*SD* = 0.187)	-0.139 (*SD* = 0.085)	-0.118 (*SD* = 0.069)
	N = 77	*N* = 77	*N* = 37	*N* = 58	*N* = 95

Note. "Partner" is the effect of Partnering Schools compared to non-MSP Schools; "Particip" is the effect of Participating Schools compared to non-MSP Schools; "MSP" is the effect of MSP Schools (Partnering combined with Participating) compared to non-MSP Schools

Implications, Lessons Learned, and Future Work

In this study, we focus on a sample of MSPs participating in six states. The MSP schools were carefully matched with non-MSP schools on eight demographic variables to form a comparison group. This paper offers detailed documentation on how we operationalize two matching methods for comparative purposes. This is compliant with the U.S. Department of Education's Academic Competitive Council's (ACC) charge to evaluate the effectiveness of STEM education interventions under rigorous conditions. In a hierarchy with "Experimental Methods such as Randomized Controlled Trials (RCTs)" at the top and "Other designs, such as Pre- and Post-Test Studies, and Comparison Group Studies without careful matching" at the bottom, our matching methodology falls in between as one that is a "Quasi-experimental

Table 7.3
Results for Phase III – High Schools

School Year	**Combined States C, D, E & F**	
	Mathematics	**Science**
	Particip	**Particip**
2004-2005	0.068 (*SD* = 0.134)	-0.204 (*SD* = 1.400)
2005-2006	0.12 (*SD* = 0.142)	-0.03 (*SD* = 0.003)
2006-2007	0.059 (*SD* = 0.200)	0.054 (*SD* = 0.000)
	N = 52	*N* = 52

Note. "Particip" is the effect of Participating Schools compared to non-MSP schools.

Method such as Well-Matched Comparison Group Study." In the absence of having the prime condition of being able to conduct a randomized controlled trial of MSP-funded schools, we will continue to refine our matching methodology to provide the most appropriate quasi-experimental method so that it may act as a model for similar program analyses.

As observed in this pilot study, we are unable to find any effect in the statistically significant results. Then again, this outcome is from combining six MSPs out of a possible twenty-two (22) Cohort I MSPs. We think this could change if we added more MSPs and increased the standard for what it means to be classified as a Participating school. We also need to look into discovering which of our non-MSP schools have MSP-like activities and to make them into their own category of school.

Our matching results suggest that carefully executed matching methods are promising for large-scale comparative analysis on the effects of the MSP Program across different states. Our next step is to do a closer look at the states we've already analyzed to see if there's an effect we're missing, and expand the methods to include additional states with operating Cohort I MSPs and additional years of data. We will go back to try and take into account other mathematics and science programs that other schools may be participating in that may be contributing to an evident lack of effect from the MSP. By doing this, we may actually create four categories of schools in each state: 1) participating in the MSP, 2) a partnership school in the MSP, 3) participating in another mathematics/science partnership outside of NSF, and 4) no extra outside mathematics/science help. We will also consider looking at each classification of passing on the state standardized tests, such as "below basic," "basic," "proficient," and "above proficient." It may be that by not looking at each category separately we are missing large gains in individual classifications, like large groups of students moving from proficient to above proficient, or even many students moving from below basic to basic.

Ultimately, the goal is to analyze the relationship between MSP school participation and state standardized achievement test gains. We shall do this through our matching methodology, which controls for various extraneous factors that may affect student test scores. We hope that our effort in defining and operationalizing an appropriate comparison group in the MSP program evaluation will contribute to a broader discussion in program evaluation.

Endnotes

1. It should be noted that Dimitrov's study only uses the condition that 30 percent or more of a school's targeted teachers participated in 30 or more hours of MSP-sponsored activities.

2. Title I was established by the Elementary and Secondary Education Act of 1965 in order to "distribute funding to schools and school districts with a high percentage of students from low-income families." In order to qualify for Title I funding at least 40% of the students must come from low-income families as defined by the U.S. Census. (Encyclopedia Britannica, "Elementary and Secondary Education Act." http://www.britannica.com/EBchecked/topic/184196/Elementary-and-Secondary-Education-Act, Accessed October 20, 2008.

3. See http://nces.ed.gov/ccd/commonfiles/glossary.asp

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NORMES

Intermediate Trends in Math and Science Partnership-Related Changes in Student Achievement With Management Information System Data

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This substudy in the evaluation design of the Math and Science Partnership (MSP) Program Evaluation examines student proficiency in mathematics and science for the MSPs' schools in terms of changes across three years (2003/04, 2004/05, and 2005/06) and relationships with MSP-related variables using Management Information System data with the Annual K-12 District Survey. First, changes in percentages of students at or above proficient on state assessments in math and science were investigated by gender, ethnicity, special education, and students with limited English proficiency across the targeted three-year period (2003/04 – 2005/06). The classification of MSP schools with and without focus on math or science during this time period was also taken into account. The results indicated that the MSP-related schools demonstrate sustained increase in percent of students at or above proficient in both math and science at the elementary and middle school levels, but not quite so at the high school level. Second, schools were examined by frequency and effect size of increase, decrease, or no change in student math and science proficiency. The schools with positive changes were in much higher numbers and higher mean effect size of change compared to schools with negative (or no) changes in student math and science proficiency. Third, the relationship between the schools' targeted teacher participation in MSP-related activities over the entire period of three years and the student math and science proficiency at the "end" year of this period (2005-06) was also investigated. This relationship was positive, yet small, at all school levels for mathematics, and also positive, yet much better pronounced, at the high school level for science. Forth, longitudinal growth trajectories in math and science proficiency across the three years were also investigated. The results showed that the schools with MSP focus on math (or science) increase at higher rate in math (or science) proficiency compared to those without MSP focus on math (or science) at the middle school level.

Note from the Editor: All tables and figures are presented at the end of the article.

This study analyzes data from the MSP-Management Information System (MSP-MIS) initiated by NSF as a web-based data collection system. Specifically, the study examines student proficiency in mathematics and science for the MSPs' schools in terms of changes across three years (2003/04, 2004/05, and 2005/06) and relationships with MSP-related variables. The purpose of the MSP-MIS is, in part, to assess the overall implementation of the MSP Program and to monitor the progress of individual MSP grants. Such implementation and monitoring are complex affairs because of the complexity of the MSP grants. The MSP-MIS data are self-reported at the school level. Each grant is a partnership, minimally involving a K-12 district and an institution of higher education (IHE). More often, however, multiple districts and multiple IHEs are engaged in a single MSP grant. The MSP-MIS collects annual data from all grantees, based on multiple instruments. The present study used data from one of the instruments, the Annual K-12 District (school-level) Survey for years 2002/03, 2003/04, 2004/05, and 2005/06. Descriptive analyses from this survey are reported elsewhere (Silverstein, Bell, Frechtling, & Miyaoka, 2005). (Another MSP-MIS instrument provided information on an MSP's math or science focus at the school level.)

The initial year, 2002/2003, is not included in this analysis for two reasons. First, the number of schools that provided MIS data for 2002/03 is disproportionately smaller than those in the subsequent three years. For example, the number of schools with MIS data on math performance across all four years, 2002/03-2005/06, versus the number of schools with such data across the last three years, 2003/04-2005/06, is 24 versus 214, for elementary schools, 15 versus 180, for middle schools, and 5 versus 177, for high schools. Second, the initial trends across the first three years, 2002/03-2004/05, were previously reported by MSP-PE (e.g., Dimitrov, 2006, 2007, 2008; National Science Foundation, 2006, 2007a).

The following four major research questions (RQs) are addressed:

RQ1: What are the trends in mathematics and science proficiency changes across the targeted three-year period (2003/04 – 2005/06) for MSP-related schools based on a) MIS data for all schools that reported student achievement data for any of the three years, and b) longitudinal MIS data — only schools with student achievement data over the three-year period (2003/04 – 2005/06). Of particular interest is the examination of such trends for schools with MSP focus on the subject of interest (math or science) and schools without MSP focus on the subject (math or science).

RQ2: What is the distribution of MSP-related schools across categories of change (increase, decrease, or no change) in math and science proficiency and what is the mean effect size for the categories of significant change (increase or decrease) over the entire three-year period of time (2003/04- 2005/06) for schools with MSP focus on the subject (math or science) and schools without MSP focus on the subject?

RQ3: What are the longitudinal growth trajectories (initial school performance, rate of change, and interaction between them) in math and science proficiency across the three-year period (2003/04 – 2005/06) for schools with MSP focus on the subject (math or science) and schools without MSP focus on the subject?

RQ4: What is the relationship between schools' targeted teacher participation in MSP-related activities over the three-year time period and the schools' success in math and science proficiency at the end year of this time period (2005/06)?

These four research questions address different aspects of changes in math or science proficiency for schools with (or without) MSP focus on math or science across three years (2003/04-2005/06). Specifically, a) RQ1 focuses primarily on the statistical significance of changes and their effect size, b) RQ2 deals with the distribution of schools by direction of change (decrease, no change, increase), c) RQ3 investigates the trajectories of change in terms of initial status in math or science (i.e., proficiency in year 2003/04), rate of change, and possible interaction between these two basic parameters of growth across three years (2003/04-2005/06), and d) RQ4 investigates the relationship between school's targeted teacher participation in MSP-related activities over the three-year time period and the school's success in math and science proficiency at the end year of this time period (2005/06). That is, whether a "critical mass" of three year targeted teacher participation in MSP-related activities can explain the school performance in math and science (percent of students at or above proficient) at the end year (2005/06). The first research question (RQ1) was addressed using MSP-MIS student achievement data from MSP-related schools in two scenarios. Namely, using schools that have reported such data for any of the three years 2003/04, 2004/05, and 2005/06 (in Table 2), and then using only schools that have reported data across these three years (see Table 3).

Tables 2 and 3 also show that there is a substantial overlap in the number of schools assessed in math or science in these two scenarios. For example, the number of common schools in the two scenarios in mathematics at the elementary school level is 245 (out of 320 in 2003/04, 586 in 2004/05, and 762 in 2005/06). For science, also at the elementary school level, there are 114 common schools (out of 135 in 2003/04, 204 in 2004/05, and 308 in 2005/06). Nevertheless, the first scenario data (Table 2) are used only for descriptive purposes, whereas the second scenario data (Table 3) are used for inferential analysis of changes in school math and science proficiency, including effect sizes of such changes, across all three years (2003/04-2005/06).

The second research question (RQ2) was addressed using the longitudinal data from schools with MSP-MIS data on student proficiency in math (or science) across all three years (see Table 3). This question was answered by examining the frequency distribution of MSP-related schools across categories of change (increase, decrease, or no change) in math and science proficiency, as well as the mean effect size for the categories of significant change (increase or decrease) over the entire three-year period of time (2003/04- 2005/06).

The third research question (RQ3) was also addressed using the longitudinal data from schools with MSP-MIS data on student proficiency in math (or science) across all three years (see Table 3). The school scores in this longitudinal analysis were adjusted for the school's sample size and score variation. This was done by weighting the school's proportion of students at or above proficient in math (or science) by the reciprocal of the standard error of this proportion:

$$Adjusted\ p_i = p_i / s_i \qquad (1)$$

where p_i is the school's proportion of students at or above proficient in math (or science) and s_i is the standard error: $s_{p_i} = \sqrt{p_i(1 - p_i/n_i)}$ with n_i being the sample size of the *i*th school — that is, the number of students assessed in math (or science) in school i.

With this score adjustment, if some schools have equal initial scores, p_i, the larger the school sample size, n_i, the larger the factor by which the school score (proportion of students at or above proficient) will increase. Along with improving the reliability and validity by using weighted scores (e.g., Kane & Case, 2004), the score adjustment in this case was necessary because the growth analysis involves the school means and, therefore, averaging proportions that come from schools with different sample size would produce misleading results. After the adjustment, the square root transformation was applied to the resulting scores, with the purpose to reduce the (positive) skewness of their original distributions, thus improving the technical conditions required with this type of longitudinal growth modeling (e.g., Snedecor & Cochran, 1989; Stevens, 2002). The square root transformation makes the data distribution more suitable for the analytic procedures involved in the growth analysis with RQ3 and does not lead to problems with validity of interpretations. The relationship between the original and adjusted proportions was found to be positive monotonic with a Pearson correlation of .73 between them. It is important to emphasize in this regard that the main purpose of RQ3 is to examine growth trajectories in math and science proficiency for two groups of schools — *with* or *without* MSP focus on math (or science) — not to compare these two groups of schools on their original percent of student proficiency; (such comparisons are addressed, from different angles, with research questions RQ1 and RQ2).

Finally, the fourth research question (RQ4) was addressed using schools for which MSP-MIS data were available on targeted teacher participation at any of the three years (2003/04-2005/06) and student achievement data for the last year (2005/06). As alluded to earlier, the idea was to investigate the relationship between the school's "critical mass" of targeted teacher participation in MSP-related activities over all three years and student math and science proficiency at the end of this time period. It is important to note also that the variable "targeted teacher participation in MSP-related activities" is not involved in the previous three research questions.

Tables 2 and 3 summarize the information about the data that have been used in statistical analyses related to each of the research questions addressed in this study.

Method

Data

From the Annual K-12 District Survey, the data used in this paper covered schools with available data for the four research questions as described in the previous section. Table 2 provides data on number of schools for which MSP-MIS data on student math or science proficiency were available for any of the three years (2003/04, 2004/05, and 2005/06), number of students in these schools who had taken the state assessment in math or science, *n*, and number of students who "pass" (at or above proficient) the assessment. The data are also provided by gender, ethnicity, special education students, and limited English proficiency students. Table 2 shows, for example, that the highest relative sample representation of schools is for mathematics at the elementary school level. Table 3 includes only schools with MSP-MIS student achievement data across all three years (2003/04-2005/06).

Variables and Scales

There are three main variables investigated in this school-level MSP-MIS study:

1. S*tudent achievement* — the proportion of students at or above proficient on state assessments in mathematics and science, calculated by the number of students attaining proficiency divided by the total number of students taking the test;
2. *Targeted teacher participation in MSP-related activities* — this variable is identified in MSP-MIS by the condition that 30 percent or more of a school's targeted teachers participated in 30 or more hours of MSP-sponsored activities during a single school year. Given the binary scale (1 if the condition was met, and 0 otherwise), the score for any school on this specific variable over three school years (2003/04, 2004/05, and 2005/06) may vary from zero to three (0 = the condition was not met during any of the three years, and 3 = the condition was met all three years); and
3. MSP focus on math (or science) for each school (0 = No, 1 = Yes), with "yes" meaning that the MSP indicated such a focus in any of the three years being studied.

Statistical Analysis

All research questions were addressed by school level (elementary, middle, and high school). To address RQ1, longitudinal analyses were conducted to compare schools with an MSP focus on math (or science) versus schools without such focus on trends and effect size of changes in percent of students at or above proficient. Cohen's effect size (ES) index for a difference in two proportions, *h* (Cohen, 1988), was calculated for each school with a statistically significant change (increase or decrease). The *h* effect size for the difference in two proportions, say $P_1 - P_2$, is:

$h = 2arcsin\sqrt{P_1} - 2arcsin\sqrt{P_2}$. The magnitude of the effect size is operationally defined as *small* (h = .20), *medium* (h = .50), and *large* (h = .80) effect size (Cohen, 1988, p. 181).

To address RQ2, each school was assigned to one of three categories of change in terms of percent of students at or above proficient in math or science: *increase* — if the school has a statistically significant positive change, *decrease* — if the school has a statistically significant negative change, and *no change* — if the school's change was not statistically significant. The frequency distribution of schools by direction of change (increase, decrease, no change) in math and science proficiency was examined by schools *with* or *without* MSP focus on math (or science). The *changes* across three school years were measured by the differences in percent of students at or above proficient on state assessments in mathematics and science from 2003/04 to 2004/05 (*one-year immediate change*) and from 2003/04 to 2005/06 (*two-year sustained change*).

To address RQ3, longitudinal growth modeling was applied to adjusted scores of school proficiency in math and science to investigate the *initial status* (intercept) and *rate of change* (slope), as well as possible interaction between them, in growth trajectories of school proficiency in math and science across all three years (2003/04-2005/06). The role of schools with (or without) MSP focus on the respective subject matter (math or science) was also taken into account with this longitudinal growth analysis. Longitudinal growth modeling (LGM; e.g., Muthén, 2004) was employed with the individual schools being the units of analysis, the square root of the adjusted school proportion of students at or above proficient (see Equation 1) being the outcome variable across three years (2003/04, 2004/05, and 2005/06), and the school variable "MSP focus on math or science" (0 = No, 1 = Yes) being a background variable. Graphically, the LGM used in this study is depicted in Figure 1. The longitudinal growth analysis was conducted separately for math and science at each (elementary, middle, and high) school level using the computer program M*plus* (Muthén & Muthén, 2007).

To address RQ4, the Pearson product-moment correlation was used to investigate the relationship between the school's targeted teacher participation in MSP-related activities over the time period of all three years and student math and science proficiency at the end of this time period (2005/06). This analysis was conducted separately for math and science at each (elementary, middle, and high) school level.

Results

The results are reported in four parts representing the four research questions (RQ1, RQ2, RQ3, and RQ4) addressed in this MSP-PE substudy.

Trends and Effect Sizes of Changes in Math and Science Proficiency

This section provides results related to the first research questions, RQ1: "What are the trends in mathematics and science proficiency changes across the targeted three-year period (2003/04 – 2005/06) for MSP-related schools based on MIS data for all schools that reported student achievement data for any of the three years, and *longitudinal* MIS data — only schools with student achievement data across all three years (2003/04-2005/06). Of particular interests is the examination of such trends for schools *with* MSP focus on the subject of interest (math or science) and schools *without* MSP focus on the subject (math or science)."

The results are presented separately for student achievement in mathematics and science. The change of each school in percent of students at or above proficient in math (or science) is tested for statistical significance using 90% confidence intervals (90% CI) for the change. The choice of 90% CI over 95% CI was guided by the principle of increasing test power.

Mathematics. Figures 2 and 3 (upper panels) show the percent of students at or above proficient on state assessments in mathematics by school level (elementary, middle, and high) for all schools with MSP-MIS student achievement data at any of the three years (2003/04-2005/06) and only for schools with MSP-MIS student achievement data across all three years, respectively. The trends of school changes in math proficiency delineated in these two exhibits are very similar due to the fact that the data used for Figure 3 (upper panel) is a substantial subset of the data used for Figure 2 (upper panel) (see also Tables 1 and 2). Therefore, the school data used for Figure 3 (upper panel), that is, student achievement data available across all three years, were also used for inferential comparisons and calculation of effect sizes for school changes in math proficiency across the three years (2003/04-2005/06) (see Table 3).

Figures 2 and 3 (upper panels) also show that there is a sustained increase in math proficiency at the elementary and middle school levels, but not at the high school level — specifically, there is an initial decrease (2003/04-2004/05) after which the math proficiency for high schools remains stable. The results by schools *with* (or *without*) MSP focus on math are presented with Table 4 and Figure 4. Clearly, the elementary and middle schools with MSP focus on math show a consistent increase in math proficiency, with the largest effect size (ES = +.35) for the sustained increase from 2003/04 to 2005/06. Conversely, the elementary and middle schools without MSP focus on math show an overall decrease in math proficiency (with the exception of a slight initial increase, ES = +.09, for middle schools). At the high school level, however, the math proficiency change is not in favor of schools *with* MSP focus on math. Specifically, there is a small decrease for these schools versus a small increase for high schools *without* MSP focus on math.

