Math Science Partnership

Evaluator’s Report:
Overall Findings

November 2010

by

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November 2010
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>3</td>
</tr>
<tr>
<td>Overview of the Math Science Partnership Program</td>
<td>3</td>
</tr>
<tr>
<td>The Math Science Partnership Program of Southwest Pennsylvania</td>
<td>3</td>
</tr>
<tr>
<td>Evaluation</td>
<td>5</td>
</tr>
<tr>
<td>Evaluation Design and Implementation</td>
<td>5</td>
</tr>
<tr>
<td>SW PA MSP Logic Model and Theory of Action</td>
<td>6</td>
</tr>
<tr>
<td>Logic Model</td>
<td>7</td>
</tr>
<tr>
<td>Theory of Action</td>
<td>7</td>
</tr>
<tr>
<td>Relationship Between Logic Model and Evaluation Questions</td>
<td>8</td>
</tr>
<tr>
<td>Major Findings</td>
<td>9</td>
</tr>
<tr>
<td>Partnership</td>
<td>9</td>
</tr>
<tr>
<td>Instructional and Institutional Change</td>
<td>13</td>
</tr>
<tr>
<td>Student Learning</td>
<td>16</td>
</tr>
<tr>
<td>Educational Change</td>
<td>17</td>
</tr>
<tr>
<td>Final Comments</td>
<td>20</td>
</tr>
<tr>
<td>Individual Reports</td>
<td>21</td>
</tr>
<tr>
<td>MSP Teacher Content Knowledge: 2004-2010</td>
<td>24</td>
</tr>
<tr>
<td>MSP to State PSSA Report: 2008-2009</td>
<td>40</td>
</tr>
<tr>
<td>Learning Lab Evaluation Report: 2009</td>
<td>101</td>
</tr>
<tr>
<td>Focus Group Interview Evaluation Report: February 2010</td>
<td>124</td>
</tr>
<tr>
<td>Lesson Study Summary Report: August 2010</td>
<td>136</td>
</tr>
<tr>
<td>Case Study Report: 2009-2010</td>
<td>148</td>
</tr>
<tr>
<td>District Profile Report: 2008-2009</td>
<td>175</td>
</tr>
<tr>
<td>Impact of MSP on Student Achievement Report</td>
<td>185</td>
</tr>
<tr>
<td>Key Project Personnel Final Interview Report: November 2010</td>
<td>259</td>
</tr>
</tbody>
</table>
INTRODUCTION

Overview of the Math Science Partnership Program

The National Science Foundation’s (NSF) Math Science Partnership (MSP) program was an outgrowth of the No Child Left Behind (NCLB) Act of 2001, focusing on three issues: an excess of teachers teaching out of field; too few students taking advanced coursework; and too few schools offering challenging curricula and textbooks. Although previous NSF programs targeting math and science educational reform in levels K – 12 have focused on similar issues, the Math Science Partnership program also included higher education as a critical partner and potential benefactor of its efforts.

The Math Science Partnership program supported two types of partnerships: comprehensive and targeted. The comprehensive projects were funded for a five-year period for up to $7 million annually. These projects were intended to implement change in mathematics and/or science education in both institutions of higher education (IHEs) and school districts, resulting in improved student achievement across the K-12 and IHE continuum. The targeted projects focused on improving student achievement in a narrower grade range within K-12 or with a focus on a single discipline (math or science), and were funded for up to $2.5 million per year for up to five years. In addition, the Math Science Partnership program funded research, evaluation, and technical assistance (RETA) projects that build and enhance large-scale research and evaluation capacity for all Math Science Partnership awardees and provided them with tools and assistance in the implementation and evaluation of their work.

NCLB also authorized a parallel Math Science Partnership program at the U.S. Department of Education. This program required partnerships to include a state educational agency or a public regional intermediary, such as one of Pennsylvania’s Intermediate Units (IUs), to work with the engineering, math or science department of an institution of higher education, and a high-needs school district. Unlike the NSF program, where funds were awarded in a national competition, the Math Science Partnership program at the Department of Education awarded funds to states to administer.

The Math Science Partnership of Southwest Pennsylvania

The Math Science Partnership of Southwest Pennsylvania (SW PA MSP) was one of seven comprehensive partnership projects funded by NSF in 2003. It was a partnership of 53 school
districts, four institutions of higher education (IHEs), and four partner Intermediate Units (IUs). The NSF award supported 40 of the school districts since the project’s inception, and another five were added in year 4 (2006-07) as part of a planned expansion. A Math Science Partnership award in the U.S. Department of Education program, through the Pennsylvania Department of Education (PDE), supported the remaining eight districts. The MSP was headquartered at the Allegheny Intermediate Unit (AIU) near Pittsburgh; this IU serves the greatest density of participating/partner school districts in the region.

The region of Southwestern Pennsylvania served by the MSP includes the urban fringe of the city of Pittsburgh, several smaller urban areas, suburbs, and rural areas. Total enrollment in the MSP school districts was approximately 114,000 students, with approximately 3,800 teachers who taught math or science topics. On average, about 39% of students in MSP schools are economically disadvantaged, compared with a statewide average of 36%. This figure was higher in the PDE MSP districts (59%) than in the NSF MSP districts (35%). The enrollment of underrepresented minorities was approximately 19%, compared with a statewide average of 22%. Again, this figure was higher in the PDE MSP districts (25%) than in the NSF MSP districts (18%). These demographics vary widely across schools. The reported percentages for both economically disadvantaged and minority populations vary from 0% to nearly 100% in individual schools.

