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Establishing Long-Term Partnerships between K-12 Districts and Science, Technology, Engineering, and Mathematics (STEM) Faculty

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PREFACE

This study is one in a series of briefs for the Math and Science Partnership Program Evaluation (MSP-PE), conducted for the National Science Foundation's Math and Science Partnership Program (NSF-MSP). The MSP-PE is conducted under Contract No. EHR-0456995. Since 2007, Bernice Anderson, Ed.D., Senior Advisor for Evaluation, Directorate for Education and Human Resources, has served as the NSF Program Officer. The author is Robert K. Yin, Ph.D., of COSMOS Corporation. Darci Terrell and Laura Cooper (COSMOS) provided research assistance.

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

ABSTRACT

To strengthen K-12 mathematics and science education, one strategy has been to engage faculty from institutions of higher education (IHEs)—and in particular the faculty from science, technology, engineering, and mathematics (STEM) disciplines—to collaborate with K-12 schools. The faculty are assumed to bring a high level of substantive expertise, to benefit both K-12 teachers and students.

Such an assumption is central to NSF's Math and Science Partnership (MSP) program. The program requires STEM discipline faculty and K-12 schools to collaborate and ultimately to "...undergo the institutional change to sustain the partnership effort beyond the funding period" (NSF-03-541). Unfortunately, numerous earlier experiences have shown how these collaborative efforts are rarely sustainable. A major problem derives from the inability to create mutual benefits, with STEM faculty especially gaining little benefit to offset its need to pursue its own disciplinary teaching and research.

The present study examined the variety of collaborative activities supported by the MSP program, to determine which ones might hold any promise of continuing. Most of the activities resembled those of previous collaborative efforts.

However, one activity—the design and offering of formal IHE courses in STEM discipline departments for enrollment by existing K-12 teachers (therefore, not preservice programs)—differed from the past and appeared promising. This activity may produce mutual benefits and may form the basis for sustaining university-school partnerships. The study concludes that federal, state, and local agencies also can encourage this activity. For instance, school districts could require their teachers to satisfy their professional development needs by taking such courses.

Establishing Long-Term Partnerships between K-12 Districts and Science, Technology, Engineering, and Mathematics (STEM) Faculty

Lagging K-12 student performance in mathematics and science, especially in comparison to world-class standards and the performance of students in other countries (NCES, 2004), has led to renewed efforts to strengthen K-12 education systems. More highly-performing students are needed, both to add to the science and mathematics workforce in general and to address projected shortages in qualified mathematics and science teachers at the K-12 level (Gerald and Hussar, 2003).

To strengthen K-12 education, one strategy has been to engage faculty from institutions of higher education—and in particular the faculty from science, technology, engineering, and mathematics (STEM) disciplines—to collaborate with K-12 systems. The assumption is that such faculty will bring a high level of substantive expertise that can benefit both K-12 teachers and students.

The MSP Program: Built around Interorganizational Partnerships

The Math and Science Partnership Program, started by the National Science Foundation (NSF) in 2002, has been a major supporter of this strategy. Inherent in the very title of the program, each grantee in the program is to form a partnership between one (or more) institution(s) of higher education (IHEs) and one (or more) K-12 school district(s).[1] These designees serve as the "core" partners in every MSP. The core partnership must include the "substantial engagement" of the IHE's STEM discipline faculty. Such faculty are members of STEM departments, typically found in an IHE's School of Arts and Sciences, not its School of Education. In this sense, the NSF notes that:

> *"MSP builds on the Nation's dedication to improve mathematics and science education through support of partnerships that unite the efforts of local school districts with faculties of colleges and universities—especially disciplinary faculties in mathematics, science, and engineering—and with other stakeholders"* (NSF-03-541).

NSF also encourages the MSPs to include other partnering organizations, but they do not need to serve as core partners. For any given MSP, the non-core partners can include:

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[1] In most cases, the IHE has been a university; however, it also can be a four-year college or a community college. In rare instances, the "IHE" partner also has been a regional education service agency.

nonprofit, community, public, and private organizations (including science centers and other "informal" science institutions); businesses and industry; and state departments of education. In most locales, all of these organizations are part of the broader mathematics and science education community. Yet, notwithstanding the participation of these other stakeholders, NSF points to the engagement of the IHE-STEM faculty as:

> *"...one of the attributes that distinguishes the MSP Program from other programs seeking to improve K-12 student outcomes in mathematics and science"* (NSF-06-539).