By gender, the results in Table 5 show that the largest (2003/04-2005/06) increase in math proficiency for both males and females is at the elementary school level, with a close to medium effect size (*ES* = +.35). By ethnicity, the results in Table 6 show that the largest (2003/04-2005/06) increase in math proficiency is for the elementary school *with* MSP focus on math — (small to medium) effect size for African-American students (*ES* = +.37), Hispanic students (*ES* = +.37), and students who have not reported their ethnicity (ES = +. 31). An exception is the sizable increase in math proficiency (medium to high effect size: *ES* = +.54) at the high school level for students in the "other" grouping by ethnicity from the schools *without* MSP focus on math. Further, the results in Table 7 show that a) for special education students, the overall positive change in effect size is in favor of schools *with* MSP focus, and b) this trend is even stronger for students with limited English proficiency at the elementary and middle school levels, but not at the high school level.

Science. Figures 2 and 3 (lower panels) show that there is a substantial increase in science proficiency at the elementary school level, less pronounced increase for the middle schools, and an initial decrease, followed up by a very small increase, at the high school level. The results by schools with (or without) MSP focus on science are presented with Table 8 and Figure 5. The effect size results in Table 8 show that, overall, the schools *with* MSP focus on science do better than those *without* MSP focus on science at the elementary and middle school levels, but this is not the case at the high school level. High schools *with* MSP focus on science exhibit a close to medium decrease (*ES* = –.36), whereas high schools *without* MSP focus on science exhibit a small increase (*ES* = +.14) in science proficiency (2003/04-2005/06). Note that the comparison by "percent proficient students" can be misleading due to the much larger sample size of students (and schools) for schools *with* MSP focus on science compared to MSP schools *without* focus on science. The effect size takes this into account and represents a more valid scale for comparison of changes in student proficiency.

By gender, the results in Table 9 show that the largest (2003/04-2005/06) increase in science proficiency is for the elementary schools *with* MSP focus on science, with small effect size for both males and females (*ES* = +.21). By ethnicity, the results in Table 10 show that the largest (2003/04-2005/06) increase in science proficiency is for schools *with* MSP focus on science . There is an increase of medium effect size for the African-American students (*ES* = +.47) and Asian students (*ES* = +. 42), at the elementary school level, and for Asian students at the middle school level (*ES* = +.36).

For special education students, the largest (2003/04-2005/06) increase in science proficiency is for the middle schools *with* MSP focus on science (*ES* = +.56) (see Table 11). For students with limited English proficiency, the largest (2003/04-2005/06) increase in science proficiency is at the middle school level, but with *ES* +.56 for schools *without* MSP focus on science and *ES* = +.30 for schools with MSP focus on science. There is a similar trend at the elementary school level for these students, with *ES* = +.30 for schools *without* MSP focus on science and *ES* = +.21 for schools with MSP focus on science. However, there is no change in science proficiency at the high school level for these students (see Table 11).

Schools by Direction of Change in Math and Science Proficiency

The results in this section relate to the second research question, RQ2: “What is the distribution of MSP-related schools across categories of change (increase, decrease, or no change) in math and science proficiency and what is the mean effect size for the categories of significant change (increase or decrease) over the entire three-year period of time (2003/04- 2005/06) for schools *with* MSP focus on the subject (math or science) and schools *without* MSP focus on the subject?”

Specifically, this section provides information about the percentage of schools by direction of change (increase, decrease, no change) in math and science proficiency over a two-year period (2003/04-2005/06), separately for schools with and without MSP focus on math (or science) — see Figures 6, 7 and 8, for math, and Figures 9, 10, and 11, for science.

Clearly, the percentage of schools with a two-year increase is much higher than the percentage of schools with a two-year decrease at all school levels for both math and science. For schools that fall into the "increase" category, the percentage of schools *with* focus on math (or science) is higher than the percentage of schools *without* focus on math (or science) at the elementary and middle school levels for both math and science (see Figures 6, 7, 9, and 10). This, is not the case at the high school level (Figures 8 and 11).

Longitudinal Growth Trajectories in School Math and Science Proficiency

The results in this section relate to the third research questions, RQ3: “What are the longitudinal growth trajectories (initial school performance, rate of change, and interaction between them) in math and science proficiency across the three-year period (2003/04 – 2005/06) for schools *with* MSP focus on the subject (math or science) and schools *without* MSP focus on the subject?”

The longitudinal growth model (LGM) of changes in school math and science proficiency across three years (2003/04-2005/06) is depicted in Figure 1. The results are summarized in Table 12. The unit of measurement are individual schools, the school score is the adjusted proportion of students at or above proficient (see Equation 1), and the school "MSP focus on math (or science)" is a background variable (0 = No, 1 = Yes).

The results for tests of model fit in Table 12 show that the LGM model fits the school data fairly well, given the following three criteria of a good model fit used in this study: *Comparative Fit Index* (CFI > .95), *Tucker-Lewis Index* (TLI > .95), and *Standardized Root Mean Square Residual* (SRMR < .06). For the estimates of the CFI, for example, with the exception of a slightly lower CFI at the elementary school level (.844), all CFIs vary from .959 to .999 — see Table 12.

Given the coding (0 = No, 1 = Yes) for the school variable "MSP focus on math (or science)," the statistically significant coefficients in the column "Initial Status on MSP

Focus" in Table 12 indicate that a) the schools with MSP focus on math have higher initial status (higher adjusted proficiency score in 2003/04) than those without MSP focus on math at the elementary and high school levels (0.33 and 0.37), but not on the middle school level (-1.46); and b) the schools with MSP focus on science have lower initial status (lower adjusted proficiency score in 2003/04) than those without MSP focus on science at the elementary school level (-1.63).

The statistically significant positive coefficients in the column "Rate of Change on MSP Focus" in Table 12 show that a) the schools with MSP focus on math increase at higher rate in math proficiency compared to those without MSP focus on math at the middle school level (0.25), and b) the schools with MSP focus on science increase at higher rate in science proficiency compared to those without MSP focus on science at the middle school level. Still in Table 12, the statistically significant negative correlation coefficient (-.53) in the column “Initial Status correlated with Rate of Change” indicates that middle schools with lower initial proficiency in math increase at a higher rate. On the other hand, the statistically significant positive correlation coefficient (.25) shows that high schools with higher initial proficiency in science increase with higher rate.

Relationship Between Targeted Teacher Participation in MSP-related Activities and Student Proficiency in Math and Science

The results in this section relate to the fourth research question, RQ4: “What is the relationship between schools’ targeted teacher participation in MSP-related activities over the three-year time period and the schools’ success in math and science proficiency at the end year of this time period (2005/06)?”

Specifically, this section provides results about the relationship between the targeted teacher participation in MSP-related activities over the span of three years (2003/04-2005/06) and the student proficiency in math and science at the end year (2005/06). The Pearson product-moment correlation coefficients for this relationship at the elementary, middle, and high school levels are provided in Table 13. The presence (or lack) of statistical significance for these coefficients and their magnitudes reveals that the relationship between the targeted teacher participation in MSP-related activities and student proficiency is statistically significant and positive (yet, small) at all school levels for mathematics, and statistically significant and well pronounced (r = .473) at the high school level for science.

Discussion

This study examines intermediate trends in MSP-related changes in student math and science proficiency using MSP-MIS data with the Annual K-12 District Survey for three years, 2003/04, 2004/05, and 2005/06. The results are summarized by the topics of the four research questions addressed in this study.

Trends of Changes in Math and Science Proficiency

The MSP-related schools demonstrate sustained increase in percent of students at or above proficient in both math and science at the elementary and middle school levels across years 2003/04, 2004/05, and 2005/06. This, however is not the case at the high school level, with an initial decrease (2003/04-2004/05) after which the proficiency for high schools remains stable for both math and science. The elementary and middle schools *with* MSP focus on math show a consistent increase in math proficiency, with the largest effect size for the sustained increase from 2003/04 to 2005/06 at the elementary school level. Conversely, the schools *without* MSP focus on math show an overall decrease in math proficiency at the elementary and middle school levels. At the high school level, however, the math proficiency change is not in favor of schools *with* MSP focus on math. There is a small decrease for high schools with MSP focus on math versus a small increase for high schools *without* MSP focus on math over the period from 2003/04 to 2005/06.

By gender, the largest (2003/04-2005/06) increase in both math and proficiency is at the elementary school level, with the same magnitude for both males and females — specifically, a close to medium effect size math and a small effect size in science. By ethnicity, the largest (2003/04-2005/06) increase in student proficiency is at the elementary school level — for African-American students and Hispanic students in math, and for African American students and Asian students in science. At the middle school level, the increase in math proficiency is relatively small and about the same for all ethnic groups. A close to medium increase in science proficiency for Asian students is followed by a small increase for African-American students, and negligible increase for White and Hispanic students.

For special education students, the largest (2003/04-2005/06) increase in math proficiency, with a small effect size, is at the elementary school level, whereas the largest increase in science for these students is at the middle school level, with a medium to large effect size. For students with limited English proficiency, the largest (2003/04-2005/06) increase in math proficiency, with a medium effect size, is at the elementary school level, whereas the largest increase in science proficiency for these students is at the middle school level, with a small to medium effect size.

Schools by Direction of Change in Math and Science Proficiency

For both math and science, the percentage of schools with an increase in student proficiency is higher than that with a decrease in student proficiency at all school levels over the period from 2003/04 to 2005/06. Also, for schools that fall into the "increase" category, the percentage of schools *with* MSP focus on math (or science) is higher than that of schools *without* MSP focus on math (or science) at the elementary and middle school levels for math (or science). This, however, is not the case at the high school level.

Longitudinal Growth Trajectories in School Math and Science Proficiency

The schools *with* MSP focus on math have higher initial (2003/04) proficiency in math than those *without* MSP focus on math at the elementary and high school levels, but not on the middle school level. On the other side, the schools with MSP focus on science have lower initial proficiency in science than those without MSP focus on science at the elementary school level. The schools with MSP focus on math (or science) increase at higher rate in math (or science) proficiency compared to those without MSP focus on math (or science) at the middle school level. Middle schools with lower "start" (initial proficiency) in math increase at a higher rate in math proficiency across the three years (2003/04-2005/06). High schools with higher "start" (initial proficiency) in science increase with higher rate in science proficiency across the three years (2003/04-2005/06).

Relationship Between Targeted Teacher Participation in MSP-related Activities and Student Proficiency in Math and Science

The relationship between the targeted teacher participation in MSP-related activities and student proficiency is positive (yet, small) at all school levels for mathematics, and positive, and better pronounced, at the high school level for science.

Limitations and Upcoming Analyses

The results in this study must be interpreted with understanding of limitations that stem from restricted MIS data with the Annual K-12 District Survey. One limitation, for example, is the lack of matching data from "control" schools (not involved in MSP) to evaluate the degree to which the changes in students' proficiency in math and science can be attributed to school participation in MSP. That is why this study does not engage in testing a hypothesis about the degree to which the delineated trends in math and science performance of MSP-related schools are different from trends that may exist in non-MSP related schools. A strong insight in this regard, however, is provided by the comparisons of MSP-related schools *with* and *without* MSP focus on math (or science) on different aspects of changes in math (or science) proficiency across the three years — *percent of students at or above proficient*, *distribution of schools by direction of change* (decrease, no change, increase), and *growth trajectories* (initial status in proficiency, rate of change, and interaction between them). Additional evidence about explanatory effects of MSP-related activities in schools on student proficiency in math and science is sought through the fourth research question by analyzing the correlation between the targeted teacher participation in MSP-related activities and student proficiency. Triangulations with findings in other MSP-PE substudies that control for MSP participation of schools (e.g., Wong & Socha, 2008) may provide more evidence on the role of MSP factors in the math and science proficiency of MSP-related schools.

Another potential limitation stems from the lack of MIS data that can be used to equate school proficiency measures in math and science across states. It should be noted, however, that mapping state performance standards on to a common scale (e.g., using *NAEP* data) is a difficult task still challenging the research on large-scale performance analyses (e.g., Braun & Qian, 2007; McLaughlin & Bandeira de Mello, 2003). The purpose of such equating is to take into account differences (in content and passing standards) among state assessments in math and science for the comparison of states on a common scale. Such comparisons, however, are not targeted in this study. Instead, the focus here is on changes and growth trajectories in student math and science proficiency and its relationship with school's targeted teacher participation in MSP-related activities.

When necessary, the aggregation of schools (e.g., by elementary, middle, and high school level) was done not by averaging the proportions of students at or above proficient across schools, but by aggregating the number of students assessed and the number of those who "pass" (at or above proficient) thus producing a "clean" measure of student proficiency at the aggregated school level. Likewise, the measure of school proficiency by direction of change (decrease, no change, increase) in math or science proficiency, used with RQ2, is based on testing for statistical significance of the change for each school, and not on aggregated proportions across schools. When averaging of proportions was necessary with the growth modeling in RQ3, it was done after adjusting the proportions for school size and variability in math and science proficiency.

In upcoming analyses with the continuation of this study, efforts will be directed in reducing validity threats associated with aggregation of student achievement trends across states — e.g., through a) mapping the aforementioned binary scores of change in school math or science proficiency on (IRT derived) scale, b) weighting the proportions of students at or above proficient in math or science, c) using standardized effect sizes, and d) mapping state performance standards on to a common scale when appropriate data (collected outside MIS) is available. Additional analyses that can counteract the limitations with this study are also next steps in the MSP-PE agenda. Such analyses (e.g., using math and science course credit teacher training data) can further expand our understanding of the relationship between MSP-participation and student math and science achievement.

In conclusion, despite limitations in scope and depth of the analysis in this study, due primarily to data restrictions with the MIS Annual K-12 District Survey, the results indicate promising trends and relationships between student proficiency in mathematics and science and MSP-related variables.

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Table 1
Data Sets Used in the Statistical Analysis by Research Questions

Research Question	Data
RQ1: What is the distribution of MSP-related schools across categories of change (increase, decrease, or no change) in math and science proficiency and what is the mean effect size for the categories of significant change (increase or decrease) over the entire three-year period of time (2003/04- 2005/06) for schools *with* MSP focus on the subject (math or science) and schools *without* MSP focus on the subject?	MSP-MIS student achievement data from MSP-related schools in two scenarios: a) using schools that have reported such data for any of the three years (Table 2), and b) using only schools that have reported data across all three years (Table 3).
RQ2: What is the distribution of MSP-related schools across categories of change (increase, decrease, or no change) in math and science proficiency and what is the mean effect size for the categories of significant change (increase or decrease) over the entire three-year period of time (2003/04- 2005/06) for schools *with* MSP focus on the subject (math or science) and schools *without* MSP focus on the subject?	Longitudinal data from schools with MSP-MIS data on student proficiency in math (or science) across all three years (Table 3).
RQ3: What are the longitudinal growth trajectories (initial school performance, rate of change, and interaction between them) in math and science proficiency across the three-year period (2003/04 – 2005/06) for schools *with* MSP focus on the subject (math or science) and schools *without* MSP focus on the subject?	Longitudinal data from schools with MSP-MIS data on student proficiency in math (or science) across all three years (Table 3).The school scores were adjusted for the school's sample size and score variation.
RQ4: What is the relationship between schools' targeted teacher participation in MSP-related activities over the three-year time period and the schools' success in math and science proficiency at the end year of this time period (2005/06)?	Schools for which MSP-MIS data that were available on targeted teacher participation at any of the three years (2003/04-2005/06) and student achievement data for the last year of this time period (2005/06).

Table 2

MSP-MIS Cross-Sectional Data for Number of Schools, Number of Students Assessed and Number of Students at or Above Proficient at State Assessments in Mathematics and Science Across Three School Years: 2003/04, 2004/05, and 2005/06

	MATHEMATICS			SCIENCE		
	Elementary Schools	Middle Schools	High Schools	Elementary Schools	Middle Schools	High Schools
All students						
2003/04	*n* = 53363 pass = 25288 320 schools	*n* = 98270 pass = 35633 227 schools	*n* = 97675 pass = 39774 213 schools	*n* = 10942 pass = 3515 135 schools	*n* = 20682 pass = 8500 96 schools	*n* = 46026 pass = 23858 130 schools
2004/05	*n* = 97534 pass = 59417 586 schools	*n* = 195131 pass = 81836 358 schools	*n* = 166068 pass = 59971 312 schools	*n* = 17826 pass = 8208 204 schools	*n* = 52907 pass = 30870 192 schools	*n* = 104732 pass = 38063 210 schools
2005/06	*n* = 164369 pass = 107039 762 schools	*n* = 318916 pass = 152851 521 schools	*n* = 199838 pass = 72493 381 schools	*n* = 33859 pass = 20388 308 schools	*n* = 93200 pass = 47019 275 schools	*n* = 121547 pass = 46884 251 schools
Males						
2003/04	*n* = 26975 pass = 12602 (320 schools)	*n* = 49878 pass = 17866 (227 schools)	*n* = 49044 pass = 20049 (213 schools)	*n* = 5348 pass = 1686 (135 schools)	*n* = 10513 pass = 4417 (96 schools)	*n* = 23015 pass = 12165 (130 schools)
2004/05	*n* = 44102 pass = 26046 (490 schools)	*n* = 81262 pass = 30874 (293 schools)	*n* = 78859 pass = 27307 (266 schools)	*n* = 7921 pass = 3253 (193 schools)	*n* = 15086 pass = 7627 (142 schools)	*n* = 49283 pass = 17696 (173 schools)
2005/06	*n* = 78846 pass = 49611 (704 schools)	*n* = 143821 pass = 69459 (471 schools)	*n* = 88549 pass = 34086 (345 schools)	*n* = 16382 pass = 9850 (285 schools)	*n* = 44461 pass = 23316 (255 schools)	*n* = 58106 pass = 23317 (227 schools)
Females						
2003/04	*n* = 26064 pass = 12553 (320 schools)	*n* = 48361 pass = 17749 (227 schools)	*n* = 48245 pass = 19476 (213 schools)	*n* = 5350 pass = 1720 (135 schools)	*n* = 10156 pass = 4077 (96 schools)	*n* = 22853 pass = 11589 (130 schools)
2004/05	*n* = 42317 pass = 25515 (490 schools)	*n* = 79609 pass = 30329 (293 schools)	*n* = 77105 pass = 26515 (266 schools)	*n* = 7700 pass = 3120 (193 schools)	*n* = 14535 pass = 7103 (142 schools)	*n* = 48086 pass = 16421 (173 schools)
2005/06	*n* = 75919 pass = 48491 (704 schools)	*n* = 140155 pass = 69807 (471 schools)	*n* = 87706 pass = 33688 (345 schools)	*n* = 15960 pass = 9750 (285 schools)	*n* = 43851 pass = 22309 (254 schools)	*n* = 57726 pass = 21908 (225 schools)

Table 2 (continued)