Similarly, there was wide variation in student achievement levels across the K-12 schools in the MSP. A substantial number of MSP schools were not achieving adequate yearly progress under NCLB. At the other end of the spectrum, the MSP included several “blue ribbon” schools, which were among the highest achieving in the state.

The original four partner IHEs were small- to mid-sized, teaching-oriented, private institutions located in southwest Pennsylvania: Carlow University, Chatham University, Robert Morris University, and Saint Vincent College. Approximately 8,600 students were enrolled in these IHEs, and approximately 59 members of their math, science, engineering and education faculties participated in this project. Although some of the larger, research-oriented universities in southwest Pennsylvania were invited to participate in the MSP, they declined. In some cases, the universities were already involved in educational reform programs. For example, the University Of Pittsburgh School Of Education was already involved in a Math Science Partnership through the University’s Learning Research and Development Center.

Consistent with the objectives of the overall Math Science Partnership program, the fundamental goals of the SW PA MSP were to (1) increase K-12 students’ knowledge of mathematics and science, (2) increase the quality of the K-16 educator workforce, and (3)

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1 Intermediate Units are publicly funded educational service agencies that act as regional intermediaries between local school districts and the Pennsylvania Department of Education.

2 Pittsburgh Public Schools (PPS), the largest urban school district in the region, is not formally involved as an MSP participant.

3 As is common practice, we use free or reduced-price lunch eligibility as a proxy for economic status.

4 The racial/ethnic groups included in this category are African-American, Hispanic, Asian, and Native American students.
create a sustainable coordination of partnerships in the IUs, building intentional feedback loops between K-12 districts and IHEs, tapping the discipline-based expertise of the IHEs, and improving the mathematics and science learning experiences for all undergraduates.

EVALUATION

Evaluation Design and Implementation

The AIU originally subcontracted with the University of Pittsburgh, the RAND Corporation, and the Evaluation, Grants and Data Division of AIU to serve as evaluators for the SW PA MSP. In Year Five, the RAND exited the project and the University of Pittsburgh team assumed additional responsibilities. Individuals from these organizations formed the evaluation team, which monitored the project’s progress in order to offer formative advice to the project, measure its ultimate success in achieving its goals, and document lessons for the benefit of future initiatives that may seek to replicate it. Four research questions guided the evaluation:

1. Have MSP partners developed and implemented a comprehensive intervention targeting math and science curriculum and achievement? If so, how?
2. Have institutional practices and support structures changed at K-12 districts and IHEs participating in the MSP? If so, how?
3. Has math and science instruction changed in K-12 districts participating in the MSP? If so, how?
4. In what ways have student outcomes and course taking changed in K-12 schools and districts participating in the MSP? If change occurred, what is the connection between implementation of the MSP plan and these changes?

To address these research questions, the evaluation team adopted a mix of qualitative and quantitative methods in three distinct but overlapping areas of research and analysis: (1) formative assessment and documentation of MSP activities in relation to the institutional goals and student outcomes described above; (2) qualitative and quantitative investigation of implementation at K-12 districts, including (a) institutional change at the district level, and (b) the links between involvement in partnership activities and curriculum implementation strategies at the district and school level and K-12 student outcomes; and (3) evaluation of institutional change at IHE partners as a result of involvement in MSP activities.

The table below shows the evaluation strategies, data sources, and sampling methods used in the evaluation, and indicates which research questions are informed by those sources. The table also indicates how these data collection strategies are related to the research questions and how frequently the data were collected. Full copies of the protocols and instruments are not included in this report; however, they are available to project staff and other interested parties on request.
Table 1. Evaluation Activities.