	MATHEMATICS			SCIENCE		
	Elementary Schools	*Middle* Schools	*High* Schools	*Elementary* Schools	*Middle* Schools	*High* Schools
White						
2003/04	*n* = 12333 pass = 9318 (320 schools)	*n* = 26345 pass = 17108 (227 schools)	*n* = 20916 pass = 13044 (213 schools)	*n* = 4476 pass = 1998 (135 schools)	*n* = 8798 pass = 5560 (96 schools)	*n* = 13160 pass = 9535 (130 schools)
2004/05	*n* = 27473 pass = 21611 (495 schools)	*n* = 47433 pass = 32551 (329 schools)	*n* = 34966 pass = 21716 (283 schools)	*n* = 5984 pass = 3606 (193 schools)	*n* = 14890 pass = 10435 (170 schools)	*n* = 22800 pass = 15768 (190 schools)
2005/06	*n* = 62575 pass = 46465 (704 schools)	*n* = 99768 pass = 68278 (467 schools)	*n* = 39926 pass = 25129 (329 schools)	*n* = 10174 pass = 7200 (281 schools)	*n* = 22604 pass = 16559 (241 schools)	*n* = 23471 pass = 16540 (209 schools)
African American						
2003/04	*n* = 6668 pass = 2386 (320 schools)	*n* = 13227 pass = 3032 (227 schools)	*n* = 8394 pass = 2292 (213 schools)	*n* = 1320 pass = 229 (135 schools)	*n* = 5031 pass = 875 (96 schools)	*n* = 5296 pass = 2445 (130 schools)
2004/05	*n* = 14653 pass = 7037 (418 schools)	*n* = 24594 pass = 6743 (296 schools)	*n* = 16843 pass = 3936 (259 schools)	*n* = 2340 pass = 737 (125 schools)	*n* = 6463 pass = 1843 (141 schools)	*n* = 11658 pass = 3390 (166 schools)
2005/06	*n* = 38796 pass = 24190 (616 schools)	*n* = 48151 pass = 18776 (417 schools)	*n* = 18756 pass = 5756 (291 schools)	*n* = 12669 pass = 8774 (205 schools)	*n* = 21116 pass = 8302 (196 schools)	*n* = 13106 pass = 4687 (177 schools)
Hispanic/Latino						
2003/04	*n* = 30588 pass = 11514 (320 schools)	*n* = 48220 pass = 9555 (227 schools)	*n* = 61155 pass = 20766 (213 schools)	*n* = 3835 pass = 803 (135 schools)	*n* = 4386 pass = 1027 (96 schools)	*n* = 22838 pass = 9148 (130 schools)
2004/05	*n* = 44831 pass = 24143 (586 schools)	*n* = 102259 pass = 31277 (358 schools)	*n* = 100665 pass = 28611 (312 schools)	*n* = 8178 pass = 3327 (204 schools)	*n* = 26366 pass = 16635 (192 schools)	*n* = 60487 pass = 14577 (210 schools)
2005/06	*n* = 46059 pass = 23164 (762 schools)	*n* = 123816 pass = 44444 (521 schools)	*n* = 107894 pass = 32418 (381 schools)	*n* = 7712 pass = 2662 (308 schools)	*n* = 39578 pass = 17344 (275 schools)	*n* = 68828 pass = 18339 (251 schools)
Asian						
2003/04	*n* = 399 pass = 291 (320 schools)	*n* = 5380 pass = 3905 (227 schools)	*n* = 3903 pass = 2175 (213 schools)	*n* = 248 pass = 119 (135 schools)	*n* = 627 pass = 286 (96 schools)	*n* = 2326 pass = 1595 (130 schools)
2004/05	*n* = 1202 pass = 831 (417 schools)	*n* = 7516 pass = 5350 (298 schools)	*n* = 5431 pass = 2503 (257 schools)	*n* = 259 pass = 162 (125 schools)	*n* = 762 pass = 435 (139 schools)	*n* = 4399 pass = 2439 (165 schools)
2005/06	*n* = 1918 pass = 1414 (614 schools)	*n* = 10863 pass = 8223 (407 schools)	*n* = 6066 pass = 3048 (285 schools)	*n* = 493 pass = 357 (204 schools)	*n* = 3129 pass = 2420 (197 schools)	*n* = 4492 pass = 2639 (174 schools)
Other						
2003/04	*n* = 914 pass = 394 (320 schools)	*n* = 2052 pass = 789 (227 schools)	*n* = 849 pass = 266 (213 schools)	*n* = 278 pass = 33 (135 schools)	*n* = 256 pass = 75 (96 schools)	*n* = 221 pass = 48 (130 schools)
2004/05	*n* = 1306 pass = 808 (586 schools)	*n* = 2578 pass = 1170 (358 schools)	*n* = 2307 pass = 520 (312 schools)	*n* = 141 pass = 54 (204 schools)	*n* = 319 pass = 98 (192 schools)	*n* = 1523 pass = 311 (210 schools)
2005/06	*n* = 2698 pass = 1549 (762 schools)	*n* = 3590 pass = 1560 (521 schools)	*n* = 2165 pass = 555 (381 schools)	*n* = 522 pass = 364 (308 schools)	*n* = 990 pass = 526 (275 schools)	*n* = 1543 pass = 451 (251 schools)

Table 2 (continued)

	MATHEMATICS			SCIENCE		
	Elementary Schools	Middle Schools	High Schools	Elementary Schools	Middle Schools	High Schools
Special Education Students						
2003/04	*n* = 4748 pass = 1451 (320 schools)	*n* = 9071 pass = 1352 (227 schools)	*n* = 6874 pass = 1020 (213 schools)	*n* = 993 pass = 157 (135 schools)	*n* = 2797 pass = 552 (96 schools)	*n* = 2526 pass = 712 (130 schools)
2004/05	*n* = 8864 pass = 3108 (431 schools)	*n* = 13436 pass = 2301 (255 schools)	*n* = 9772 pass = 1490 (242 schools)	*n* = 1419 pass = 411 (142 schools)	*n* = 3361 pass = 853 (118 schools)	*n* = 5945 pass = 1011 (163 schools)
2005/06	*n* = 16013 pass = 6538 (635 schools)	*n* = 21657 pass = 4161 (395 schools)	*n* = 10042 pass = 1679 (247 schools)	*n* = 3072 pass = 1554 (221 schools)	*n* = 6847 pass = 1599 (208 schools)	*n* = 6206 pass = 1056 (163 schools)

Limited English Proficiency Students						
2003/04	*n* = 21867 pass = 7334 (320 schools)	*n* = 33610 pass = 5226 (227 schools)	*n* = 26748 pass = 4323 (213 schools)	*n* = 1770 pass = 134 (135 schools)	*n* = 1135 pass = 121 (96 schools)	*n* = 8269 pass = 829 (130 schools)
2004/05	*n* = 30413 pass = 14462 (420 schools)	*n* = 64655 pass = 12509 (239 schools)	*n* = 63460 pass = 8991 (232 schools)	*n* = 3713 pass = 438 (133 schools)	*n* = 1363 pass = 188 (97 schools)	*n* = 45470 pass = 4692 (150 schools)
2005/06	*n* = 31687 pass = 14782 (625 schools)	*n* = 53339 pass = 10378 (387 schools)	*n* = 41657 pass = 5858 (249 schools)	*n* = 3480 pass = 583 (217 schools)	*n* = 10503 pass = 1344 (196 schools)	*n* = 23481 pass = 1757 (155 schools)

Note. *n* = number of students assessed; pass = number of students who “pass” (at or above proficient) the state assessment.

Table 3

MSP-MIS Longitudinal Data for Number of Students Assessed and Number of Students at or Above Proficient at State Assessments in Mathematics and Science – Same Schools Across Years 2003/04, 2004/05, and 2005/06

	MATHEMATICS			SCIENCE		
	Elementary Schools	Middle Schools	High Schools	Elementary Schools	Middle Schools	High Schools
All students						
2003/04	*n* = 44409 pass = 20405 (245 schools)	*n* = 90046 pass = 32714 (196 schools)	*n* = 94878 pass = 38417 (192 schools)	*n* = 9417 pass = 2747 (114 schools)	*n* = 11099 pass = 5273 (57 schools)	*n* = 44492 pass = 22814 (116 schools)
2004/05	*n* = 46523 pass = 26732 (245 schools)	*n* = 110187 pass = 41361 (196 schools)	*n* = 122847 pass = 41975 (192 schools)	*n* = 9336 pass = 3290 (114 schools)	*n* = 10873 pass = 5329 (57 schools)	*n* = 75218 pass = 26111 (116 schools)
2005/06	*n* = 57577 pass = 33942 (245 schools)	*n* = 119893 pass = 48170 (196 schools)	*n* = 124088 pass = 42758 (192 schools)	*n* = 9065 pass = 3480 (114 schools)	*n* = 10750 pass = 5480 (57 schools)	*n* = 77832 pass = 27048 (116 schools)
Males						
2003/04	*n* = 22576 pass = 10209 (241 schools)	*n* = 45697 pass = 16398 (198 schools)	*n* = 47681 pass = 19378 (194 schools)	*n* = 4741 pass = 1363 (114 schools)	*n* = 5596 pass = 2691 (57 schools)	*n* = 22278 pass = 11671 (116 schools)
2004/05	*n* = 23412 pass = 13263 (245 schools)	*n* = 54941 pass = 20618 (196 schools)	*n* = 61216 pass = 20922 (192 schools)	*n* = 4667 pass = 1635 (114 schools)	*n* = 4932 pass = 2509 (57 schools)	*n* = 37567 pass = 13311 (116 schools)
2005/06	*n* = 29084 pass = 16364 (245 schools)	*n* = 59993 pass = 22244 (196 schools)	*n* = 61467 pass = 21186 (192 schools)	*n* = 4484 pass = 1678 (114 schools)	*n* = 4864 pass = 2575 (57 schools)	*n* = 38776 pass = 13838 (116 schools)
Females						
2003/04	*n* = 21823 pass = 10190 (241 schools)	*n* = 44326 pass = 16300 (198 schools)	*n* = 46886 pass = 18850 (194 schools)	*n* = 4669 pass = 1384 (114 schools)	*n* = 5495 pass = 2580 (57 schools)	*n* = 22119 pass = 11095 (116 schools)
2004/05	*n* = 22485 pass = 13100 (245 schools)	*n* = 53762 pass = 20190 (196 schools)	*n* = 59444 pass = 20235 (192 schools)	*n* = 4558 pass = 1584 (114 schools)	*n* = 4772 pass = 2410 (57 schools)	*n* = 36432 pass = 12345 (116 schools)
2005/06	*n* = 27952 pass = 16092 (245 schools)	*n* = 58346 pass = 22195 (196 schools)	*n* = 59793 pass = 20464 (192 schools)	*n* = 4430 pass = 1705 (114 schools)	*n* = 4762 pass = 2476 (57 schools)	*n* = 37791 pass = 12729 (116 schools)

Table 3 (continued)

	MATHEMATICS			SCIENCE		
	Elementary Schools	Middle Schools	High Schools	Elementary Schools	Middle Schools	High Schools
White						
2003/04	*n* = 10257 pass = 7847 (241 schools)	*n* = 24747 pass = 16068 (198 schools)	*n* = 20268 pass = 12526 (194 schools)	*n* = 4354 pass = 1921 (114 schools)	*n* = 5697 pass = 3576 (57 schools)	*n* = 12496 pass = 8974 (116 schools)
2004/05	*n* = 11437 pass = 8950 (245 schools)	*n* = 27964 pass = 19280 (196 schools)	*n* = 23855 pass = 14450 (192 schools)	*n* = 4249 pass = 2253 (114 schools)	*n* = 5707 pass = 3629 (57 schools)	*n* = 16275 pass = 10818 (116 schools)
2005/06	*n* = 20064 pass = 13759 (245 schools)	*n* = 35201 pass = 21672 (196 schools)	*n* = 22930 pass = 14368 (192 schools)	*n* = 4121 pass = 2240 (114 schools)	*n* = 5457 pass = 3641 (57 schools)	*n* = 15995 pass = 10755 (116 schools)
African American						
2003/04	*n* = 4962 pass = 1732 (241 schools)	*n* = 10517 pass = 2583 (198 schools)	*n* = 8178 pass = 2234 (194 schools)	*n* = 1122 pass = 145 (114 schools)	*n* = 2109 pass = 348 (57 schools)	*n* = 5215 pass = 2395 (116 schools)
2004/05	*n* = 5122 pass = 2233 (245 schools)	*n* = 15262 pass = 3617 (196 schools)	*n* = 10659 pass = 2356 (192 schools)	*n* = 1011 pass = 202 (114 schools)	*n* = 1921 pass = 469 (57 schools)	*n* = 7516 pass = 2400 (116 schools)
2005/06	*n* = 4825 pass = 2015 (245 schools)	*n* = 15947 pass = 3141 (196 schools)	*n* = 10273 pass = 2817 (192 schools)	*n* = 886 pass = 255 (114 schools)	*n* = 2090 pass = 487 (57 schools)	*n* = 7314 pass = 2736 (116 schools)
Hispanic/Latino						
2002/03	*n* = 126 pass = 90 (24 schools)	*n* = 611 pass = 261 (15 schools)	*n* = 1011 pass = 419 (8 schools)	*n* = 26 pass = 21 (9 schools)	*n* = 16 pass = 15 (5 schools)	*n* = 19 pass = 17 (2 schools)
2003/04	*n* = 27653 pass = 10027 (241 schools)	*n* = 45166 pass = 8537 (198 schools)	*n* = 59563 pass = 20152 (194 schools)	*n* = 3138 pass = 402 (114 schools)	*n* = 1152 pass = 434 (57 schools)	*n* = 22703 pass = 9085 (116 schools)
2004/05	*n* = 28005 pass = 14540 (245schools)	*n* = 56823 pass = 12247 (196 schools)	*n* = 79291 pass = 21548 (192 schools)	*n* = 3180 pass = 516 (114 schools)	*n* = 1252 pass = 457 (57 schools)	*n* = 44911 pass = 9872 (116 schools)
2005/06	*n* = 28894 pass = 15123 (245 schools)	*n* = 57472 pass = 13514 (196 schools)	*n* = 81397 pass = 21666 (192 schools)	*n* = 3088 pass = 620 (114 schools)	*n* = 1375 pass = 566 (57 schools)	*n* = 47921 pass = 10351 (116 schools)
Asian						
2003/04	*n* = 398 pass = 290 (241 schools)	*n* = 5369 pass = 3900 (198 schools)	*n* = 3888 pass = 2161 (194 schools)	*n* = 248 pass = 119 (114 schools)	*n* = 443 pass = 231 (57 schools)	*n* = 2290 pass = 1564 (116 schools)
2004/05	*n* = 237 pass = 180 (245 schools)	*n* = 5675 pass = 4408 (196 schools)	*n* = 4281 pass = 2021 (192 schools)	*n* = 97 pass = 65 (114 schools)	*n* = 341 pass = 226 (57 schools)	*n* = 3574 pass = 2109 (116 schools)
2005/06	*n* = 459 pass = 347 (245 schools)	*n* = 6305 pass = 4862 (196 schools)	*n* = 4352 pass = 2150 (192 schools)	*n* = 89 pass = 68 (114 schools)	*n* = 326 pass = 224 (57 schools)	*n* = 3525 pass = 2178 (116 schools)
Other						
2003/04	*n* = 844 pass = 370 (241 schools)	*n* = 2032 pass = 788 (198 schools)	*n* = 828 pass = 264 (194 schools)	*n* = 273 pass = 33 (114 schools)	*n* = 182 pass = 53 (57 schools)	*n* = 203 pass = 45 (116 schools)
2004/05	*n* = 735 pass = 401 (245 schools)	*n* = 2078 pass = 879 (196 schools)	*n* = 2113 pass = 477 (192 schools)	*n* = 89 pass = 17 (114 schools)	*n* = 153 pass = 36 (57 schools)	*n* = 1341 pass = 277 (116 schools)
2005/06	*n* = 852 pass = 362 (245 schools)	*n* = 2083 pass = 710 (196 schools)	*n* = 1742 pass = 390 (schools)	*n* = 122 pass = 24 (114 schools)	*n* = 131 pass = 35 (57 schools)	*n* = 1366 pass = 378 (116 schools)

Table 3 (continued)

	MATHEMATICS			SCIENCE		
	Elementary Schools	Middle Schools	High Schools	Elementary Schools	Middle Schools	High Schools
Special Education Students						
2003/04	*n* = 3742 pass = 1111 (241 schools)	*n* = 8013 pass = 1257 (198 schools)	*n* = 6754 pass = 991 (194 schools)	*n* = 825 pass = 123 (114 schools)	*n* = 1427 pass = 341 (57 schools)	*n* = 2471 pass = 685 (116 schools)
2004/05	*n* = 3828 pass = 1277 (245 schools)	*n* = 6954 pass = 1251 (196 schools)	*n* = 6447 pass = 1110 (192 schools)	*n* = 576 pass = 121 (114 schools)	*n* = 1304 pass = 246 (57 schools)	*n* = 3892 pass = 647 (116 schools)
Limited English Proficiency Students						
2003/04	*n* = 20830 pass = 6968 (241 schools)	*n* = 32161 pass = 4817 (198 schools)	*n* = 26160 pass = 4229 (194 schools)	*n* = 1629 pass = 97 (114 schools)	*n* = 349 pass = 77 (57 schools)	*n* = 8247 pass = 820 (116 schools)
2004/05	*n* = 23348 pass = 11839 (245 schools)	*n* = 51336 pass = 10777 (196 schools)	*n* = 54002 pass = 7918 (192 schools)	*n* = 2031 pass = 151 (114 schools)	*n* = 347 pass = 100 (57 schools)	*n* = 37586 pass = 3895 (116 schools)
2005/06	*n* = 23501 pass = 11912 (245 schools)	*n* = 35138 pass = 6677 (196 schools)	*n* = 33713 pass = 5076 (192 schools)	*n* = 1794 pass = 217 (114 schools)	*n* = 436 pass = 155 (57 schools)	*n* = 17566 pass = 1332 (116 schools)

Note. *n* = number of students assessed; pass = number of students who “pass” (at or above proficient) the state assessment.

Table 4
Longitudinal School Changes in Mathematics Proficiency

School Year	Percent Proficient Students		Effect Size (*ES*) of Change	
	MSP FOCUS ON MATH		MSP FOCUS ON MATH	
	YES	NO	YES	NO
Elementary Schools			Year 2–Year 3 (2003/04-04/05)	
2003/04	41.39% Students: 37,252 Schools: 160	69.65% 7,157 81	Increase *ES* = +.28	Decrease *ES* = -.08
			Year 2–Year 4 (2003/04-05/06)	
2004/05	55.53% Students: 38,033 Schools: 160	66.09% 8,490 85	Increase *ES* = +.35	Decrease *ES* = -.22
2005/06	58.95% Students: 39,373 Schools: 160	58.96% 18,204 85		
Middle Schools			Year 2–Year 3 (2003/04-04/05)	
2003/04	28.82% Students: 70,801 Schools: 151	63.95% 19,245 47	Increase *ES* = +.05	Increase *ES* = +.09
			Year 2–Year 4 (2003/04-05/06)	
2004/05	31.26% Students: 91,366 Schools: 153	68.02% 18,821 43	Increase *ES* = +.14	Decrease *ES* = -.10
2005/06	35.14% Students: 94,908 Schools: 153	59.32% 24,985 43		
High Schools			Year 2–Year 3 (2003/04-04/05)	
2003/04	39.53% Students: 84,574 147	48.37% 10,304 47	Decrease *ES* = -.14	No Change
			Year 2–Year 4 (2003/04-05/06)	
2004/05	32.89% Students: 112,811 Schools: 145	48.58% 10,036 47	Decrease *ES* = -.15	Increase *ES* = +.20
2005/06	32.44% Students: 114,441 Schools : 145	58.44% 9,647 47		

Table 5
Longitudinal School Changes in Mathematics Proficiency by Gender

Gender	School level	MSP Focus on Math	Percent at or above proficient			Change *Effect Size*	
			Year 2 2003/04	Year 3 2004/05	Year 4 2005/06	Year 2-3	Year 2-4
Males	Elementary	YES	40.73	54.69	57.90	.280	.345
		NO	69.12	65.52	52.68	-.077	-.339
	Middle	YES	28.28	31.15	34.74	.063	.139
		NO	63.69	67.73	45.79	.085	-.362
	High	YES	39.77	33.02	32.40	-.140	-.154
		NO	47.60	46.85	57.89	-.015	.206
Females	Elementary	YES	42.07	56.30	59.68	.286	.354
		NO	70.18	66.69	53.13	-.075	-.353
	Middle	YES	29.36	31.16	35.59	.039	.133
		NO	64.20	68.34	47.24	.087	-.343
	High	YES	39.13	32.57	32.12	-.137	-.146
		NO	49.24	50.38	59.03	.023	.197

Table 6

Longitudinal School Changes in Mathematics Proficiency by Ethnicity

Ethnicity	School level	MSP Focus on Math	Percent at or above proficient			Change *Effect Size*	
			Year 2 2003/04	Year 3 2004/05	Year 4 2005/06	Year 2-3	Year 2-4
White	Elementary	YES	78.96	81.61	83.56	.070	.120
		NO	73.94	74.65	59.92	No change	-.300
	Middle	YES	60.96	66.5711	69.9493	.120	.190
		NO	70.26	73.33	49.56	.070	-.426
	High	YES	63.60	60.51	61.73	-.064	-.039
		NO	57.10	60.78	65.83	.075	.180
African-American	Elementary	YES	27.64	38.57	45.48	.233	.373
		NO	75.46	77.86	12.10	.057	-1.394
	Middle	YES	15.16	17.69	17.69	.068	.152
		NO	69.99	70.86	8.69	.019	-1.384
	High	YES	25.45	20.82	23.35	-.110	-.049
		NO	33.46	28.18	47.02	-.114	.278
Hispanic	Elementary	YES	35.86	52.52	54.17	.337	.370
		NO	48.73	39.64	30.12	-.183	-.383
	Middle	YES	18.31	20.93	23.77	.066	.134
		NO	27.29	33.79	19.33	.141	-.189
	High	YES	33.83	27.10	26.20	-.146	-.167
		NO	33.94	30.67	46.13	-.070	.249
Asian	Elementary	YES	79.08	75.59	80.64	No change	No change
		NO	66.83	79.17	52.44	No change	-.2945
	Middle	YES	62.20	66.04	69.18	.080	.147
		NO	84.44	87.25	83.69	.080	-.021
	High	YES	54.50	45.55	46.05	-.179	-.169
		NO	59.73	57.91	69.56	-.037	.206
Race not reported	Elementary	YES	47.60	39.70	63.12	-.167	.306
		NO	38.46	44.29	98.33	.118	1.545
	Middle	YES	37.52	36.34	32.35	-.024	-.109
		NO	38.65	44.36	36.02	.120	-.050
	High	YES	50.64	42.30	40.06	-.168	-.213
		NO	31.48	43.37	42.86	.246	.236
Other	Elementary	YES	41.85	56.35	50.66	.291	.177
		NO	47.60	49.48	29.23	.038	-.380
	Middle	YES	27.11	34.16	37.54	.153	.224
		NO	57.75	61.45	27.65	.075	-.619
	High	YES	32.36	22.23	20.91	-.228	-.260
		NO	29.66	29.41	56.16	No change	.543

Table 7
Longitudinal School Changes in Mathematics Proficiency for Special Education and Limited English Proficiency Students

Special education and LEP	School level	MSP Focus on Math	Percent at or above proficient			Change *Effect Size*	
			Year 2 2003/04	Year 3 2004/05	Year 4 2005/06	Year 2-3	Year 2-4
Special Education	Elementary	YES	25.50	29.69	37.97	.094	.269
		NO	42.29	45.81	25.57	.071	-.356
	Middle	YES	10.39	12.95	16.06	.080	.168
		NO	31.21	31.23	9.75	No change	-.550
	High	YES	13.94	17.48	17.48	.097	.0165
		NO	17.62	16.20	30.71	No change	.3083
Limited English Proficiency	Elementary	YES	33.34	51.39	52.24	.367	.384
		NO	38.66	27.70	16.92	-.234	-.494
	Middle	YES	14.49	20.82	19.22	.167	.127
		NO	22.72	25.83	15.12	.072	-.195
	High	YES	15.74	14.48	14.56	-.035	-.0328
		NO	28.33	25.61	36.70	No change	.179

Table 8

Longitudinal School Changes in Science Proficiency

School Year	Percent Proficient Students		Effect Size (*ES*) of Change	
	MSP FOCUS ON SCIENCE		MSP FOCUS ON SCIENCE	
	YES	NO	YES	NO
Elementary Schools			Year 2–Year 3 (2003/04-04/05)	
2003/04	23.28% Students: 7,696 Schools: 96	55.49% 1,721 18	Increase *ES* = +.16	No Change
2004/05	30.33% Students: 7,678 Schools: 96	57.96% 1,658 18	Year 2–Year 4 (2003/04-05/06)	
2005/06	33.39% Students: 7,473 Schools: 96	58.96% 1,592 18	Increase *ES* = +.22	Increase *ES* = +.13
Middle Schools			Year 2–Year 3 (2003/04-04/05)	
2003/04	44.43% Students: 9,679 Schools: 51	68.52% 1,420 6	No Change	Increase *ES* = +.14
2004/05	45.09% Students: 9,430 Schools: 51	74.64% 1,443 6	Year 2–Year 4 (2003/04-05/06)	
2005/06	48.48% Students: 9,299 Schools: 51	66.99% 1,451 6	Increase *ES* = +.08	No Change
High schools			Year 2–Year 3 (2003/04-04/05)	
2003/04	49.50% Students: 41,638 Schools: 104	77.22% 2,854 12	Decrease *ES* = -.36	Increase *ES* = +.11
2004/05	31.99% Students: 71,083 Schools: 104	81.62% 4,135 12	Year 2–Year 4 (2003/04-05/06)	
2005/06	32.07% Students: 73,709 Schools : 104	82.78% 4,123 12	Decrease *ES* = -.36	Increase *ES* = +.14

Table 9
Longitudinal School Changes in Science Proficiency by Gender

Gender	School level	MSP Focus on Science	Percent at or above proficient			Change *Effect Size*	
			Year 2 2003/04	Year 3 2004/05	Year 4 2005/06	Year 2-3	Year 2-4
Males	Elementary	YES	22.56	29.52	31.78	.159	.208
		NO	56.19	59.33	64.35	.064	.167
	Middle	YES	44.95	46.88	50.26	.039	.106
		NO	69.77	74.86	67.36	.114	-.052
	High	YES	50.74	32.82	33.12	-.366	-.359
		NO	76.87	80.38	82.65	.086	.144
Females	Elementary	YES	24.06	30.16	33.75	.138	.214
		NO	54.77	56.48	59.51	.034	.096
	Middle	YES	43.93	46.12	49.53	.044	.112
		NO	67.28	74.42	74.42	.158	No change
	High	YES	48.24	30.93	30.77	-.356	-.360
		NO	77.57	82.86	82.90	.133	.134

Table 10

Longitudinal School Changes in Science Proficiency by Ethnicity

Ethnicity	School level	MSP Focus on Science	Percent at or above proficient			Change *Effect Size*	
			Year 2 2003/04	Year 3 2004/05	Year 4 2005/06	Year 2-3	Year 2-4
White	Elementary	YES	35.01	45.35	47.20	.210	.250
		NO	81.91	85.84	86.53	.107	.127
	Middle	YES	57.95	57.91	62.18	No change	.0864
		NO	93.63	93.63	90.00	No change	-.133
	High	YES	69.26	61.76	62.55	-.158	-.142
		NO	90.72	91.35	91.42	No change	No change
African-American	Elementary	YES	6.34	13.37	22.14	.240	.471
		NO	42.03	47.45	50.98	.109	.180
	Middle	YES	15.84	22.00	23.50	23.500	.193
		NO	19.26	34.21	22.49	.340	No change
	High	YES	40.24	24.57	30.46	-.337	-.205
		NO	62.4251	63.7845	66.7620	No change	.091
Hispanic	Elementary	YES	11.41	15.08	17.89	.108	.184
		NO	19.00	21.29	30.04	No change	.258
	Middle	YES	37.31	35.88	41.46	No change	.085
		NO	43.06	46.05	36.96	No change	No change
	High	YES	40.00	21.94	21.56	-.394	-.404
		NO	64.70	79.41	73.53	No change	No change
Asian	Elementary	YES	35.46	47.50	56.00	.250	.415
		NO	76.32	80.70	84.38	No change	No change
	Middle	YES	49.74	62.50	67.16	.258	.355
		NO	69.09	81.16	76.36	No change	No change
	High	YES	68.30	58.42	61.21	-.206	-.149
		NO	66.6667	82.7586	85.5422	No change	No change
Race not reported	Elementary	YES	45.20	33.38	35.80	-.243	-.192
		NO	NO data available				
	Middle	YES	37.59	34.16	38.44	-.072	No change
		NO	NO data available				
	High	YES	47.38	39.67	37.90	-.156	-.192
		NO	NO data	33.3333	75.0000	--	--
Other	Elementary	YES	9.96	14.47	14.15	No change	No change
		NO	58.33	46.15	56.25	No change	No change
	Middle	YES	28.81	20.98	25.40	No change	No change
		NO	40.00	60.00	60.00	No change	No change
	High	YES	21.10	20.14	20.14	No change	.148
		NO	75.00	90.00	100.0	No change	No change

Table 11

Longitudinal School Changes in Science Proficiency for Special Education and Limited English Proficiency Students

Special education and LEP	School level	MSP Focus on Science	Percent at or above proficient			Change *Effect Size*	
			Year 2 2003/04	Year 3 2004/05	Year 4 2005/06	Year 2-3	Year 2-4
Special Education	Elementary	YES	10.44	13.20	17.67	No change	.210
		NO	.1485	37.91	44.14	No change	.281
	Middle	YES	32.20	23.08	60.00	No change	.565
		NO	38.56	41.57	33.86	No change	No change
	High	YES	27.71	15.65	15.48	-.295	-.300
		NO	27.84	33.98	33.98	No change	.3575
Limited English Proficiency	Elementary	YES	4.69	6.19	10.23	.066	.214
		NO	11.85	14.52	23.08	No change	.299
	Middle	YES	20.00	29.54	33.42	.222	.305
		NO	32.20	23.08	60.00	No change	.565
	High	YES	9.95	10.35	7.57	No change	-.084
		NO	NO data	60.00	33.33	NO data	NO data

Table 12

Growth Trajectories of Schools in Math and Science Proficiency Across Three Years 2003/04-2005/06) – Relationships Between Initial Status of School Proficiency, Rate of Change, and MSP Focus on Math (or Science)

Subject/School level	Tests of Model Fit			Parameter Estimates		
	CFI	TFI	SRMR	Initial Status on MSP Focus	Rate of Change on MSP Focus	Initial Status correlated with Rate of Change
MATH Elementary schools	.844	.833	.079	0.33*	-0.04	-0.30
MATH Middle schools	.959	.876	.035	-1.46**	0.25*	-.53*
MATH High schools	.976	.927	.032	0.37*	-0.01	0.09
SCIENCE Elementary schools	.977	.932	.026	-1.63**	0.01	0.01
SCIENCE Middle schools	.963	.888	.105	-1.27	0.35*	-0.17
SCIENCE High schools	0.999	0.999	.041	-0.56	-0.35	0.25*

Note. * $p < .05$; ** $p < .01$.

Table 13
Correlations Between Teacher Participation in MSP Activities Across Three Years (2003/04, 2004/05, 2005/06) and Student Proficiency at the End Year (2005/06)

Subject/ School level	*r*	*N*	*n*
Mathematics			
Elementary	.093*	498	109,981
Middle	.149*	293	230,525
High	.241**	286	162,342
Science			
Elementary	.105	210	18,292
Middle	.027	209	67,629
High	.473**	188	101,692

Note. *N* = number of schools (used for the calculation of the correlation coefficient, *r*); *n* = number of students who have taken the state assessment in these schools; $*p < .05$, $** p < .01$.

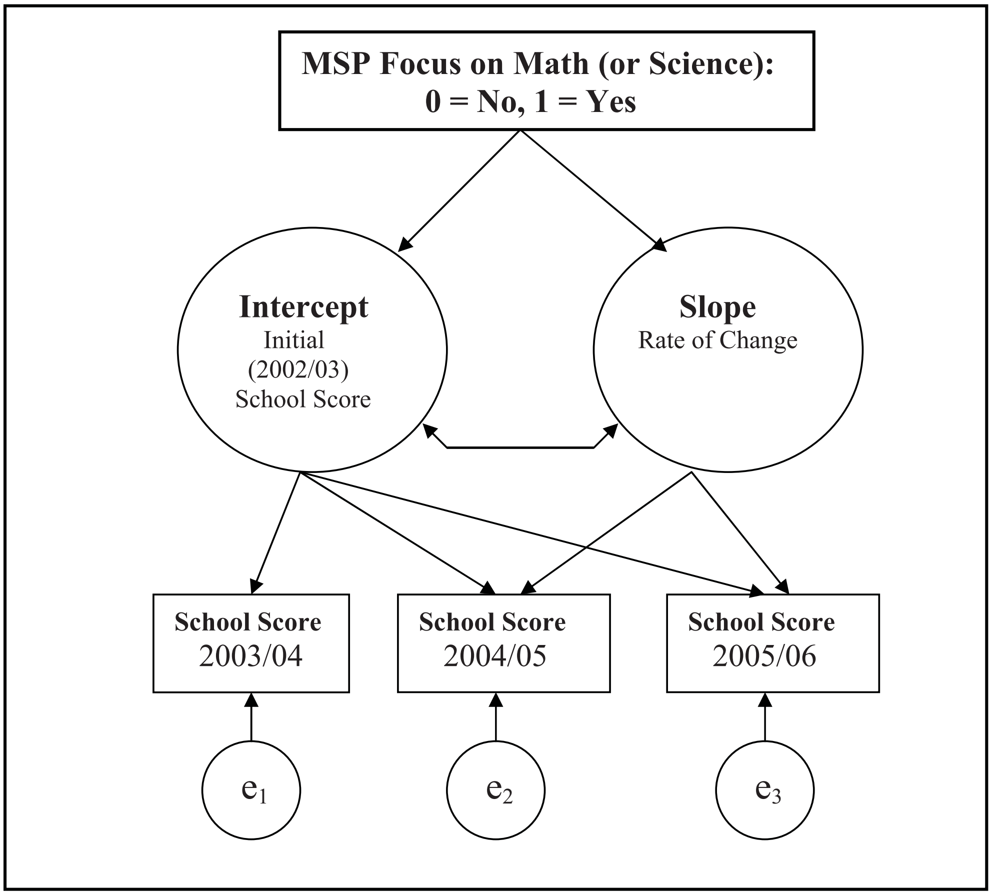


Figure 1. Longitudinal growth model of changes in school math and science proficiency across three years (2003/04-2005/06).

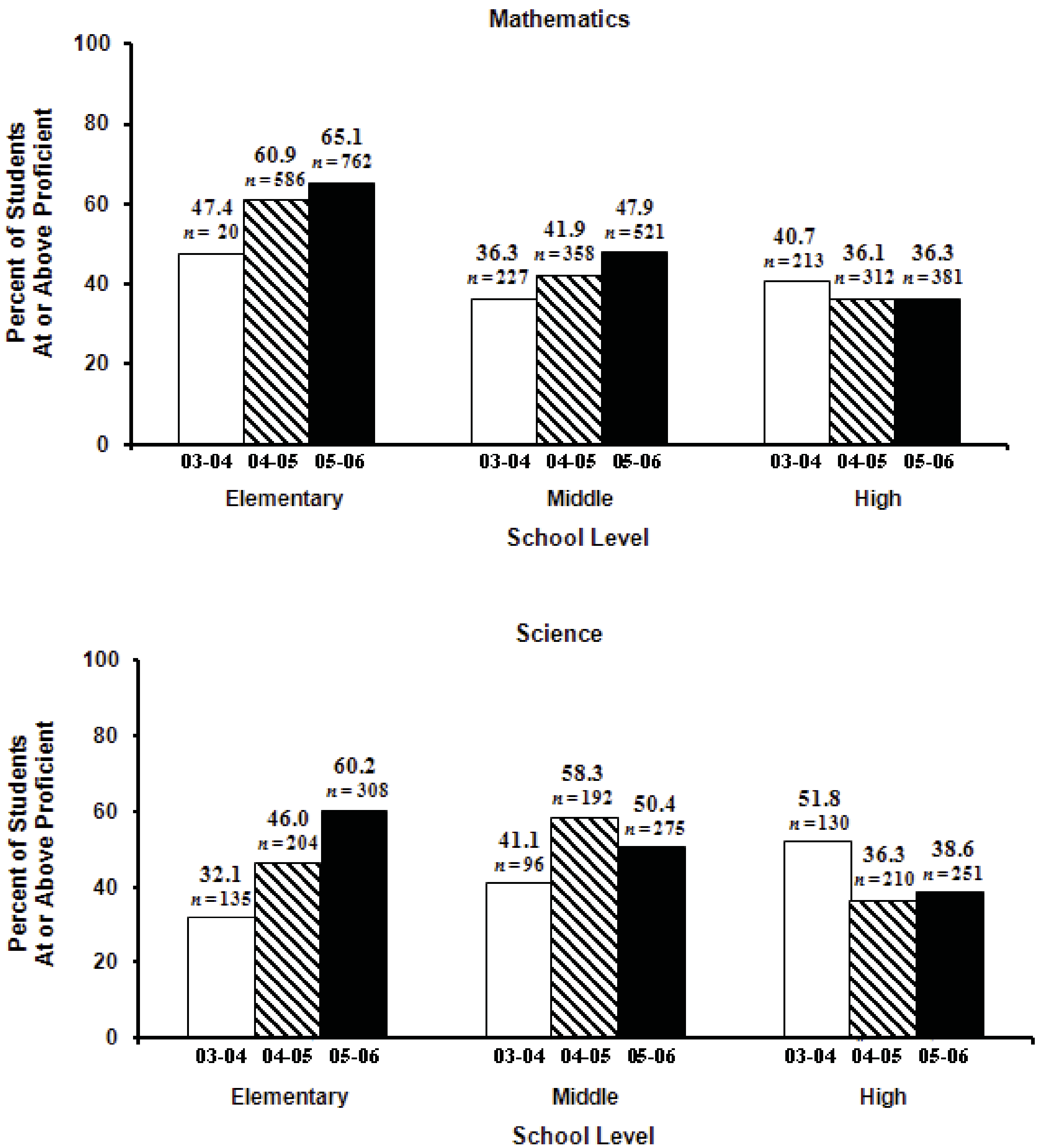
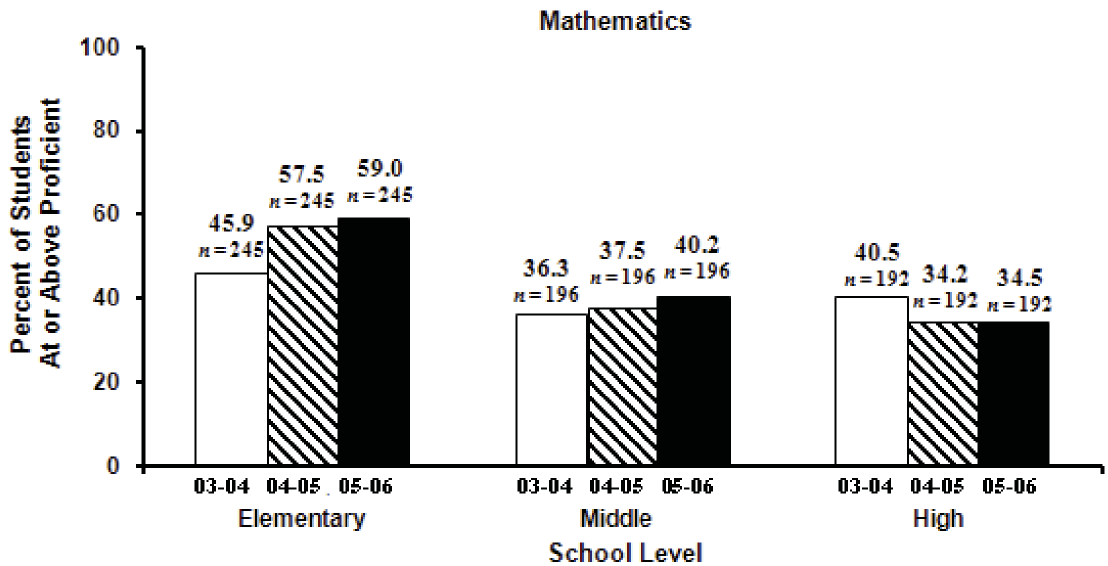


Figure 2. Bar-graphs for achievement trends (percent of students at or above proficient) for schools that have reported data for any of the three years: 2003/04, 2004/05, and 2005/06.