<table>
<thead>
<tr>
<th>Evaluation Strategy</th>
<th>Data Source</th>
<th>Research Questions Addressed</th>
<th>Frequency of Data Collection</th>
<th>Type of Information Gathered</th>
<th>Sampling Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Observations</td>
<td>MSP Events</td>
<td>1, 2</td>
<td>Years 1-7</td>
<td>Implementation data</td>
<td>Representative set of major project activities</td>
</tr>
<tr>
<td>Interviews / Focus Groups</td>
<td>Project PI and MSP Coordinators</td>
<td>1, 2</td>
<td>Years 1-7</td>
<td>Implementation data</td>
<td>All</td>
</tr>
<tr>
<td>Interviews / Focus Groups</td>
<td>IHE Faculty</td>
<td>1, 2</td>
<td>Years 1-4</td>
<td>Implementation data</td>
<td>Representative sample</td>
</tr>
<tr>
<td>Case studies</td>
<td>School districts</td>
<td>1, 2, 3</td>
<td>Years 2-7</td>
<td>Implementation and impact data</td>
<td>Purposive sample of school districts</td>
</tr>
<tr>
<td>Case Studies</td>
<td>IHEs</td>
<td>1, 2</td>
<td>Years 4 &amp; 5</td>
<td>Implementation and impact Data</td>
<td>All IHEs</td>
</tr>
<tr>
<td>Lesson Study Observation</td>
<td>Teachers</td>
<td>2, 3</td>
<td>Years 5 &amp; 6</td>
<td>Impact data</td>
<td>Lesson study meetings across teams</td>
</tr>
<tr>
<td>Learning Lab Observation</td>
<td>Teachers</td>
<td>2, 3</td>
<td>Years 5 &amp; 6</td>
<td>Impact data</td>
<td>Learning Lab summer PD sessions</td>
</tr>
<tr>
<td>Survey</td>
<td>Teachers</td>
<td>2, 3</td>
<td>Years 1 &amp; 4</td>
<td>Impact data</td>
<td>Random sample of teachers</td>
</tr>
<tr>
<td>Survey</td>
<td>Principals</td>
<td>2, 3</td>
<td>Years 2 &amp; 4</td>
<td>Impact data</td>
<td>All principals</td>
</tr>
<tr>
<td>Survey</td>
<td>Leadership Action Teams (LAT)</td>
<td>2, 3</td>
<td>Year 6</td>
<td>Impact data</td>
<td>All LAT participants across years of project</td>
</tr>
<tr>
<td>Content Knowledge (Math and Science)</td>
<td>Teachers</td>
<td>3</td>
<td>Years 3-7</td>
<td>Impact data</td>
<td>Teacher leaders and teachers</td>
</tr>
<tr>
<td>Pre-post and statewide comparisons</td>
<td>Student achievement data</td>
<td>4</td>
<td>Years 1-7</td>
<td>Impact data</td>
<td>K-12 students in tested grades</td>
</tr>
<tr>
<td>Pre-post and regional comparisons</td>
<td>Course completion data</td>
<td>4</td>
<td>Years 1-7</td>
<td>Impact data</td>
<td>K-12 graduates</td>
</tr>
</tbody>
</table>

SW PA MSP Logic Model and Theory of Action

To assist in the evaluation, the evaluation team developed a logic model to illustrate the interrelationships among the SW PA MSP program’s goals, activities, and outcomes. Logic models are common evaluation tools, and offer visual representations of a program’s path to achieving its intended outcomes. The model not only describes the MSP project, but also furnished the evaluation team with a unified set of terms and relationships to facilitate discussion and thinking about the MSP project. The logic model was viewed as a work in
progress that evolved with the evaluation team’s thinking and analysis of the MSP project. The logic model is shown in Figure 1. It includes the traditional components of inputs, activities, outputs, and outcomes.

Figure 1. SW PA MSP Logic Model.

Theory of Action

The theory of action that underlies the MSP logic model is premised on the view that student achievement in mathematics and science can be enhanced by administrators and classroom teachers who are willing to become learners and deepen their own conceptual understanding of the big ideas in mathematics and science. Similar to the theory of action for the NSF-supported Local Systemic Change program, this theory of action argues that providing teachers with opportunities to deepen their content and pedagogical knowledge in the context of high-quality instructional materials will result in better prepared teachers. With ongoing support, teachers will be more inclined to change their instruction in ways advocated by national standards, and will have more capacity to do so. These changes in instructional practices are

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5 Math & Science Collaborative Journal, v11, p.20.
expected to improve student thinking and learning, a core focus of the MSP, which will in turn lead to higher student achievement.

This theory of action is supported by a number of research studies. In particular, Catherine Lewis’s seminal work on “lesson study” and research by Japanese and U.S. educators has outlined key pathways to instructional improvement, most of which are mirrored in the MSP logic model. These key pathways include: increased knowledge of subject matter; increased knowledge of instruction; increased ability to observe students; stronger collegial networks; stronger connection of daily practice to long-term goals; strong motivation and sense of efficacy; and improved quality of lesson plans (Lewis et al., 2004). The intervention strategies that the MSP has employed provide mechanisms for achieving program goals along each of these pathways. The teacher leadership academies develop understanding of content and pedagogy and are important pathways for achieving increased knowledge of instruction as well as content. Content deepening seminars are designed to update and deepen teacher knowledge in a specific content area and contribute to increased knowledge of subject matter. Stronger collegial networks are built via a number of routes, including participation in Network Connections6, district professional learning communities, and Educator Networks. The emphasis on curriculum alignment and pedagogical and course refinement offers opportunities to improve the quality of instructional materials and lesson plans. However, in addition to these pathways, the MSP theory of action also argues that support from district leadership is an important component of instructional improvement. Thus, Lenses on Learning was a key intervention strategy for gaining administrator support early in the intervention. In order for administrators to support effective teaching and learning in the classroom, they must first learn what good instruction is and how to recognize it. With these new “lenses,” administrators were better prepared to support teacher-led instructional change, through improved teacher observation skills, support for professional development, and the creation of strong learning communities within the schools and districts. Finally, the role of the IHE in the MSP theory of action is based on the belief that partnership between K-12 and IHEs is mutually supportive and can enhance learning, cultural awareness, and teaching practices for both partners.

Relationship Between Logic Model and Evaluation Questions

The MSP logic model and research evaluation questions formed a framework to guide the evaluation. The first research evaluation question addressed the need to provide formative assessment and documentation of MSP activities and corresponded primarily to the Intervention Strategies and MSP Activities listed in the logic model. However, the discussion of MSP activities also had implications for the Inputs and Outputs. The successful implementation of the MSP activities depended on the resources available to generate these activities. Moreover, successful implementation of MSP activities was reflected in the Outputs generated.