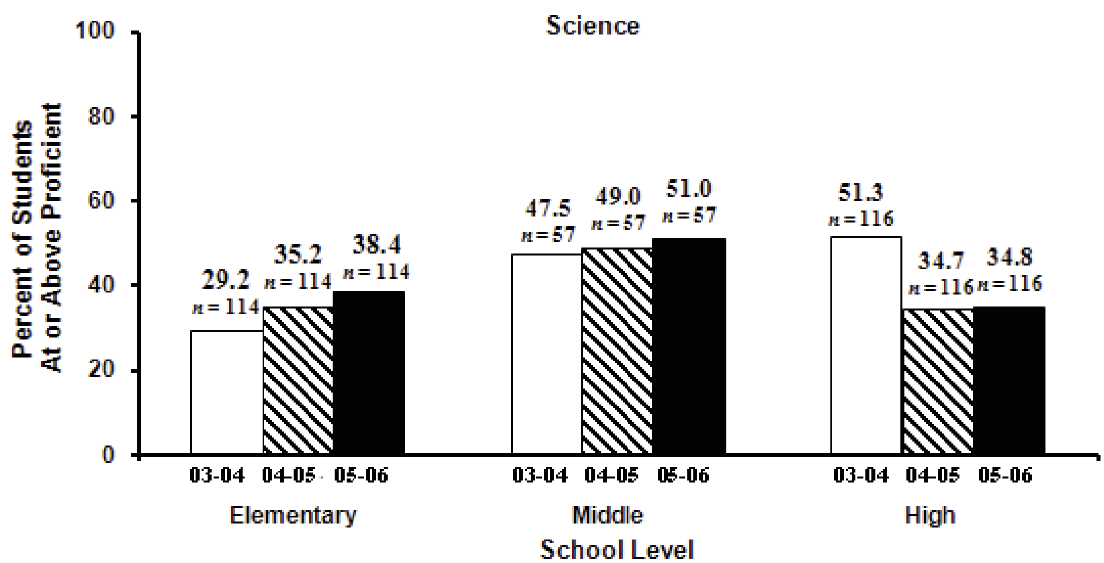


Figure 3. Bar-graphs for achievement trends (percent of students at or above proficient) for schools that have reported data for each of the three years: 2003/04, 2004/05, and 2005/06.

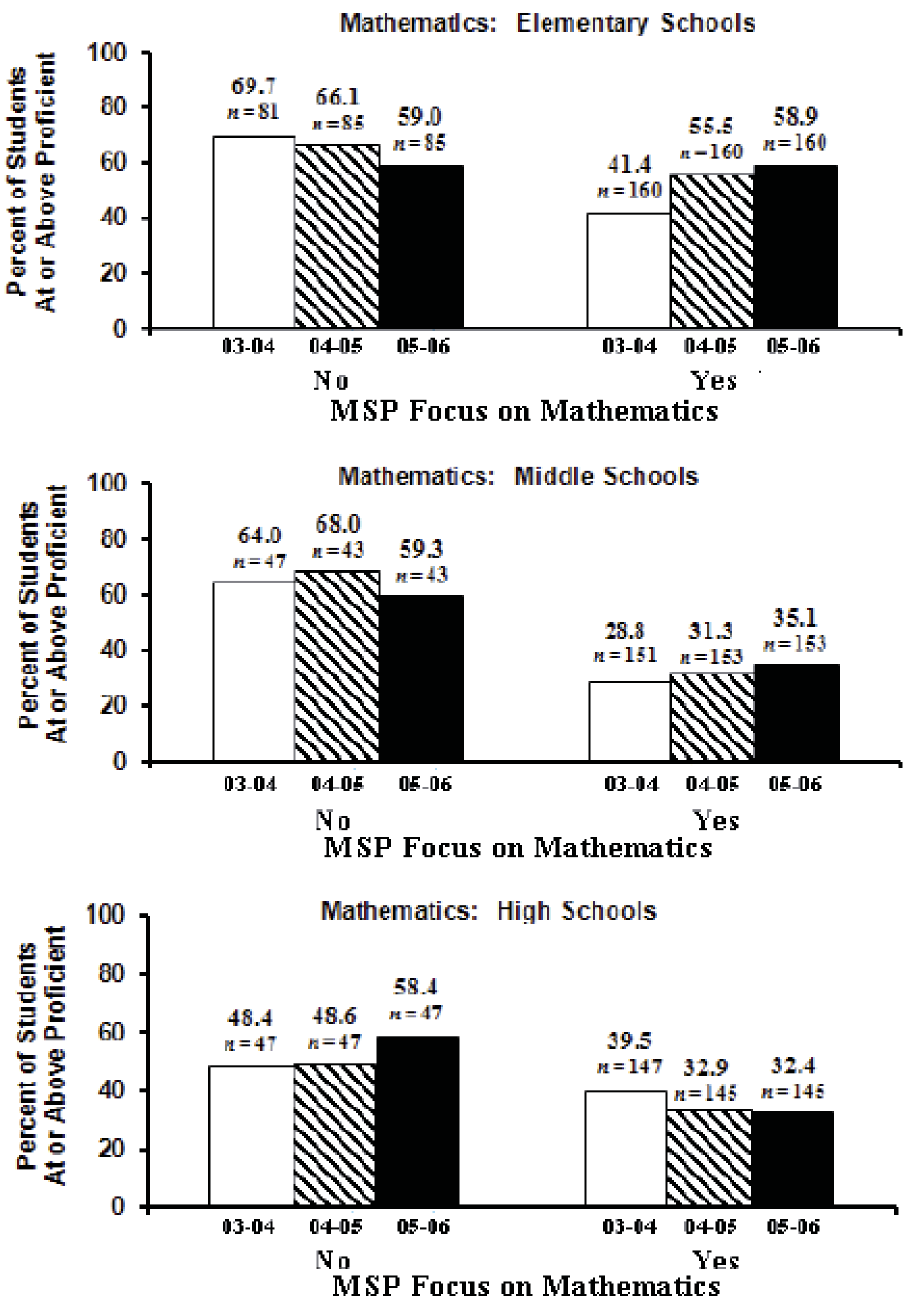


Figure 4. MSPs' focus on mathematics ("No" or "Yes"): Achievement trends for schools reporting data all three years (2003/04, 2004/05, and 2005/06).

Notes: 1. "Focus on Mathematics" means that an MSP's activities addressed mathematics at that grade-span in any of the three years, whether also focusing on mathematics at that grade span or not ("Yes" = did focus; "No" = did not focus).

2. Using a 90% confidence interval (CI), the changes in percent of students at or above proficient in mathematics from 2003/04 to 2004/05 (2005/06) were statistically significant except for the change from 2003/04 to 2004/05 for high schools without focus on mathematics. The 90% CI provides a smaller margin of error than a 95% CI and, despite a slight decrease in the level of confidence, increases the chances of detecting changes when they exist.

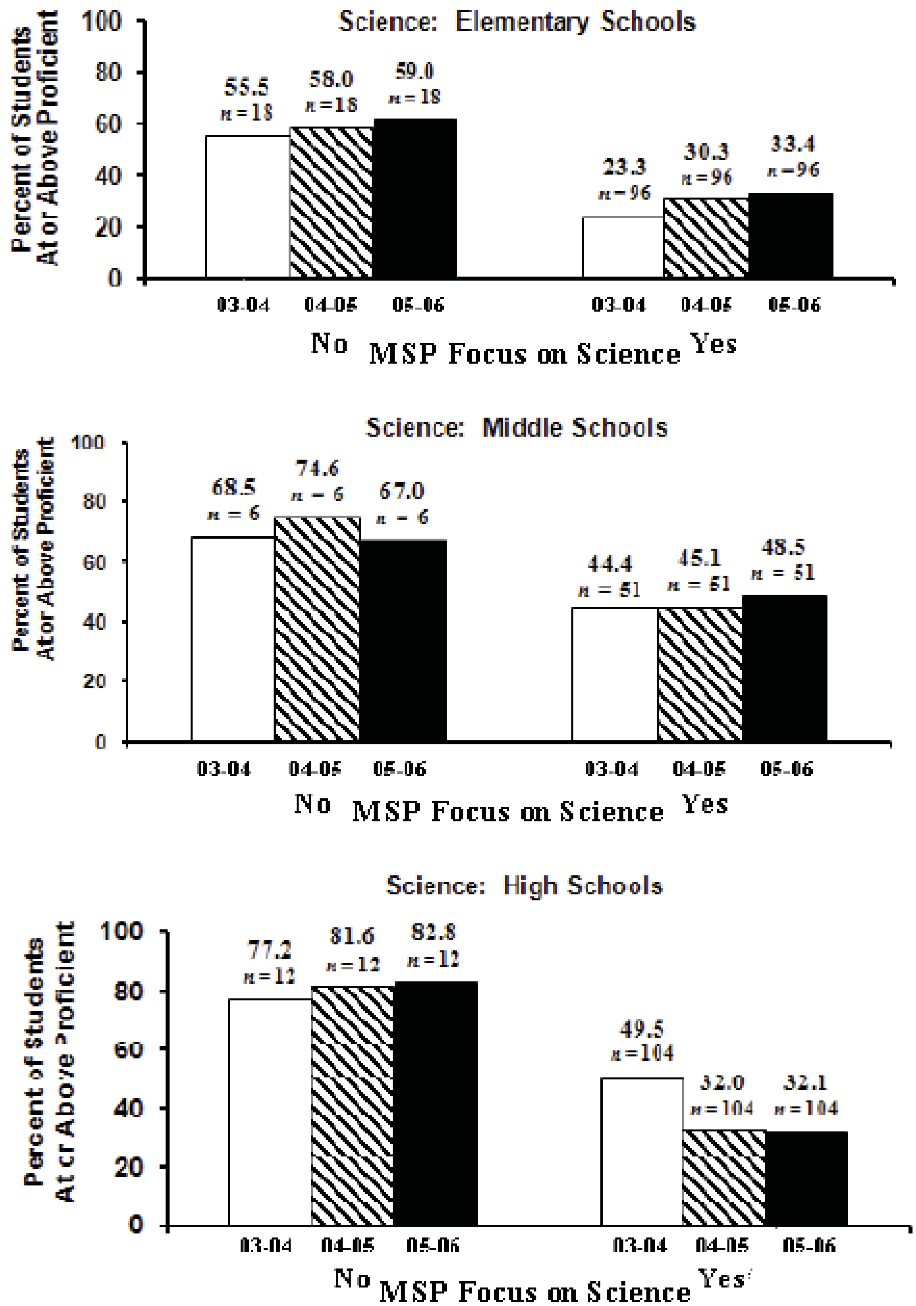


Figure 5. MSPs' focus on science ("No" or "Yes"): Achievement trends for schools reporting data all three years (2003/04, 2004/05, and 2005/06).

Notes: 1. "Focus on Science" means that an MSP's activities addressed science at that grade-span in any of the three years, whether also focusing on science at that grade span or not ("Yes" = did focus; "No" = did not focus).

2. Using a 90% confidence interval (CI), the changes in percent of students at or above proficient in science from 2003/04 to 2004/05 (2005/06) were statistically significant except for (a) from 2003/05 to 2004/05 for elementary schools without focus on science and (b) from 2003/04 to 2004/05 (2005/06) for middle schools regardless of their focus (Yes/No) on science. The 90% CI provides a smaller margin of error than a 95% CI and, despite a slight decrease in the level of confidence, increases the chances of detecting changes when they exist.

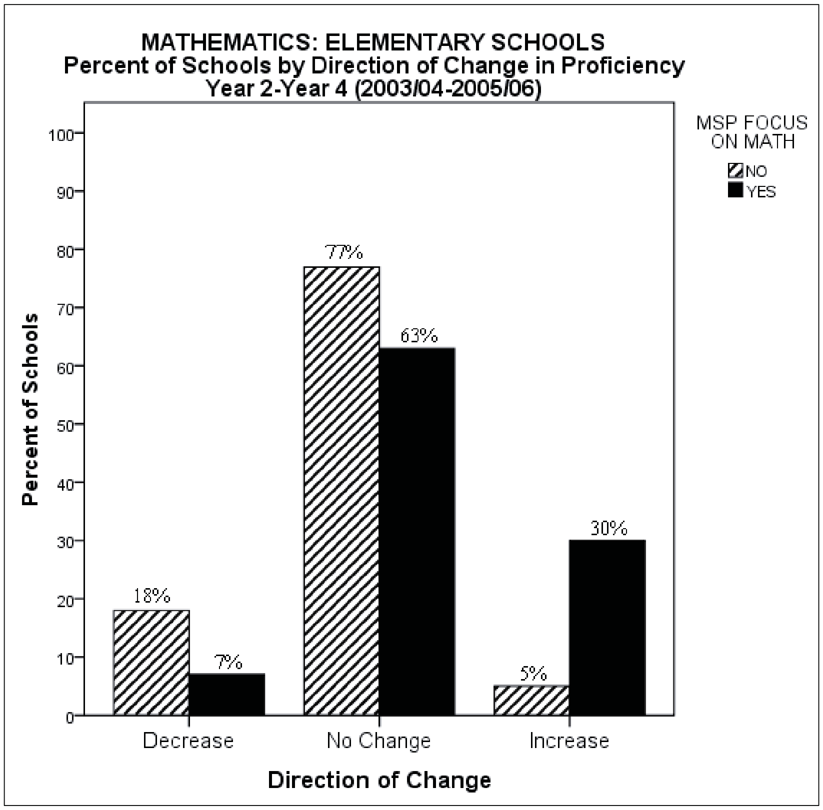


Figure 6. Percent of elementary schools by direction of statistically significant change in proficiency (at or above proficient) in mathematics from 2003/04 to 2005/06.

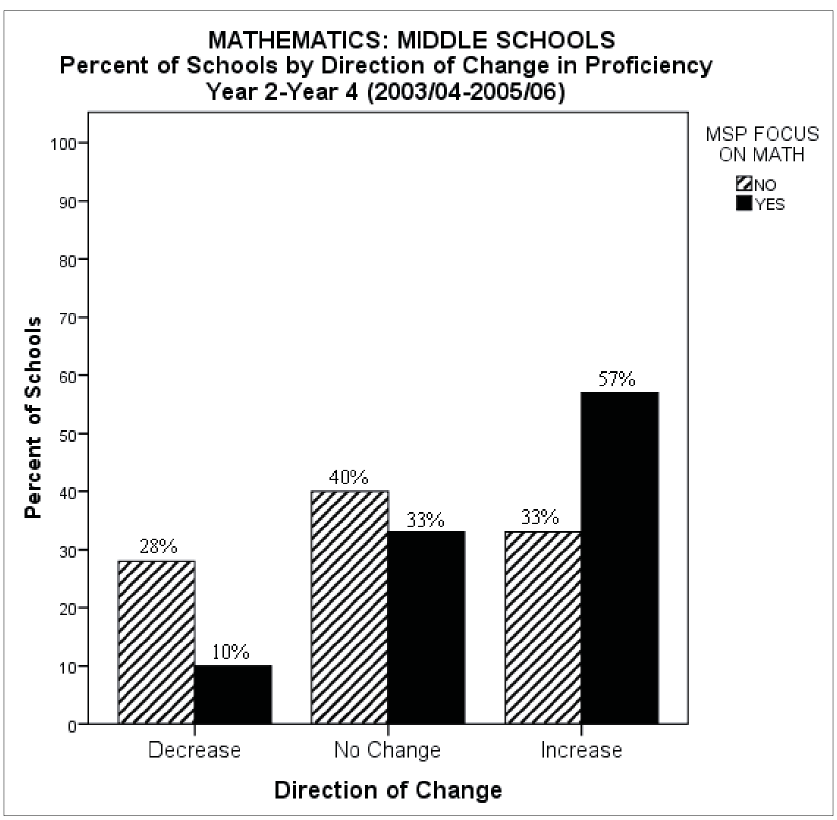


Figure 7. Percent of middle schools by direction of statistically significant change in proficiency (at or above proficient) in mathematics from 2003/04 to 2005/06.

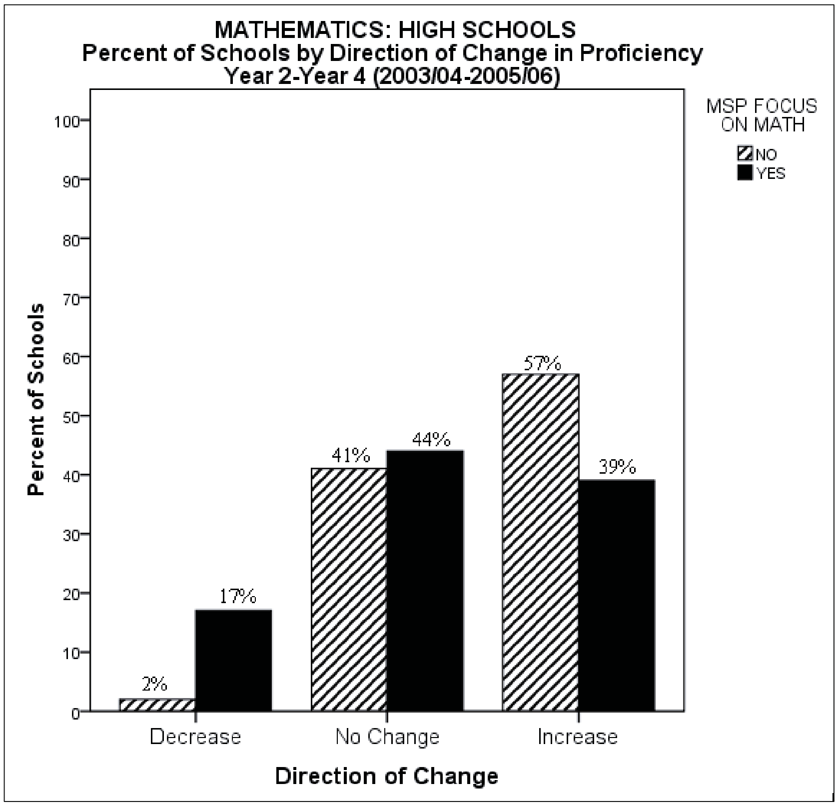


Figure 8. Percent of high schools by direction of statistically significant change in proficiency (at or above proficient) in mathematics from 2003/04 to 2005/06.

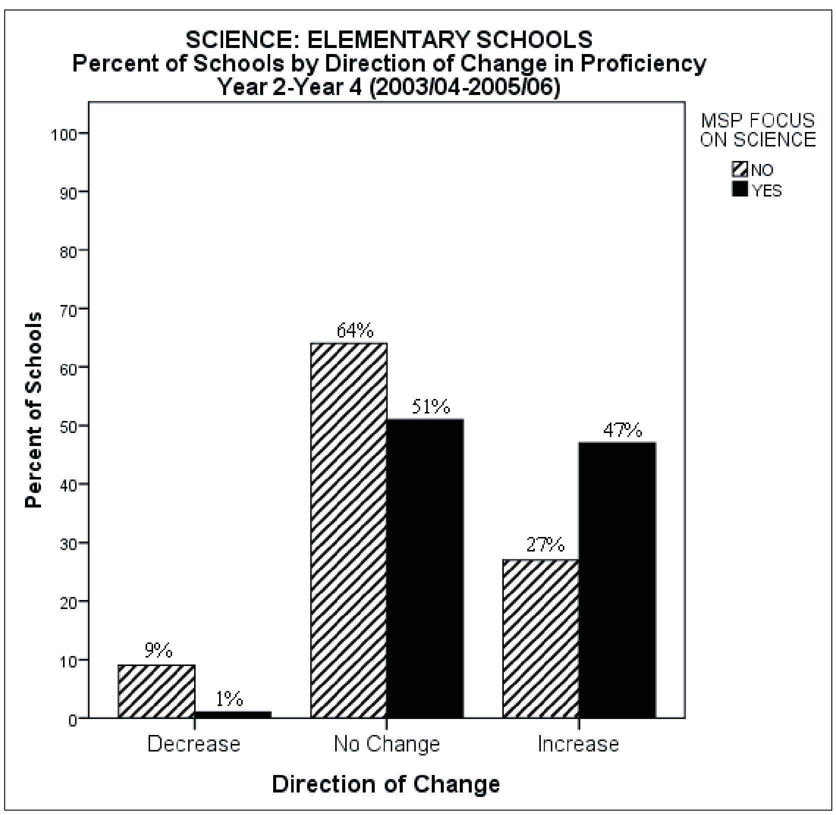


Figure 9. Percent of elementary schools by direction of statistically significant change in proficiency (at or above proficient) in science from 2003/04 to 2005/06.

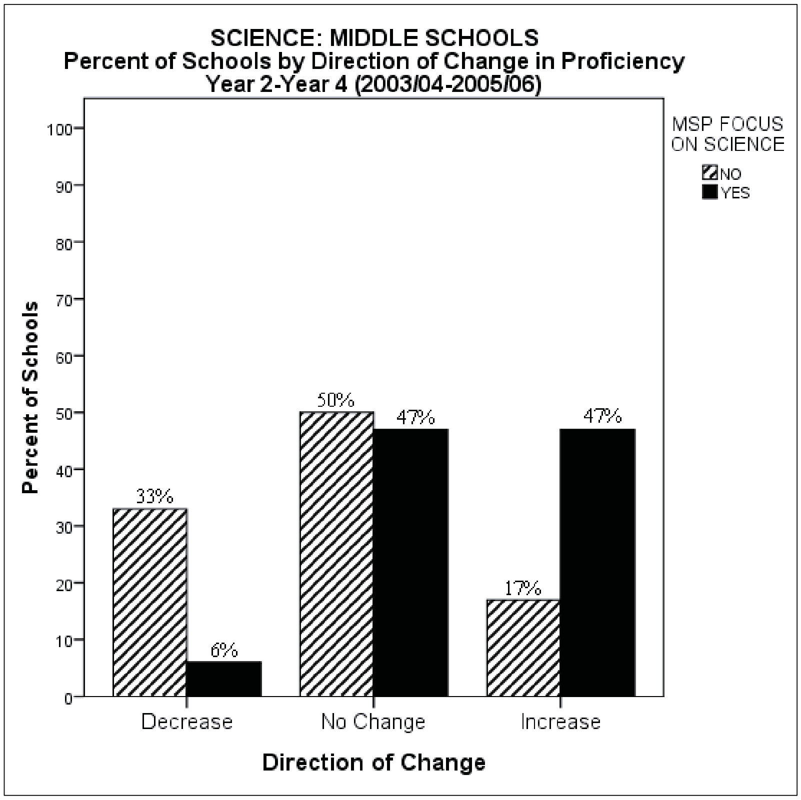


Figure 10. Percent of middle schools by direction of statistically significant change in proficiency (at or above proficient) in science from 2003/04 to 2005/06.

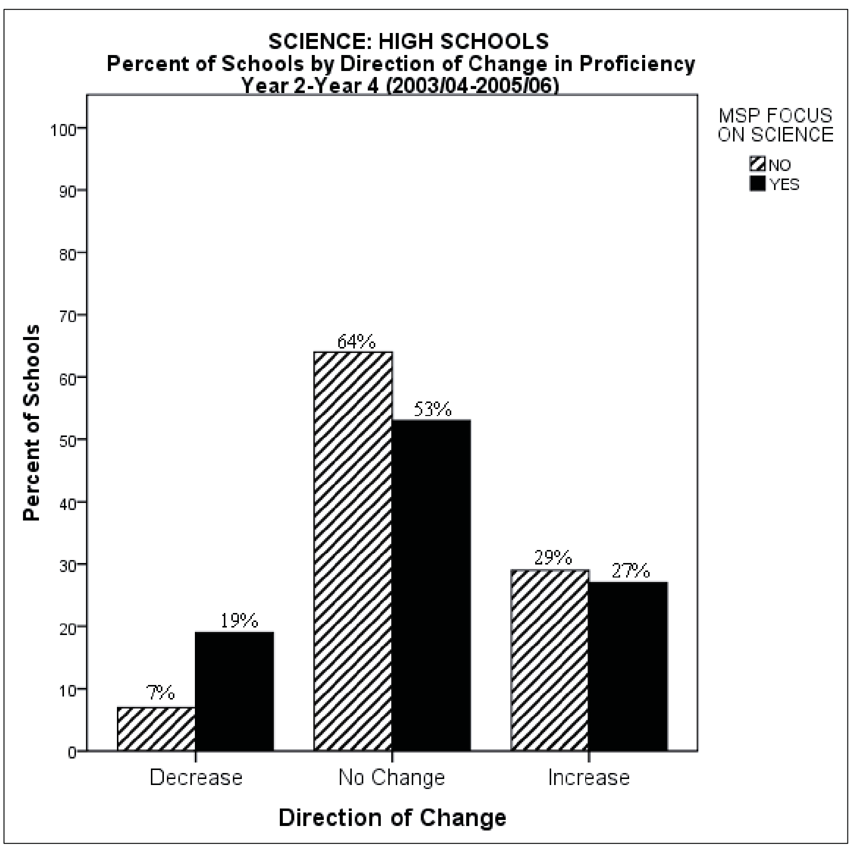


Figure 11. Percent of high schools by direction of statistically significant change in proficiency (at or above proficient) in science from 2003/04 to 2005/06.

Appendix

WORDING OF MSP-MIS QUESTIONNAIRE ITEMS* REFERENCED IN THE PRESENT REPORT

Student Achievement:

Item 7g (2002-04) (Item 11e (2004-05)): Provide the following information about the number of students who took this assessment at [NAME OF SCHOOL] during the [INSERT SCHOOL YEAR] school year:

- *Number of students at this grade level taking assessment during the [INSERT SCHOOL YEAR] school year*
- *Number of students taking assessment and scoring at or above proficient level*

School Participation in MSP Activities (categorical response):

Item A (2002-05): Which of the following conditions apply to this school? **(*check all that apply*)**

- *30 percent or more of targeted teachers participated in 30 or more hours of MSP-sponsored activities during the [INSERT SCHOOL YEAR] school year*
- *30 percent or more of targeted students were engaged in a challenging mathematics or science curriculum that was initiated or revised with MSP support during the [INSERT SCHOOL YEAR] school year*
- *30 percent or more of targeted students participated in a MSP-supported academic enrichment activity during the [INSERT SCHOOL YEAR] school year*
- *None of the above conditions apply to this school for the [INSERT SCHOOL YEAR] school year*

School Participation in MSP Activities (*numeric response*):

Item 1 (2002-05): Provide the following information about the TOTAL number of teachers in [NAME OF SCHOOL] at the beginning of the [INSERT SCHOOL YEAR] school year:

Item 2 (2002-04) (Item 5 (2004-05)): Using the definition for "participating teachers" below, provide the following information about the number of teachers in [NAME OF SCHOOL] that actively participated in your MSP during the [INSERT SCHOOL YEAR] school year:

Definition for "participating teachers": Those teachers who have participated in 30 or more hours of MSP-sponsored activities during a given school year. Examples include teachers who: 1) developed or delivered an MSP-sponsored activity to K-12 students or other teachers; 2) participated in an MSP-sponsored effort to revise math or science curriculum; 3) received MSP-sponsored professional development; and/or 4) took part in MSP-related learning communities.

- *[Number of] math teachers*
- *[Number of] science teachers*

* All items are from the instrument, *K-12 District Survey for Comprehensive and Targeted MSPs* (some item numbers changed from year-to-year).

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Student Achievement Data and Findings, As Reported In Math and Science Partnerships' Annual and Evaluation Reports

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A primary feature of the Math and Science Partnership Program Evaluation (MSP PE) is the examination of K-12 student achievement changes associated with the National Science Foundation's (NSF) Math and Science Partnership (MSP) Program. This article describes one of three complementary assessments of K-12 student achievement being conducted by the MSP-PE, and consists of a synthesis of student achievement findings reported by the MSP projects themselves (the other two assessments also are described in this volume). The assessment described in this article covers 39 of the 48 MSP project awards made by NSF from 2002 to 2004. Data sources included the MSP projects' annual and evaluation reports submitted to NSF through 2006-07 and research manuscripts developed by the MSPs for presentation at three MSP evaluation conferences. A two dimensional cross-MSP matrix was developed to reveal the disparate research efforts undertaken by the MSPs and present a cross-MSP perspective. The article describes a number of challenges faced by the MSPs as revealed by the current assessment, including: a) many of the MSPs report districtwide data even though the MSPs may not have implemented activities at the district level; b) MSPs that have chosen to define pre-established benchmarks for later comparison to actual performance have not usually discussed any rationale for selecting their particular numeric benchmarks; c) many MSPs report scores for multiple grade levels for both science and mathematics, making an overall interpretation difficult; d) the MSPs should endeavor to identify the amount of professional development that appears to make a discernable difference in student achievement outcomes; and e) most of the evaluation frameworks reported by the MSPs are not poised to go beyond establishing concurrent trends and testing more strongly the actual efficacy of an MSP's activities.

Introduction: Three Complementary Studies on K-12 Student Achievement Trends Associated with the Math and Science Partnership (MSP) Program

The MSP Program consists of a series of separate project awards to individual math and science partnerships (MSPs) made by the National Science Foundation (NSF). Each award went to a different institution of higher education (IHE), which was required to partner with one or more school districts and their numerous schools (see Scherer, this volume). The ensuing partnership was expected to fulfill several objectives. The most prominent of these objectives, as stated in the MSP Program's solicitations issued by NSF, is as follows: "MSP projects are expected to raise the achievement levels of all [K-12] students and significantly reduce achievement gaps in the mathematics and science performance of diverse student populations" (e.g., NSF 09-507, p. 2). Assessing the relationship between the MSP Program and K-12 student achievement therefore has served as a critical part of the Math and Science Partnership Program Evaluation (MSP-PE).

The importance of this evaluation function has led the MSP-PE to design and conduct three complementary assessments. The present article is one of the three assessments focused on student achievement. The three are complementary in that each follows a different research design and uses a different source of data. Each has different strengths and weaknesses, but all are aimed at assessing the potential association between the MSP Program and K-12 student achievement.

The first of the three assessments (Dimitrov, this volume) analyzes student achievement trends based on extensive school-level data submitted into the MSP Program's Management Information System (MSP-MIS) by the MSP projects' schools and districts. The analysis is limited to trends at the MSP sites only, thus far covering three academic years (2003-04 to 2005-06). Among other topics, the MSP-MIS database permits inquiries into the direction of the multi-year trends as well as the association, if any, between the amount of a school's teachers participating in MSP-supported activities and the school's later student achievement. However, because the data source has no information about non-MSP schools or sites, no comparative framework is possible.

The second of the three assessments (Wong, Boben, Kim, & Socha, this volume) compares student achievement patterns between MSP and non-MSP schools, based on school-level data from state education agencies' Web sites. The study's distinctive strength is its careful demographic matching of MSP and non-MSP schools. However, the time-consuming nature of accessing data from individual state Web sites has limited the inquiry to only a small proportion of the MSP projects thus far. Moreover, the study has not yet been able to ascertain the extent of "MSP-like" activities taking place at the non-MSP schools. The non-MSP schools, though accurately matched demographically, therefore cannot be assumed to be "no-treatment" sites.

The present and third assessment, represented by the present article, consists of a synthesis of student achievement findings reported by the MSP projects themselves in their annual and evaluation reports submitted to NSF through 2006-07. Each MSP has an individual evaluator working with the partnership. These evaluators have employed their own (different) evaluation designs to investigate any relationship between their MSP's activities and student achievement outcomes. In reviewing the MSPs' and evaluators' reports, this third assessment assumes the nature of a research synthesis or secondary analysis, across the MSP projects.

The three assessments all focus on the MSP Program as a whole. They do not attempt to evaluate the individual MSP projects. Overall, the tri-study effort is appropriate for evaluating a program as broad and diverse as the MSP Program. The program does not suggest, much less require, that projects implement any pre-specified educational practices, professional development models, or other uniform initiatives. Instead, each project has been free to devise its own agenda, to meet its own local needs, for improving K-12 student achievement in mathematics and science.

For instance, some MSP projects have undertaken comprehensive activities covering both mathematics and science, across all grade levels. Other projects have limited themselves to either mathematics or science and to specific elementary, middle, or high school grade spans. As another example, some MSP projects have provided large amounts of inservice training to existing K-12 teachers of mathematics and science, whereas other projects have provided less (and different) inservice training but have reorganized the preservice programs at local universities for the purpose of training new teachers.

The varied efforts across the MSPs, combined with their different if not unique partnership configurations, make it impossible to use a single evaluation study or study design to evaluate the relationship between MSP activities and student achievement outcomes (Yin, 2008). Trying to implement a single experimental design or a single evaluation study would lead to either an overly narrow or a superficial depiction of the MSP Program. The alternative has been to pursue three separate assessments, a later goal being to conduct a research synthesis to determine whether the three assessments produce converging findings about the MSP Program. Depending on the nature of the final data, the synthesis can follow more traditional methods (e.g., Cooper, 1998) or employ meta-analytic techniques (e.g., Cooper & Hedges, 1994).

Synthesis Procedure

Scope of Inquiry

The present assessment covers 39 of the 48 MSP project awards made by NSF from 2002 to 2004.[1] The awards were made in annual cohorts, so that the MSP projects were reporting about their third, fourth, or fifth year of work in the reports reviewed for this synthesis. Much of the evaluative data in these reports are based on the work of the evaluators affiliated with each MSP. Nevertheless, the reports are official submissions by the MSPs and potentially suffer from the known limitations of self-reported data.

The synthesis draws from an analysis of the latest available project reports,[2] including both annual and evaluators' reports, as well as from research manuscripts related to presentations at the MSP Program's three evaluation conferences.[3] The data and analyses provided by the individual MSPs were then compiled into a cross-MSP matrix, discussed next. The Appendix to this article contains brief summaries about the nature, status, and findings about student achievement reported by the individual MSP projects, based on the various sources.

Two-Dimensional, Cross-MSP Matrix

To represent the disparate research efforts by each MSP but nevertheless to create the needed cross-MSP perspective, the synthesis characterized every MSP's reported status according to two dimensions, detailed in Table 1:

a) *Evaluation framework*: whether and how an MSP was establishing any comparative framework for interpreting the student achievement outcomes; and

b) *Direction, if any, of findings regarding student achievement trends*: Whether the MSP had started analyzing the data, and if so, whether the data represented mixed, positive, or negative trends over the course of the MSP's award period to date.[4]

The first dimension shown in Table 1, *evaluation framework*, had five categories:

1) "none" (no data had been collected or no framework yet established);
2) "MSP sites only" (the framework had no comparative perspective);

3) "MSP compared to pre-established benchmark or to district- or state-wide averages" (a pre-established benchmark might be an MSP's stated goal that scores would increase by five percent each year; a comparison to either district or statewide averages would reflect an MSP's goal of exceeding these averages);

4) "distinctive within-group comparisons" (see text below for further description of these designs); and

5) "MSP and non-MSP groups compared" (the framework included data from comparison groups of non-MSP classrooms, schools, or districts).

It should be noted that the first and second categories yield no information about any possible association (much less attribution) between an MSP project's work and student achievement. Similarly, the third, fourth, and fifth categories only begin to test such an association, with the third category still being a fairly weak framework.

Table 1
Student Achievement Trends Reported by Cohort I, II, and III MSPs (n = 39)*

Evaluation Framework for MSPs' Analyses	MSPs' Interpretation of *Direction of Findings* (1) No Analysis Yet	(2) No Notable Differences or Mixed Pattern	(3) More Positive than Negative Findings	(4) More Negative than Positive Findings	Total
(1) None	10	0	0	0	10
(2) MSP Sites Only	2	2	3	0	7
(3) MSP Compared to Pre-established Benchmark or to District- or Statewide Averages	0	5	5	0	10
(4) Distinctive Within-group Comparisons	0	3	1	0	4
(5) MSP and non-MSP Groups Compared	2	4	2	0	8
TOTAL	14	14	11	0	39

Note. *The analysis covers the awards to 48 MSPs made by NSF from 2002 to 2004, covering "comprehensive," "targeted," and "institute" types of MSPs. Of the original 48 awards, two were discontinued and seven were "institute" awards that were not included in the present analysis. During the same three-year period, the program also supported 28 other awardees that are not MSPs but that are conducting research, evaluation, and technical assistance activities. These 28 awardees also fall outside of the present analysis. Finally, starting in 2006, the program has since made additional MSP awards that were too new to be included in the analysis. Source: MSPs' Annual and Evaluators' Reports.

The second dimension in Table 1, *direction of findings*, had four categories:

1) "no analysis yet" (whether data had been collected or not, the MSP had made no tallies or observations about the data);

2) "no notable differences" (the MSPs interpreted their own findings as reflecting either no differences or mixed results—i.e., improvement for some academic subjects but not others; or for some grade levels, but not others);

3) "more positive than negative scores" (all or most of the scores favored a positive assessment of the MSP's efforts to date); and

4) "more negative than positive scores" (all or most of the scores favored a negative assessment of the MSP's efforts to date).

In regard to this second dimension, it should be emphasized that the "direction of findings" data represents an MSP project's own interpretations, as stated in its annual or evaluation reports, not on any independent re-analysis or re-interpretation of the MSP's original data.

Remainder of This Article

The remainder of this article has two sections. The first presents the pattern of findings reported by the MSPs. The second comments about the findings and the MSPs' methods for assessing student achievement performance and trends.

Findings Reported by MSPs

Table 1 shows the distribution for the 39 MSP projects under review, according to the two dimensions and their various categories, producing a matrix of 20 cells: The five rows in the matrix represent the *evaluation framework* dimension, and the four columns represent the *direction of findings* dimension. [When relevant, the discussion below cites the designated rows (1, 2, 3, 4, or 5) or columns (1, 2, 3, and 4) in Table 1.]

Evaluation Framework

Examining the *evaluation framework* dimension, the reported frameworks are consistent with an earlier report (Yin, 2007) and are still not especially strong. The five rows are arrayed in ascending order, from weaker (Row 1) to stronger (Row 5) frameworks.

The distribution in Table 1 shows that:

1) 17 (or 44 percent) of the 39 MSPs reported no framework or that they were analyzing "MSP sites only" (Rows 1 and 2), while

2) 10 (26 percent) of the 42 reported comparing their MSP scores with some external benchmark (Row 3), and

3) the remaining 14 (31 percent) reported using a more formal research design involving either some potentially "distinctive within-group comparison" or a non-MSP comparison group (Rows 4 and 5).

Although the total number of MSPs had risen from 34 covered in the earlier update to the 39 in the present one, and although the present analysis took place one year after the earlier update, the proportion of MSPs in these rows still closely mimicked the proportion in the earlier update, which had reported 47, 21, and 32 percent respectively for the same three categories (Yin, 2007).