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6 Network Connections is a semi-annual gathering of LATs from across the SW PA MSP together with appointed teams from other non-participating districts in the region to consider current research and materials to impact K-12 science and mathematics education.
For the MSP, this is evidenced by the quantity and quality of instructional leaders, curriculum materials, and opportunities for interactions. The second and third research evaluation questions assess some of the key outcomes of the MSP — changes in institutional practices, changes in support structures at both the district and IHE levels, and changes in instructional practices at the classroom level. Although these questions primarily track the Mid-term outcomes in the logic model, the Short-term outcomes were important precursors that indicated the likelihood that these Mid-term outcomes would be achieved. Finally, the fourth research evaluation question focuses on the bottom line of student outcomes and changes in course taking practices. In essence, this question is asking whether the project achieved its goals, which were outlined by the long-term outcomes of the logic model. One of the most important aspects of this assessment was to determine whether achievement of these long-term outcomes is linked to MSP activities.

MAJOR FINDINGS

The evaluation activities across seven years of the program have yielded many findings of noteworthy value, formatively and summatively. These have been systematically articulated to the program staff, each year through Cabinet and staff review of individual and collective reports and presentations. The program has regularly acted on the findings and recommendations by the evaluators to address the emerging needs and issues, each year. The evaluation project director served on the Cabinet throughout the project and this inclusion helped to place evaluation at the core of decision making for the project, as did the commitment of the PI and staff to the use of data-based planning and management. Findings from specific years of the program, as well as the actions taken by the Cabinet and project staff, can be reviewed in the annual project and evaluation reports.

The findings presented here are designed to capture the larger program impacts across the seven years of the MSP program since this report serves as a summative effort. The findings are organized by the major outcome areas identified in the logic model presented earlier: partnership, instruction, institutional structure and policy, and student learning. Additionally, we have learned quite a bit across the seven years of this program about educational reform planning, implementation, and scale up. We offer our observations on each of these areas in the following sections.

Partnership

1. Some will come, different needs and different levels of commitment will emerge, and fewer will stay.

The MSP began with four IHE partners, 53 K-12 school districts and 7 Intermediate Units in partnership. Seven years later, the partnership looks different in number and members. One of

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7 Annual evaluation and project reports are available for review through the SW PA MSP offices
the IHE partners exited the project at the conclusion of Year 5 and 39 K-12 districts remain actively involved, as do 3 Intermediate Units. The original IHE partners were smaller private institutions having both STEM and Education interests through academic programs. This intersection helped to make clear the important connection between education and math/science efforts. The size of the institutions also played a part in their involvement. Each institutional partner was able to bridge communication and articulate the project across the boundaries involving mathematics, sciences, and education. This may present more challenge in larger and more complex settings. One large institution that was approached early turned down the opportunity for partnership, in part because of complexities of involvement. While size seemed to matter at the outset regarding partnership, it seemed not the ultimate factor for sustained involvement. Of the original four partners, changes in leadership, level of faculty engagement, and representation of the institution within the project varied across institutions and years. The institutions that were able to sustain and extend involvement successfully maintained a senior level commitment to the project, consistently engaged senior faculty, rewarded and incentivized faculty involvement, and regularly attended MSP activities and representative meetings such as the Cabinet and MSC Steering Council. As changes occurred in the institutions that successfully continued as partners, involved faculty and administrators advocated for sustained involvement and commitment to the effort. Project leaders and staff were available to meet with new institutional leaders and faculty to extend the hand of the partnership in tangible form.

Similarly, K-12 schools experienced much change across the seven years of the project. During this period, more than half of the school administrators in the districts changed (principals, superintendents, central office staff). Teachers and teacher leaders, to a lesser extent than their administrative colleagues, shifted positions, assignments, and districts. Some individuals retired or moved out of the area, and new people were hired and placed. These changes required the development of various cohorts and project activity "on ramps" to allow those new to the project to develop prerequisite knowledge, skills, and dispositions. From an institutional perspective, personnel change, especially over an extended period such as seven years, can present a huge challenge for consistency in implementation or sustainability. Institutions that were successful partners across time tended to have more leadership stability, and even when individuals changed chairs, there was a cadre of people within the district to maintain an institutional memory that served as a foundation for continued or sustained activity. In some cases, new leadership coming into a district was able to bring their past experience of the MSP from prior settings into a new context for implementation. In all cases, the transition across change required advocacy by both people inside the institution (district and/or schools) and the availability of support from the external MSP project staff to assist with issues across the transitional period.

II. Those that stay, give much, learn much, and change.

The institutions that maintained a commitment across the years of the project, both IHE and K-12, worked hard to engage in the project, learned much, and evidenced change in practice and culture. The MSP worked toward deep individual and institutional change. Individuals were
asked to move far beyond a comfort zone in their knowledge (content knowledge for K-12, pedagogical knowledge for IHE), skills (reframed and changed pedagogical practice for IHE and K-12), and dispositions (reframing oneself as a learner and deprivatizing practice for IHE and K-12). Institutions were expected to redesign courses, change scheduling, redefine faculty/teacher responsibilities and expectations, reconsider supervision and promotion models, and to reconceptualize basic understandings such as what constitutes professional development and adult learning, how to engage all students in rigorous science and mathematics, and how to adopt shared leadership models. These changes are neither easily embraced nor achieved in educational institutions that are more apt to replicate past structures and functions than to consider and implement change models.