Among the five types of frameworks, one type–"distinctive within-group comparisons" (Row 4)—has been listed separately because it can include pertinent comparisons by taking into account different amounts of "exposure" to MSP activities, on the part of an array of sites in the same MSP. The row includes what might be considered frameworks that are stronger than those in Rows 1, 2, and 3, even though they are based on *within*-group comparisons. This is because an MSP-only group can nevertheless be subdivided into two (or more) subgroups. One subgroup can then be exposed to one part of an MSP's activities (e.g., one strand of a curriculum), and another subgroup exposed to a different part (e.g., a different strand). The within-group design then examines whether, if the MSP activities have any potency, the first subgroup performed better when tested on the first part (strand) but not the second, and whether the second subgroup performed better when tested on the second part (strand) but not the first (see Table 2).[5]

Table 2

A Helpful Within-Group Design

School	% of Students Achieving Proficiency in Grade 5 Science, December 2005			
	Strand 1	Strand 2	Strand 3	Strand 4
CEHE	59.7	49.0	42.5	56.4
CENT	48.3	51.8	36.0	53.3
COSP	54.6	49.1	54.9	54.7
EAST	55.5	46.7	42.2	52.3
EBEN	52.0	48.1	44.5	53.1
HARM	64.4	54.0	43.8	62.9
LNES	60.6	**60.5**	51.6	**67.5**
LAES	61.5	54.1	57.9	62.3
MONT	53.3	46.7	41.7	46.0
TMO	72.4	60.8	48.9	65.9
SCOT	58.6	54.5	39.5	46.0
SHAR	**71.1**	51.0	**56.9**	54.7
SHEP	62.5	58.4	54.8	57.7
TCES	51.7	46.6	40.1	50.1
TRES	56.8	53.4	44.8	56.7
UGES	51.1	57.9	56.7	57.1
WHES	57.6	58.4	53.8	65.2
DISTRICT	58.2	52.9	47.5	57.2

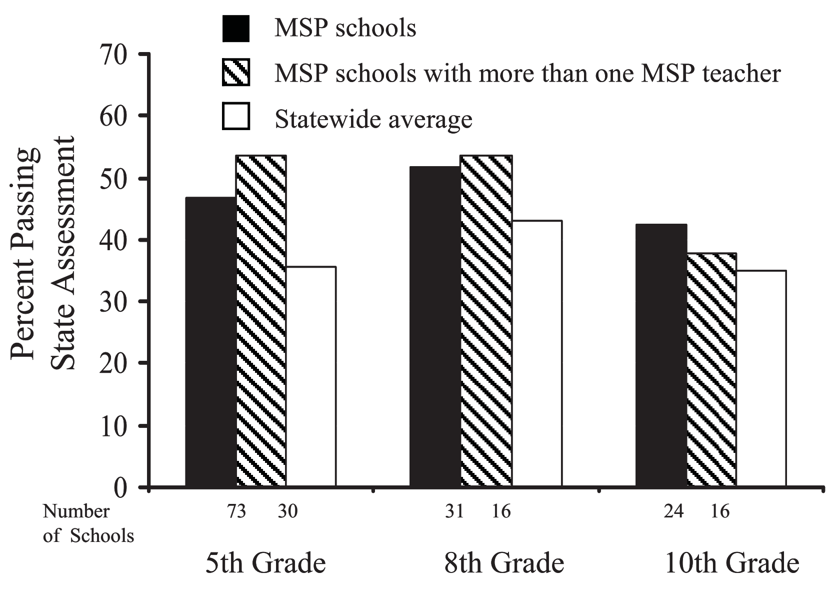
Source: MSP's Annual and Evaluator's Reports.

Another within-group strategy among the MSPs has been to compare student achievement trends among classrooms or schools receiving varying degrees of MSP exposure. Because such exposure varied among MSP participants, an analysis could explore whether greater exposure was associated with better student achievement, compared to participation involving less exposure. All participants, however, were MSP participants, and in this sense the framework remained a within-group framework.

For example, Figure 1 presents the data from one MSP that compared: a) schools with one MSP-trained teacher with b) schools having more than one MSP-trained teacher, and with c) statewide averages. A fuller rendition of this design, attempted by a couple of other MSPs and also exemplifying the within-group efforts in Row 4, called for examining the potential correlation between different amounts of MSP exposure with differing degrees of student achievement. The few MSPs that were able to implement this design found no correlation and hence were categorized as having found "no notable differences."

In contrast, the MSP-non-MSP designs in Row 5 made explicit attempts to collect data from sites totally uninvolved with the MSP's activities. However, except for one MSP, none of the other MSPs defined their non-MSP groups in an especially compelling manner. Whereas the MSP sites were those whose teachers or students had participated in an MSP's activities, the non-MSP sites were simply the neighboring classrooms, schools, or districts that were not participating. Only rarely did the MSPs discuss the possibilities of self-selection between the two groups, and only rarely did the analyses control for other differences between the two groups.

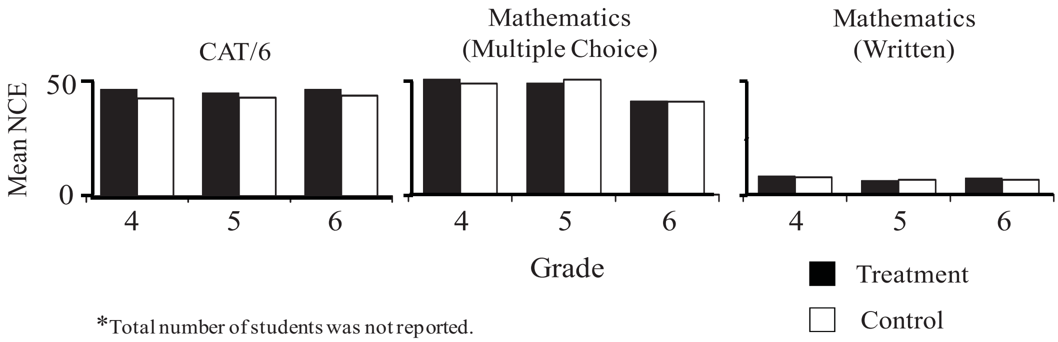
As an exceptional example, only one MSP completed its analysis of results when classrooms were randomly assigned to "treatment" and "non-treatment" conditions. Figure 2 shows that the MSP found no statistically significant differences in the student achievement scores between the two groups; however, the figure also shows that the MSP found no differences in the instruction provided to the two groups. The lack of instructional differences came somewhat as a surprise, because the teachers of the treatment group had participated in the MSP's activities while those of the non-treatment group had not.[6]



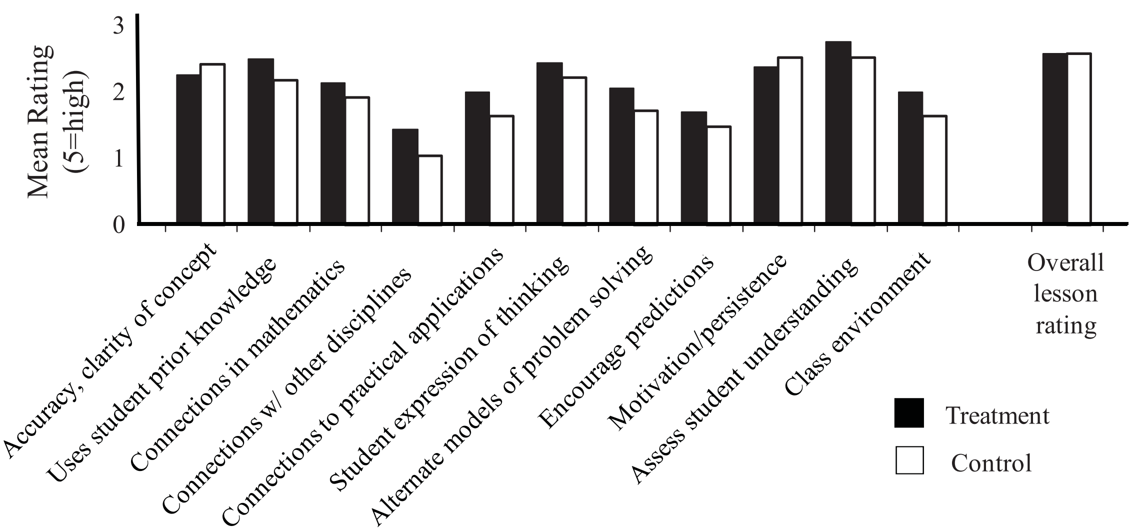
Source: MSP's Annual and Evaluator's Reports

Figure 1. MSP schools' scores higher than statewide averages in science, spring 2006.

Students' Math Scores from Two Randomly-Assigned Groups of Schools*



Mathematics Classroom Observations from
Two Randomly-Assigned Groups of Schools, Spring 2005
(*n* = 35 classrooms)



Source: MSP's Annual and Evaluator's Reports

Figure 2. An MSP that randomly assigned classrooms to "treatment" and "non-treatment" conditions.

Other MSPs in Row 5, as previously mentioned, merely identified the non-MSP comparison group as a neighboring classroom, school, or district that had not participated in the MSP's activities. One such MSP was slowly scaling up its work within a participating district and found that its non-MSP group (the remainder of the schools that had not been scaled up) was slowly diminishing.

Direction of Findings

The first important observation about the *direction of findings* is that 14 (31 percent) of the 39 MSPs reported "no analysis yet" (see Table 1, Column 1), while the remaining 25 (69 percent) of the 39 MSPs reported some analytic findings (see columns 2, 3, and 4). Again, although the total number of MSPs has increased, this proportion is strikingly similar to that in the earlier update (Yin, 2007), which reported 32 and 68 percent respectively for the same two categories.

Somewhat disappointing were the 14 of the 39 MSPs that were still reporting, at this rather late stage of their work, no analysis of student achievement trends. These 14 MSPs only included three projects that were from the later Cohort III awards, so the absence of analysis mainly occurred among MSPs that were already in their fourth or fifth year of work. Several of the MSPs had collected baseline data, but they had not yet collected or analyzed data covering a later period of time. In a few cases, the MSPs were befuddled by a change in their state's assessment test, which in their view made the earlier assessment data impossible to use. These MSPs then reported that they were waiting to obtain at least two years' of scores on the new test, before attempting any analysis. However, one of these MSPs admitted that its coming analysis therefore could not include the desired baseline year of its work.

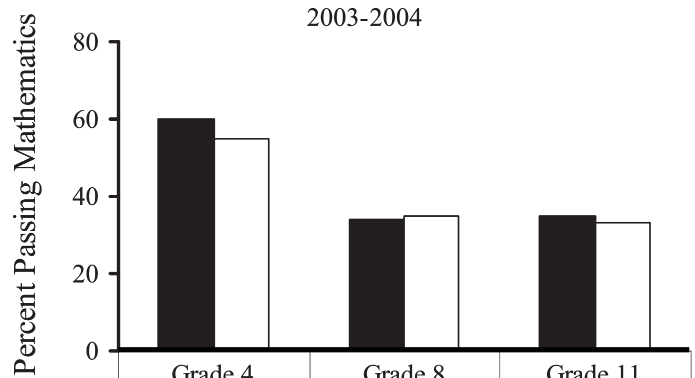
Among the 14 MSPs that had not yet done any analysis, Table 1 shows that ten also had not reported any analytic framework. Assuming the accuracy of the MSPs' reports, the lack of a framework or evaluation design, still a relevant condition during the MSPs' fourth or fifth year of award, may pose an additional challenge when these MSPs eventually pursue any analysis of student achievement data.[7]

Among the 25 MSPs reporting some analytic findings in Table 1, 14 reported no notable differences or mixed patterns, 11 reported more positive than negative findings, and none reported more negative than positive findings. (The overwhelmingly positive slant poses renewed caution in using self-reported data.) Of the 14 MSPs that had found either no notable differences or a mixed pattern of results, Figure 3 contains the data reported by one MSP showing the similarity of scores between MSP and non-MSP schools and that therefore resulted in the MSP's reporting no notable differences. Similarly mixed patterns were reported by MSPs who might have tested two or more grade levels or two or more academic subjects, or both, but who then found some scores improving and others not.

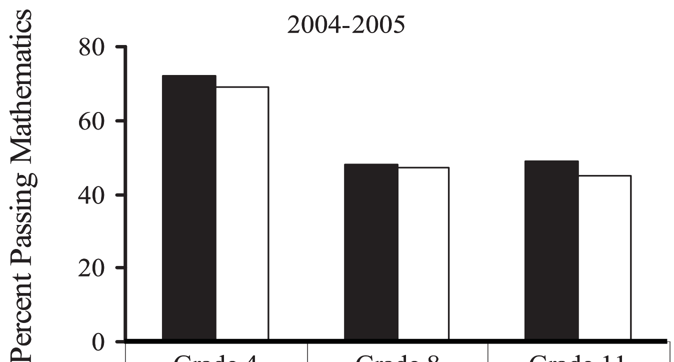
Figure 4 presents the data illustratively reported by one of the MSPs finding more positive than negative results. The MSP has focused on providing professional development to teachers of mathematics in partnering middle and high schools, and in particular on the performance of the Hispanic students who comprise 67 percent of the enrollment at these schools. The MSP claims that the Hispanic students have attained greater enrollment in higher-level mathematics courses, compared to statewide and county averages. More important, and as shown in Figure 4, the students performed better on the 10th grade state assessment in mathematics in the three years (2003-04 to 2005-06) following the start of the MSP's activities (2002-03).

Frameworks and Direction of Findings Combined

Observing the overall pattern of frequencies in Table 1, and if one accepts that the Rows are arrayed in a sequence from less to greater analytic strength, the distribution of data for the 39 MSPs suggests that the MSPs using the weaker frameworks (Rows



	Grade 4	Grade 8	Grade 11
■ MSP	60	34	35
□ Non MSP	55	35	33



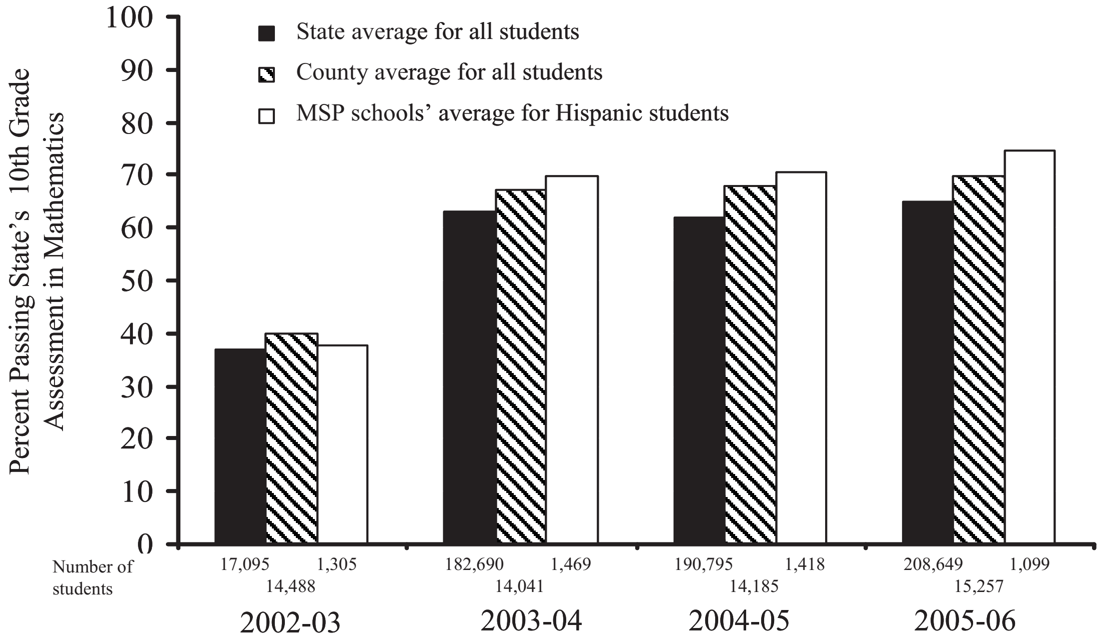
	Grade 4	Grade 8	Grade 11
■ MSP	72	48	49
□ Non MSP	69	47	45

Source: MSP's Annual and Evaluator's Reports.

Figure 3. Comparison between students who attain at proficient and advanced achievement levels (passing performance) on the mathematics assessment tests in MSP and non-MSP schools for 2003-04 and 2004-05.

2 and 3) had a slight tendency to report more positive findings in Column 3, compared to "no notable differences" in Column 2, in contrast to the MSPs using the stronger frameworks (Rows 4 and 5).

Although the tendency was only slight, a possible explanation for the preceding pattern starts with the observation that achievement scores in every state tend to rise over time (sometimes because of the scoring systems, and not necessarily because of learning gains). Observing trends at the "MSP sites only" would then reflect this rise, but putting the MSPs in a comparative mode (e.g., with non-MSP sites or with a within-group comparison) might diminish the appearance of a distinctive rise related to the MSP sites alone.



Source: MSP's Annual and Evaluator's Reports.

Figure 4. MSP's 10th grade Hispanic students' improvement over state and county averages in mathematics, 2002-03 to 2005-06.

Pattern Across 39 MSPs: Tentative Conclusions

The overall distribution in Table 1 reflects underdeveloped research frameworks and analyses being reported by the MSP projects, regarding their attempts to examine the relationship between their activities and K-12 student achievement. At this rather late juncture, with many MSPs in their fourth or fifth years, 10 of 39 (26 percent) still report no framework and no analysis (Row 1), and 17 of 39 (44 percent) are using frameworks (Rows 2 and 3) that have neither a distinctive within-group nor a non-MSP comparison.

In addition, but not revealed by the distribution in Table 1, only a few of the MSPs have reported using any statistical methods to analyze their data. Such methods are commonly found in evaluations of complex educational programs (e.g., Datnow, Borman, Stringfield, Rachuba, & Castellano, 2003; Supovitz & Taylor, 2005; Yin, Schmidt, & Besag, 2006). Yet, the MSPs have mainly reported their data descriptively. When they report positive or negative differences, such reports are typically based on an author's observations, and not on statistical tests that might determine the strength of any differences. One exception to this cross-MSP tendency is illustrated by an MSP project whose preliminary findings are presented in Table 3. That project is continuing to acquire updated data and to refine its regression models, and its analysis potentially represents the kind of work to be emulated by other MSPs.

Along the same lines, only a few of the MSPs, even those using the stronger frameworks, have reported any attempts to control for demographic and other artifactual conditions when comparing MSP sites to performance by other groups. The

Table 3

Findings From an Analysis Using Fixed-Effect Regression Models (All Schools in State, n = 1,041)

Student Achievement Outcome (No Grade Levels Given)	**Time Period**	**Related to MSP Participation by School***
Change in Math Proficiency Scores	2001-04	Yes, statistically significant
Change in Science Proficiency Scores	2001-04	No
Change in Reading Proficiency Scores	2001-04	Yes, statistically significant

Note. *School characteristics used as covariates: racial/ethnic composition; percentage of students eligible for Free and Reduced-Price Lunch; teacher-student ratio; source: MSP's Annual and Evaluator's Reports.

project depicted in Table 3 again serves as one exception (see the footnote in the table that identifies the covariates used in the regression models).

Conclusions about the MSPs' Existing Assessments of Student Achievement

This synthesis covers ongoing assessments by awardees in NSF's MSP Program. The midstream status of the assessments precludes any conclusions about student achievement. However, the synthesis does lead to several conclusions about the challenges faced by the MSPs.

First, many of the MSPs have reported districtwide data, although the MSPs may not have implemented their activities on a districtwide basis. A similar situation can exist at the school level, where the MSPs' reports may have reported aggregate school-level data, even though a given MSP's activities only may have involved some but not all of the classrooms in the school. In either situation, scale-up may still be occurring, but until fully scaled, the MSPs may need to match more closely their scope of achievement data with the venues in which the MSP activities have taken place.

Second, those MSPs that have chosen to define pre-established benchmarks for later comparison to actual performance have not usually discussed any rationale for selecting their particular numeric benchmark. For instance, the MSPs do not discuss whether such benchmarks as "improving performance by five percent each year" might be too conservative or overly ambitious. The latter could exist if a school already had been improving by substantial percentage points for the preceding years. Where benchmarks are to be used, some discussion and rationale for the selected cut-points would be helpful.

Third, many MSPs report scores for multiple grade levels and for both science and mathematics assessments. MSPs in this situation might want to consider setting another type of benchmark: whether all scores are expected to improve or whether only one or a few are.

Fourth, a promising within-group design examines the relationship between different degrees of MSP participation (e.g., different amounts of professional development hours) with student achievement outcomes. The hypothesis is that greater participation should be correlated with stronger outcomes. However, such analyses need to be preceded by some pilot study demonstrating the threshold number of hours needed to produce a measurable outcome in the first place. Absent the identification of such a threshold, the possibility remains that the observed professional development hours, in the later correlative analysis, all may fall either under or over the threshold, thereby explaining the lack of any correlation. More generally, the MSP projects should try to establish, through small-scale or pilot testing, the amount of professional development that appears to make a discernible difference in student achievement scores, regardless of whether the later assessment frameworks are based on a correlational analysis or any other analysis.

Finally, most of the evaluation frameworks reported by the MSPs are not poised to go beyond establishing concurrent (or associational) trends and testing more strongly the actual efficacy of an MSP's activities–that is, whether the activities actually had influenced the student outcomes. Because of the large size of the MSPs and the number of students and teachers involved, possibly the MSPs could try to implement some small-scale research, focusing on a few classrooms or schools, that would nevertheless use more robust research designs to assess efficacy.

The sum of these conclusions suggests room for improving the evaluation efforts among the individual MSPs in addressing student achievement outcomes. In particular, the ongoing as well as future efforts should give more attention to the technical design of their inquiries, which can include both qualitative and quantitative methods when trying to relate actions from complex educational programs with student achievement outcomes (e.g., Yin & Davis, 2007).

At the same time, the evaluators have had to struggle with making their assessments at an earlier stage than is usually found in education research. For instance, most published studies of large-scale student achievement trends contain data that are usually at least five years old. Moreover, the MSP evaluators' ability to obtain the needed data from state education agencies –and especially student-level data – may have become more difficult with states' pre-occupation with their own reporting requirements under *No Child Left Behind*. Thus, if programs like the MSP Program expect to deal with student achievement findings in the timely manner still being pursued by the evaluators, the program may want to consider encouraging stronger collaboration among the MSPs, their evaluators, and the state assessment agencies.

Appendix

K-12 Student Achievement Reported by Cohort I, II, and III MSPs (n = 39[8]): (Brief Descriptions)

Cohorts I And II

1. Awaiting 2006-07 data, to compare with 2005-06 baseline. Actual baseline would have been 2004-05 or earlier (new instructional practices started in 2004-05).

However, state changed its mathematics assessment test in 2005-06.

2. Award ended by mutual agreement between awardee and NSF.

3. Data show improvements for five districts from 2002-03 to 2003-04, for both math and science (grade levels not given), with performance in second year also exceeding state's pre-established benchmark of 70 percent proficient. Only defined one of the five districts as having a non-MSP comparison district. Data showed that this single comparison district also improved in both math and science, and it also exceeded the state's benchmark in science. Separate research study uses 2000-01 and 2003-04 data and shows significant relationship between schools' MSP participation and math, but not science scores, compared to all other schools in the state; interpretation clouded by also finding significant relationship with reading scores, though MSP had no reading-related activities (Craig, 2006).

4. District's "percent passing" scores on grades 3-11 mathematics and grades 5, 10, and 11 science all improved for each of two 2-year intervals (2002-03 to 2003-04 and 2003-04 to 2004-05), even though the state raised its standards for "percent passing" each year. The positive trends continue through 2005-06, and White-Hispanic gaps also have been decreasing strongly. However, no comparisons are made, either to statewide averages or to any comparison group, and no attempt is made to link the district's scores to specific MSP activities or the time of those activities. Report for 2005-06 contains no student achievement data.

5. Finds elementary school and middle school students improve significantly in math, compared to ELA (but ELA gains greater in grades 2 and 3), for classes exposed to the MSP's three-prong activity consisting of curriculum (pacing) guides, quarterly assessments aligned with state assessments, and PD to help focus on needed instruction (Hyde, Mann, Manrique, & Shanahan, 2005; Shanahan, Mann, & Manrique, 2006).

6. Original MSP reorganized and now has an official start date of 1/06. Subsequent reports and an MSP-PE site visit have revealed little progress in analyzing any student achievement data, even though the MSP's first goal is to increase student achievement in the partnering school district.

7. Fourth-Year evaluator's report says that mean achievement scores for three of four SCALE districts "...have varied little from prior to 2003 (before SCALE) and after 2003 (with SCALE)" (Porter, 2006, p. 4). However, the MSP's fourth-year report also indicates highly incomplete scale-up, with the "upper limits" of teacher participation estimated at 67 and 66 percent in two of the districts, 41 in the third, and 10 in the fourth, and with no discussion of effects of teacher turnover or in classroom assignments after the MSP activity took place.

8. Earlier analyses had indicated that MSP schools and non-MSP schools did not differ in baseline (Bravo & Arce, 2006). Separate evaluator's report goes on to show

that the percentage of students at or above proficiency increased between 2003-04 and 2004-05, for math in grades 4, 8, and 11, beyond a 5 percent benchmark set by the MSP. However, there were no significant differences between the gains for the MSP schools and those for the non-MSP schools, "...so the gains cannot be attributed to the MSP's reforms" (Vesperman, Mayer, & Webb, 2005, p. 84).

9. Administered TIMMS to about 200,000 students, grades 3-12, as baseline data. Implementing a complicated randomized field trial with districts assigned to multiple combinations of conditions. Trial continued through 2006-07, so no analysis yet.

10. Multi-year scores for MSP's district show no distinct baseline trends (Walker, Gosz, & Huinker, 2005). HLM regression analysis shows that MSP participation, defined as a bivariate condition only, explains but a small percentage of the variability in student proficiency in mathematics for grades 4 and 8 (partly because socio-economic status and prior achievement already account for a large percentage). (A comparison group would produce a dependent variable that is the difference between two groups, not just the performance of one group alone.) The MSP also tested a path model that produced no clear results, and the model is being modified for testing with future data (Hanssen, 2006). Major challenge is to relate PD and school activities with specific classrooms, then with classroom practices, and then with student achievement.

11. Compares multi-district performance with pre-established benchmark (that 90 percent of the MSP districts will have 75 percent or more of students passing the state assessment in mathematics; there is no state assessment in science); by the end of the MSP's third year, many districts were progressing well at grades 5 and 8 but not at grade 11.

12. Latest update (2002 through 2006) shows continuing positive trends for MSP's four regions, but these are not compared to any benchmark or to state or other averages.

13. Continues to find only small differences in teachers' instruction, between randomly-assigned participating and non-participating schools, and similarly finds no significant differences in grades 4, 5, and 6 math scores between the two groups (Bocian, Torres, Bryant, & Hammond, 2005; Torres, Bocian & Bryant, 2006).

14. Two-year achievement trends show increases in "percent passing" and also reduced number of students in "percent below basic," for nearly all 17 participating districts, from 2002-03 to 2003-04, in 6th and 9th grades math and science (Shama-Davis et al., 2005). Later trends harder to track because of changes in state assessment; still need to analyze trends using districts' end-of-grade tests.

15. Serendipitous use of a district assessment shows that, within the same test, and for the whole grade in two different schools, students perform better on two of five strands related to the MSP's science activities than on other strands, in predicted alternating fashion between the schools, mimicking differences in MSP implementation

by school. However, the MSP has not succeeded in its original assessment plan–either having the appropriate test items incorporated into the state assessment or developing its own assessment aligned with its own science kits and curriculum.

16. Cites mixed baseline achievement trends for years prior to MSP, in participating schools; also may be making comparisons with non-MSP schools and classrooms. Concerned with recent changes in state assessment.

17. Data on student achievement appear to suggest positive improvements in relation to MSP's mentoring activity. However, a difficult-to-interpret numeric table is not accompanied by any narrative, and the results also were not addressed during the site visit.

18. Report shows no particular differences between MSP's nine districts and statewide or regional averages, from 2002-03 to 2004-05 in mathematics, summing all grades 3-11. However, evaluator points out that district with 100 percent teacher participation and most intense MSP involvement improved the most and exceeded the statewide and regional averages. Later update finds increases for 8 of 9 participating districts, although MSP's activities are not necessarily covering extensive portions of each district (Lamm & Sloan, 2006).

19. The evaluation team has not completed any outcome evaluation. Earlier formative analyses showed that performance on the specific grade 7 science strand related to the MSP's PD (inquiry-based science) improved from 2001-02 to 2003-04, but not on the 7 other strands tested, at *one* MSP school (see MSP's Yr-2 annual report and the MSP-PE site visit notes, 1/9/07). Other MSP schools did not have the same pattern, possibly because of high baseline scores at the other schools. In grade 8 mathematics, another school had the highest scores in the state, and the school unexpectedly maintained its high scores for 2003-04, possibly because the MSP had implemented PD in *Connected Math*.

20. Evaluation report claims that MSP-participating students (those in the classrooms of the teachers who participated in MSP) did better than a comparison group in grades 6, 7, 8, and 10 but lower in grades 9 and 11 (specific academic subjects not identified). The report provides no further details and does not present the actual data or analysis.

21. No indication of any plan to collect student achievement data. Targeted, mentee teachers (n = about 500) come from over 15 states, and therefore numerous districts and schools, all participating in on-line professional development for beginning teachers.

22. Award ended by mutual agreement between awardee and NSF.

23. The major MSP activity has been aiding districts to implement *Everyday Math*. State assessment for 2003, but not later years, shows that schools with three or more

pilot teachers (who participated in the MSP's PD) performed significantly better in grades 3 and 6 mathematics than schools with no pilot teachers. Comparison between MSP schools and matched set of non-MSP schools show no differences between 1999 and 2004, for 3rd grade mathematics. The data also show reductions in Black-White but not Hispanic-White gaps at some grades and for some of the participating districts.

24. Evaluator reports finding no cross-sectional correlation between the amount of PD to biology teachers (average of 40 hours per teacher for one year) and student performance on biology portion of host district's science assessment for 2004-05; also no relationship between the amount of PD and change in students' scores from 2004-05 to 2005-06 (Frechtling et al., 2006).

25. With MSP's activities having a districtwide reach, districtwide student achievement improving but not different from rest of state in mathematics, Reductions in achievement gaps unclear (Apaza, Sayler, & Austin, 2005; Saylor & Apaza, 2006). MSP also reports that extent of improvement in student achievement is positively correlated with extent of teacher implementation of MSP's instructional materials.

26. Shows that middle school and high school achievement scores have improved, but with no benchmarks or comparisons; enrollment in math courses has increased but could have been influenced by a concurrent increase in the state's requirements from 2 to 3 math courses for graduation.

27. Most recent results show that the (diminishing) control group outperformed MSP groups on most high school science and math Regents exams (but controls outperformed MSP group on 3 of 7 tests in one district and on 5 of 6 tests in the other). Informal analysis suggests that the more teacher training, the better the performance; the more a student is exposed to multiple teachers with training, the better the performance. Earlier, for 2003-04, students taking courses by MSP-trained teachers performed better on state assessment in grade 8 math and science than students in other classes.

28. Minority students show greater enrollment but mixed changes in failure rate, in MSP's first cohort of three participating high schools, compared to target rates set at outset by the MSP.

29. Hispanic students' enrollment rates and reductions in achievement gap, relative to statewide averages, are meeting the MSP's pre-established benchmarks.

30. Compared test scores for 2002 and 2005 with statewide averages. Three high schools that had MSP participation (averaged 51-115 hours per teacher, over three years) did better than statewide averages in 10th grade mathematics; six middle schools that had mixed MSP participation (averaged 23 to 62 hours per teacher, over three years) also had mixed results compared to statewide averages on 8th grade mathematics (Lee, Baldasarri, & Leblang, 2006).

31. Fourth annual report (06-07) does not discuss plans or designs for analyzing student achievement data. However, evaluators have been conducting two types of analyses, one involving 8th grade state assessment data (comparing students whose teachers did or did not attend MSP's PD) and the other using end-of-course district assessments. Because the MSP helped to design the latter, the data are available by strand, so that closer comparisons can be made between test performance on specific strands and teachers' PD exposure to specific PD topics (such close comparisons cannot be conducted with the state assessment data, which are not available on an item basis). The findings are to be reported in the fall of 2007.

32. Starting to collect districts' student achievement data in 2006-07.

33. Findings show that passing rates for middle school math improved for all but two project schools in MSP's initial years. Although the rates exceeded the MSP's benchmarks that called for an increasing proportion of its schools to reach state proficiency levels, the overall improvement for 7 of 10 MSP districts from 2001 to 2007 were no greater than those for 5 comparison districts or for statewide averages.

34. Multiple comparisons to statewide averages for two cohorts show mixed results, but design of the analysis is unclear.

35. State has no 8th grade science test, so MSP has used own test to establish baseline for whole district.

36. Percent scoring proficient or above, for grades 5, 8, and 10 science, are higher than statewide averages in spring 2006, though the scores had tended to be lower than the statewide averages two years earlier. However, percentage gains from 2004 to 2006 were only greater than those for statewide averages for grade 5. Comparisons are even better when examining subset of schools with more than one MSP teacher, except for 10th grade.

Cohort III

37. Still awaiting results from recent science tests, but no discussion of plan for collecting or analyzing data.

38. August 2006 Regents scores show that MSP's summer school participants performed better than those enrolled in regular summer schools.

39. Still collecting achievement data from multiple districts. Also trying to track course enrollment, analyzing patterns for 2005-06 and 2006-07.

40. Just starting to collect baseline data, but no clear identification of target grades or comparison groups.

41. Has collected baseline data. For schools meeting a criterion level of MSP participation, plan to make later comparisons with matched non-MSP schools selected from the rest of the state, in middle school mathematics.

Endnotes

[1]NSF made 48 MSP project awards from 2002 to 2004, covering comprehensive," targeted," and "institute" types of MSPs. Of the 48 projects, two were discontinued and seven were "institute" awards that were not included in the present analysis. During the same three-year period, the program also supported 28 other project awards that are not MSPs but that are conducting research, evaluation, and technical assistance (RETA) activities. However, the RETAs do not necessarily involve activities directly related to K-12 classrooms or teachers. Therefore, the 28 RETAs also fall outside of the present analysis. Finally, starting in 2006, the program has since made additional MSP project awards that were too new to be included in the analysis.

[2] For three projects, the information came from site visits conducted by the program evaluation team (MSP-PE), because the reports did not cover the MSPs' student achievement work.

[3] These conferences were held in Minneapolis, MN, in September of 2005 and 2006, and in Washington, DC in January 2008.

[4] The annual and evaluators' reports varied in the recency of the student achievement data in their analyses. Most of the reports included student achievement data for 2004-05 and earlier years, whether the MSP was from Cohort I or II. A few of the reports included data for 2005-06 (and earlier years).

[5] In few instances, as with the cited MSP, did the MSPs perform any statistical tests to determine the significance of any differences. Where tests were performed, the results are noted in the tables and figures. Otherwise, the data in the tables and figures need to be recognized as descriptive data only.

[6] One other MSP has reported using a more complex design whereby different participating districts have been randomly assigned to multiple combinations of conditions. However, the implementation of this design was still ongoing during 2006-07, so the analysis of these results will not be available for some time.

[7] Although these MSPs may not have reported about their own student achievement analysis in their annual or evaluators' reports, all had submitted (school-level) student achievement data into the MSP Program's management information system (MSP-MIS). Such annual submissions are a requirement of the MSP Program.

[8] The analysis covers the awards to 48 MSPs made by NSF from 2002 to 2004, covering "comprehensive," targeted," and "institute" types of MSPs. Of the original

48 awards, two were discontinued and seven were "institute" awards that were not included in the present analysis. During the same three-year period, the Program also supported 28 other awardees that are not MSPs but that are conducting research, evaluation, and technical assistance activities. These 28 awardees also fall outside of the present analysis. Finally, starting in 2006, the Program has since made additional MSP awards that were too new to be included in the analysis.

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The MSP-PE is led by COSMOS Corporation. Robert K. Yin (COSMOS) serves as Principal Investigator (PI) and Jennifer Scherer (COSMOS) serves as one of three Co-Principal Investigators. Additional Co-Principal Investigators are Patricia Moyer-Packenham (Utah State University) and Kenneth Wong (Brown University).

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A Brief History of NORMES and JERPS

The office that eventually became The National Office for Research on Measurement and Evaluation Systems (NORMES), a research unit in the College of Education and Health Professions (COEHP) at the University of Arkansas in Fayetteville, began with a $500 research incentive grant awarded to Principal Investigator Dr. Sean Mulvenon in 1996. In 1998, Dr. Mulvenon and Dr. Ronna Turner founded the Office of Research, Measurement and Evaluation (ORME) for the purpose of educational database development, management, and analysis; data assessment and analysis training; academic accountability model development; and theoretical research in the fields of education, statistics, and measurement.

Researchers at ORME worked with the Arkansas Department of Education to create the Educational Data Delivery System (EDDS), which was at that time the only data system in the country that provided educators with student level data on a restricted website. In 2000, EDDS was recognized by the U.S. Department of Education and the Council of Chief State School Officers as a model program for collection and dissemination of educational data. The success of EDDS served as a springboard for ORME to expand into other arenas.

Federal funds were subsequently secured by Dr. Mulvenon through the Fund for the Improvement of Postsecondary Education (FIPSE) for the formation of the National Office for Rural Measurement and Evaluation Systems. The Office was created to develop systems for data dissemination and analysis involving rural schools, particularly in the state of Arkansas. These data were essential to provide geographically isolated schools the tools they needed to effect productive changes in their educational methodologies, primarily through improved student assessment and evaluation and the identification of educational best practices.

To aid in the dissemination of the research findings of NORMES, the Arkansas Department of Education provided funds for the formation of the *Arkansas Educational Research and Policy Studies Journal*. The *Journal*'s first issue appeared in the spring of 2001. The *Journal* was sent to all Arkansas school superintendents, as well as state legislators, to provide them with the latest findings and implications of empirical educational research.

As research progressed and additional federal funding was provided, NORMES evolved from the National Office for Rural Measurement and Evaluation Systems into the National Office for Research on Measurement and Evaluation Systems. Paralleling the evolution of the office, the *Arkansas Educational Research and Policy Studies Journal* became the *Journal of Educational Research and Policy Studies*—a national, refereed forum for the critical goal of improving this nation's education system.

NORMES continually seeks to expand its arena to other states, as well as to extend the acquisition of data into the postsecondary level to offer a holistic analysis of students' entire educational careers. The Office is also expanding research efforts to develop new, cutting-edge models for data management, analysis, and dissemination. Of particular interest is the utilization of the internet to make critical educational information widely available.

Education is the keystone of this country's well-being. The mission of NORMES is to provide educators, policymakers, parents, and other stakeholders in education with the most reliable educational achievement data possible, as well as proper analysis of that data, so that informed decisions are possible in the never-ending effort to support and improve the nation's educational system.

- *Michael J. Martin*

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The *Journal of Educational Research & Policy Studies* (formerly the *Arkansas Educational Research & Policy Studies Journal*), now a national, refereed scholarly publication, seeks quality manuscripts for consideration and possible inclusion in forthcoming issues. The *Journal* is published twice yearly at the University of Arkansas – Fayetteville.

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