Those that stayed the course across the years of the project look and behave quite differently as a result of their participation. IHE members indicate increased communication and opportunities for academic exchange among departments and faculty. So too, IHE courses were redesigned and in a number of cases, faculty report sincere changes in pedagogical decision making and practice. Student teaching practices, a particularly challenging issue in terms of scheduling and aligning students with reform-based K-12 educators, has become identified as an important issue for departments of education at the member IHEs. The inaccurate role of IHEs as external expert has been amended to one of co-learner where expertise is shared among IHE and K-12 faculty and teachers.

K-12 members show numerous examples of changed pedagogy that results in increased student engagement and potential for more rigorous examples of learning. Teachers, especially at the elementary level have shown increases in content mastery and the ability to more accurately design and deliver lessons to students. Teachers have taken on roles as teacher leaders among their peers to press for higher levels of professional expectation in adult learning and application in pedagogy. Professional learning communities have been established in a number of districts, though not without significant challenge and resistance from existing school structures and schedules that preclude meaningful interaction among adults in schools.

The seven year history of the MSP has provided many pointed and frustrating reminders that change, either at the individual or the institutional level, is exceedingly difficult to put in place, and even harder to maintain. However, the project has reviewed many cases of teachers, K-16, reflecting on how their involvement in the MSP has fundamentally changed how they teach, how they view student learning and needs, and what they know about the disciplines of math and science and pedagogy. These changes, while individual, are not minimal. Teachers impact thousands of students over their career, and each, especially as part of a project designed as such, like the MSP, also serves as a "leader" among their colleagues for extended impact.

III. We are different, yet surprisingly similar.

At the onset of the MSP, there were expected cultural tensions among IHEs and K-12 institutions and contexts. While the MSP was not designed specifically to elicit and address these differences, to develop and sustain meaningful partnership, it was required. IHEs often
view themselves as settings of expertise, and more often than not, they are. This perspective can, however, seep beyond the areas of clear content expertise and begin to influence interactions and relationships. Dysfunctional perceptions of roles, by members or outsiders, can present challenges. For example, IHE faculty to view themselves as authorities, and somewhat challenging to consider their role as a learner. Similarly, K-12 teachers may view themselves as "educators" and discount the role of IHE faculty as educators. IHE faculty may be viewed as out of touch and distanced from the realities of dealing with education in the trenches, so to speak. At times, K-12 teachers may position themselves as less powerful than their IHE counterparts and thus, take on a stance as more passive learner. These dysfunctional notions of roles and positions makes collective learning (and teaching), challenging.

So too, the institutional cultures of IHE and K-12 settings are very different. K-12 culture, especially in southwestern Pennsylvania, is determined by collective bargaining contracts, coupled with state-mandated policies and procedures. The "contract" typically has specific language covering expectations, professional development, payment for contracted teaching and other duties, and includes provisions for determining details outside of the contract (through agreement or grievance). IHE culture is dominated by more informal expectations on faculty that include broad definitions of teaching, research, and service. These activities are individually negotiated in specific enactment through relationships of faculty with chairpersons, Deans, and other administrators, and are often not codified. Reward, through tenure and/or promotion, is often ambiguous and somewhat situational depending on current personnel and cultural interpretations. Something as simple as scheduling a meetings across these very different cultures, can become a nightmare of negotiating class coverage, excused absences, whether it "counts" as valued (and rewarded) activity, and what times are acceptable alternatives.

The project learned, over time, that while the experience of IHE and K-12 members were quite different, the issues were quite similar. As reported in The Year Two Evaluator’s Report, both cultures presented challenges of incentive and reward structures, promotion and tenure, workload and time constrains, and administrative support (p. 37-42). While the details were significantly different, the underlying structural and cultural issues were very much the same. The recognition of these issues as similar helped members to focus on shared experience, rather on a more judgmental critique of the one another, and as a result, adjustments could be made more easily, and there was an increased level of respect across contexts. This resulted in more comfortable and productive learning opportunities.

IV. Partnership does not necessarily mean collaboration. Relationships take time and effort, are people-driven, and are unique.

Partnership serves as a beginning only. People and institutions come to the table to partner because there is the promise of mutual benefit. To create that actual benefit, to further enhance it and develop the relationships that can produce new and extended benefit, takes continued effort through collaboration. The MSP Cabinet served as the catalyst for that collaboration. By sharing and discussing common information, priorities, and activity, the
operational structure of the Cabinet provided an opportunity to present and deliberate next steps and issues for consideration by all partners. Relationships take time to mature across experience. As the MSP activity occurred over seven years, partners came to better understand each other’s perspectives, strengths, challenges, and needs. The growth of the personal relationships among the Cabinet members (and in some cases, the lack of growth on a personal level) was an important component of the institutional relationships among the partners. So too, the relationship of each of the institutional representatives with other members of their team (in the MSP and at their home institution) also played a role in the level of involvement and sustainability of the institution’s commitment with the MSP. Similarly, relationships across sectors and across teams deepened. Each relationship, with representatives and institutions, was unique to a certain degree. Each had their own institutional and personal context for involvement and decision-making, priorities and needs for gain from the partnership, and strengths to offer to the partnership.

**Instructional and Institutional Change**

1. *We can’t change what we don’t know and understand.*

The early and repeated emphasis on content knowledge in math and science as a foundation for all professional development for K-12 teachers was a defining characteristic of the SW PA MSP. Even when focusing on teacher leadership, all professional development included embedded content knowledge in math and science. This emphasis built on the research literature suggesting that K-12 teachers, especially those in elementary and middle schools, were underprepared in these disciplines. As teachers encountered new understandings of math and science themselves, they became increasingly aware of student (and in many cases, their own) misconceptions and how they needed to address the content differently in their pedagogy. More familiar and comfortable with content, teachers are better able to engage in deeper reconstruction of their teaching and to link content knowledge with pedagogical content knowledge.

Similarly, while IHE faculty were well versed in the math and science disciplines they teach, they received little or no preparation for teaching. In fact, often, faculty rely on their own learning experiences as students to determine their pedagogy. The pedagogical approaches that work best with highly motivated and deeply prepared students (such as current faculty in the disciplines) may be less successful with struggling learners. This mismatch of learning experience with current teaching approach creates a schism between many of the most expert faculty and the majority of nearly college students who are not necessarily well prepared for or interested in advanced exploration in math and science. The MSP provided more in-depth exposure to diverse pedagogy and consideration of the Pennsylvania standards for science and mathematics through teacher fellows embedded in practice with IHE faculty as well as the alignment of faculty-led content workshops with the standards. These interventions, focused on IHE faculty pedagogy, assisted a number of faculty in redesigning their courses and teaching approaches.
II. Willingness to support risk taking and uncertainties of change is required.

Not surprisingly, knowing and understanding what is needed is not enough to make change happen. One of the consistent findings emerging from the MSP work is that change tends to happen when a combination of factors come together. As mentioned earlier, content knowledge for K-12 teachers and pedagogical knowledge for IHE faculty serves as a foundation. Knowledge, whether related to content or pedagogy, even combined with the skills to deliver improved instruction and opportunity for learning, does not suffice. For reform to take root, these seeds must be nurtured by first a willingness to change and a culture that supports aspects of risk inherent in change. Changing teaching practice and codifying changes in policies and procedures is a process requiring continuous effort by a critical mass of people within institutions.

III. Educators can learn new information and apply it in practice, but collaboration among educators is necessary to extend and sustain change.

Evidence from this project suggests that the impetus for reform may begin with teachers or administrators, however, sustained change occurs only when both groups contribute to change across time. Teachers supply the change in pedagogy necessary to directly influence opportunities for student learning. Administrators create supportive structures and processes to allow not only teachers to implement pedagogical changes, but also, to put in place important opportunities for continuous learning among educators such as professional learning communities. Without structural and process-oriented changes to support reform-based pedagogy, instructional practices become stagnant and isolated in individual classrooms.

The primary change agent in the SW PA MSP was the Teacher Leader. Essentially, teacher leaders were trained to both change their own pedagogy and to act as a professional development catalyst among their peers. Observational evidence from over 234 math and science classes strongly suggests that these individuals changed their own practice through increased content knowledge and the application of reform-based pedagogies. IHE faculty who worked with teacher fellows and revised their courses also report changes in the pedagogy that align with more diverse learning needs of students. In both cases, these "leaders" have had some success in influencing the practices of their peers. Among K-12 sites with high fidelity of implementation (professional learning communities were established and functioning more closely to the intended model), there is evidence of reform-based pedagogy among peers. While some "reform contagion" effect is documented, successfully through designed activity such as lesson study and the development of professional learning communities, the adoption of these strategies was far less widespread as originally expected.

These data point to a repeated challenge in reform efforts, namely, depth and breadth of diffusion. Findings from SW PA MSP align with similar findings across innovation literature, indicating that inoculation tends to weaken in both depth of impact and breadth of reach from the point of initial training. (Knapp, 2002; Coburn, 2004). Mediating variables negatively
influence diffusion. As teacher leaders return to their school site, they return to primary duties, not as a reform agent, but rather, as a teacher. Their primary effort toward reform is focused on their own classroom practice, and, as time, energy, and supportive structures allow, to other colleagues. Intention for deep and broad diffusion is hampered by the inability of the individual reformer to influence the structures and processes of the system to be more conducive to impacting colleagues. A similar process occurs among IHE faculty, though the specific mediating variables are different in this culture. IHE faculty have less formal structures for sharing pedagogy or practice, less incentive to focus on pedagogy, and less informal value for these opportunities within an IHE context.

IV. Information can guide our thinking, however, it needs to be accessible, relevant, and meaningful, and we need to know how to apply it.

The SW PA MSP professional development included working with teams from participating school districts that represented a "vertical slice" of people including teachers and administrators. These teams routinely considered student achievement data to determine strategic planning for their district's professional development. Data were disaggregated by grade, special needs categories, discipline, and specific topic areas, to identify patterns of strength and weakness in each area. Data were compared annually. MSP staff accessed and organized data for district teams in ways that made the data more useable and relevant to specific questions related to professional development needs. These intermediate steps helped to clarify the questions being asked, how the data were able to address the questions and the kinds of patterns that pointed to specific paths for professional development. This supportive infrastructure provided a productive scaffold for data use through program activities.

V. Systems change because people value the impact of the changes they make individually and are willing to advocate beyond themselves.

Many of the success stories of the MSP can be reflected through examples of individual teachers developing deeper content understanding, transmitting a more rigorous curriculum through reform-based pedagogy, and renewing their connection with the discipline they teach. Those examples are noteworthy and needed. However, if educators are going to make any substantive change, they must be able to extend reform beyond their own classrooms. Reform and innovation, as mentioned previously, does not simply diffuse across people and institutions without effort and vectors to propagate change. In education, those vectors are often the individual educators (in K-12 and IHE) who come to value their own change (and results) and become advocates to colleagues and other stakeholders. While fewer than the number of examples of individuals who have changed their knowledge, skills, and dispositions, the SW PA MSP has evidence of advocacy among educators across the K-16 education sectors that have impacted colleagues, and institutional policy and procedures. Evidence of system change through advocacy includes the adoption of reform-based materials, use of data more rigorously for decision-making, use of the curriculum frameworks, and the implementation of more rigorous course sequences for students. One of the major structural elements for change that is more broadly implemented as a result of MSP impact, is the use of professional learning
communities as a primary mode of professional development. These communities support the deeper consideration and deliberation of pedagogy and can form the basis for advocacy through shared practice.

VI. Sustainability requires a dynamic and continuous support system that acknowledges the importance of person-based relationships.

Across time, the institutions, both IHE and K-12, that remained active participants with the MSP, all developed and maintained person-based (rather than position-based) relationships with the project. When problems were encountered, specific people from the project (referred to internally as "shepherds") contacted specific people within the institution (as identified contacts by the home institution). At times, as active implementation or support for reform wanes, individual relationships, coupled with opportunities for focused review of action and benchmarking information, can most quickly address issues and brainstorm potential solutions. The project kept detailed records of participation, implementation, and notes regarding involvement and emerging issues, for each site. This documentation helped to develop a narrative for each project site and transfer of information across people and relationships. The bridge of one to one relationship becomes increasingly important as time progresses and personnel change across the project's sites.

This network of relationships served as an infrastructure for the additional aspects of the intervention. Necessary components included content knowledge mastery, reform-based pedagogy, rigorous and appropriate curriculum, administrative understanding and active support, and ongoing professional development. These interventions are key factors, together comprising the "meat" of the MSP project, however, the network of relationships --- within and across K-12 schools, IHE institutions and departments, intermediate unit offices --- represent the "skeleton" that provided the infrastructure and gave shape to the project. Efforts toward sustainability must pay equal attention to both.

Student Learning

I. Increased student knowledge of math and science can be documented, but attributing it to specific interventions is very challenging.

Across years in the MSP program, we have seen students in participating schools increase their competence in math and science at pace with their peers across the state, even though MSP districts have slightly higher poverty-based needs than do comparison schools. Further, as the program has progressed across the seven years, we have been able to document the significance of teacher participation on resulting student achievement, especially notable in mathematics at the elementary and middle levels. These significant gains align with the programmatic focus of the MSP efforts across time. While these findings suggest a relationship between MSP teacher involvement and student achievement, we have been unable to more
finely detail specific linkage between particular professional development activity or strategies and the resulting impact in student learning.

II. *Student learning is a combination of engagement and performance.*

The findings summarized above are gleaned from statistical exploration of statewide math and science assessments. On the other hand we have consistently documented changes in pedagogy, via classroom observations, that are consistent with models supporting increased student engagement and learning. Observed teachers, across middle and later years of the project, consistently showed refinement in content and delivery of instruction that aligned with professional development. As a result, observers noted increased and productive engagement by students in these classrooms. Teachers also reported evidence of increased engagement and achievement by students. These collective data suggest a strong connection between student activity and engagement in learning and resulting achievement, some of which can be detected via statewide large-scale assessment, and likely some that cannot.

**Educational Change**

I. *Our existing educational structures and cultures tend to be resistant to sustainable change.*

Across the years of program implementation, the SW PA MSP was faced with many specific episodes and examples of the barriers to change in both K-12 and IHE contexts. Many of them have been noted in the summaries presented above, and are detailed more fully in the attached evaluation reports for individual activities and processes. These findings align with many studies and attempts at reform in the broader educational research literature. Some of the major categories include:

**Roles and Responsibilities**

Traditional definitions of role for IHE faculty (expert), K-12 teacher (generalist, classroom focused), and administrator (manager) are challenged in a model expecting all to equally engage in learning, professional sharing, risk-taking, and expansion of their roles beyond the traditional barriers. For school reform to extend beyond the boundaries of individual faculty or K-12 classrooms, educators must extend their responsibility from “their students” to the school, the district, the community, and beyond. Professional educators, across K-20, regardless of role, must share responsibility for their own professional development and quality assurance with the institutions that employ them, rather than being passive receivers of services.

**Availability and Use of Resources**

Over the decades in modern education, debates about resources have arisen --- some focus on equity across schools and students, some with cost-benefit of various funding initiatives, and some with alternative models including privatization and other forms of school choice. These
larger frames for resource availability and allocation remain. Additionally, however, educational institutions must consider the availability and use of existing resources, no matter the pool or mechanisms for gaining them. How are teachers assigned to responsibilities? Are responsibilities best aligned with resources and needs? Are professional development opportunities embedded across years and areas of practice? Are teachers provided opportunity to develop as leaders of their craft and of the profession? Are they valued in leadership roles and provided input to educational decision-making? Are IHE faculty provided opportunities to refine their teaching and interaction with K-12 educators? Are they valued and rewarded for these efforts?

Expectations for Learning

The SW PA MSP pressed for a different conception of dynamic learning for both students and teachers as an ongoing and expansive process. While this belief would seem intuitive in an educational institution, the current culture, especially in K-12 settings, tends to create finite barriers around knowledge that limit the notion of continuous and expanding knowledge as the overall goal of education. These barriers (age grouping, specific guidelines for time on topic, rigid definitions of standards through limited assessment, etc) may help to organize education quite effectively, but seem to carry a large cost as well.

Nature of Educational Practice

Most initiatives focused on educational change seem to have a limited lifespan, often leaving a long trail of “alphabet soup” programs having been “tried” in schools. Evidence from this project, also strongly represented in education change literature, suggests that reform is viewed as a fleeting, time bound (typically 2-3 years), and essentially unsustainable, effort. Many educators take a “this too shall pass” perspective in the face of one change after another. If real and deep change is to happen in education, the system and the people who make and maintain those systems, will need to create a different vision of educational practice as a dynamic, ever growing, constantly refining set of knowledge, skills and dispositions.

II. Clusters of beliefs and behaviors seem to characterize a propensity for reform among both individuals and systems. Alignment between individuals and systems is dynamic and important for sustainability.

Below, we present a representation of characteristics of both individual educators and educational systems (district or school) that we think captures the potential reform landscape. The seven years of case study data collected from this project, coupled with additional evaluation sources and projects, helped to develop this theory of response to educational reform in K-12 settings.

These characteristics are presented as continua, from a resistant landscape for change on the left to a welcoming landscape for change, on the right. The individual dispositions, whether resistant or welcoming, exists within the systemic landscape.
The graphic below shows one potential alignment, one where resistant individual dispositions are aligned with resistant system characteristics (on the left), and vice versa (on the right). A system aligned such as this will tend not to have emerging tensions --- the teachers within them and the system (central office and school administration) are aligned toward either not wanting change to happen, or welcoming reform. From an external perspective, it would be most difficult to work in a setting where both were aligned toward resistance, and perhaps easiest to work with an institution aligned toward welcoming change.

**Figure 2. Individual and Institutional Characteristics.**

More often then not, however, these landscapes are dynamic in perspective to one another. They are rarely aligned, and even when they are, that alignment is not static. As such, the external reform initiative has to deal with the inherent tensions in the lack of alignment, perhaps great or small. Through the years of engagement, the alignment is likely to shift, perhaps numerous times, especially as leadership and teachers change. Part of the success of reform in these dynamic systems will fall on the initiatives ability to perceive the state of the system, and the ability to be flexible in addressing the needs of each group and the resulting tensions from misalignment.

One of the benefits of the SW PA MSP’s seven-year history is the opportunity to explore these issues more thoroughly and to begin to theorize about important issues related to educational reform.
III. *Those individuals and systems who need the most may be the hardest to serve.*

One of the disappointments of this project was the inability to have deep and lasting impact among the schools that were most clearly in need. From the outset, these schools presented a plethora of problems for commitment (changing leadership), implementation (competing reform efforts and priorities), and refinement (changing teachers and competing needs for professional development). These needs and challenges are, unfortunately, all too common in many of America’s schools, especially among the more poor, urban systems. These landscapes often become a “reform potpourri” of external efforts, all attempting to bring about positive change. Among the large and many challenges in these districts, it seems especially important to have an integrated and focused vision and mission that can guide efforts over the long haul. Individual reform initiatives, such as the MSP, will need to find better mechanisms to assist these schools in managing change in sustainable ways.

**FINAL COMMENTS**

The SW PA MSP has invested much over the last seven years in the mathematics and science education landscape of this region, and beyond. Many schools in the region are doing the business of math and science education very differently, and substantively better, than they were before. Many educators have explored their own content knowledge, extended it, and mastered new techniques for conveying that knowledge to children and youth. Higher education faculty in mathematics, sciences, and education are talking differently with one another and their colleagues in K-12 about what is important for all children and citizens to know and be able to do in mathematics and science. The MSP funding has extended an already strong infrastructure for regional reform that was in place through the Math Science Collaborative and has successfully leveraged impact at the state level in the Commonwealth of Pennsylvania regarding standards, assessments, and professional development in mathematics and science. The Collaborative has just launched a new public awareness campaign, with partnerships with local media and regional assets, to connect the region’s economic re-invention as a high-tech, education-focused, service provider for the nation, to the efforts underway in math and science education. Additionally, the partnerships developed through the MSP have now leveraged new additional funding through US Department of Education sponsored MSP grant for the next three years (2010-2013). The existing relationships among institutions and people have served as a seamless transition to these new efforts.
Not all goals and objectives have been achieved, nor to the level dreamed. However, the partnership originally set ambitious goals and held itself to very high standards. There is always more work to be done in education, and the partnership knew this from the beginning of the project. It should be commended for achieving the outcomes listed here and in the following sections of this report. It is clear that capacity for additional change and continued growth is perhaps the most important achievement realized.

INDIVIDUAL REPORTS

The following sections of the report contain copies of specific evaluation reports that have been reviewed by the SW PA MSP project throughout the last program year, 2009-2010. Each report contains both a summary of findings and more detailed analyses of data. Consult the Table of Contents for a listing and the order of the reports.
References