Expectations of an MSP's Core Partners. As a stringent condition of receiving an MSP award, the core partners:

> *"...are required to provide evidence of their commitment to undergo the institutional change to sustain the partnership effort beyond the funding period. This is what distinguishes core partner organizations from other supporting partner organizations"* (NSF-03-541).

For nearly all of the MSPs, NSF's funding period has usually been for a minimum of five years.[2] The requirement to continue beyond this period, along with the expectation of commitments "...to undergo institutional change," strongly suggest that the partnerships are to last a long time.

Whether and how the MSPs are able to sustain their core IHE (STEM)-district partnerships is therefore an important evaluation issue and serves as the main topic of the remainder of this substudy. The substudy is one of a series of substudies that together comprise an ongoing program evaluation of the entire MSP Program.[3]

Brief Profile of MSPs and their Core Partners. NSF made three cohorts of awards, covering 48 MSPs in 2002, 2003, and 2004. NSF has since made additional cohorts of

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[2]A good portion of the MSPs originally funded in 2002 and 2003 have either received no-cost extensions or supplemental funds and are continuing into their sixth or seventh years.

[3]The program evaluation is being conducted by a team of researchers from COSMOS Corporation, Brown University, George Mason University, and Utah State University. Previous substudies produced by the evaluation already have appeared in published form (e.g., Moyer-Packenham et al., 2006; and Kelly and Yin, 2007), and include 15 articles appearing in either of two special journal issues, the *Peabody Journal of Education*, 2008, Vol. 83, Issue 4, and the *Journal of Educational Research and Policy Studies*, in press.

awards,[4] but the original 48 MSPs comprise the vast majority of those in the program. The present substudy covers 47 of these 48 MSPs.[5]

The 47 MSPs are scattered across the country, and the partnering school districts are situated in different urban, suburban, and rural environments. Regardless of their location, most have low-performing schools that have received the greater attention in the MSPs' work. Among the IHEs, and when applying the Carnegie classification system (see Exhibit 1), 25 of the 47 are research universities (having both "very high" or "high" research activities).

Exhibit 1

CLASSIFICATION OF MSPs' LEAD PARTNER
(n=47)

Classification	No.	Percent
A. Research University ("very high" or "high" research activity)	25	53.2
B. Doctoral or Master's Colleges and Universities	11	23.4
C. Baccalaureate, Associate's, or Tribal Colleges	2	4.3
D. Other Higher Education Offices (e.g., University Systems Offices)	3	6.4
E. Non-IHEs (e.g., K-12 regional education agencies or professional associations)	6	12.8
Total	47	100.0

A = Carnegie (2006) classifications 8 and 9; B = 10 through 13; C = 1 through 7, 14, and 15
Source: Scherer, 2006.

Potential Benefits. Together, the core partners potentially represent the entire range of formal education—from pre-kindergarten through doctoral studies—needed to train a high-quality science and engineering (S&E) workforce or to produce a scientifically literate citizenry.

[4] The awards were made in 2006 and 2008, but the two cohorts only included a few new MSPs.
[5] Of the original 48 awardees, one ended prematurely by mutual agreement. The 48 represent all three types of MSPs: Comprehensive, Targeted, and Institute MSPs.

In a few locales, the partnering IHE and district can have an even more direct relationship, functionally. They may be “feeders” to each other, in that most of the district’s high school graduates will attend the IHE, and most of the district’s newly-hired K-12 teachers will come from the preservice programs in the same IHE. In these situations, a partnership can bring added benefit. First, if the articulation between K-12 graduation and IHE admissions requirements can be strengthened, K-12 students are more likely to be able to complete higher quality postsecondary educations. Second, if the IHE undergraduate and graduate curricula for preservice teachers is aligned with what teachers will need to know to teach in the local K-12 classrooms, the teachers may be more likely to succeed.

The Challenges of Sustaining Interorganizational Partnerships: A Brief Examination of the Literature

Whether such partnerships will be long-lasting is another matter. School-university partnerships need to overcome a variety of startup and internal organizational challenges to become workable in the first place. These might include establishing sound communication procedures, being successful in anticipating the inevitable turnover of partnership participants, and having acceptable ways of resolving conflicts among the partners (e.g., Goodlad, 1996; Clark, 1999; Fullan, 2000, Jenkins, 2001, and O’Neil, 2008). As a result, the sharing of common goals and the establishment of mutual respect and power among the partners are commonly cited features if partnerships are to be functional, whether in education or other sectors such as community health (e.g., LaGuardia, 1999; Marlow and Nass-Fukai, 2000; Metzler, 2003; Phillips, Reyes, and Clarke, 2003; and Waschak and Kingsley, 2007).

Many education partnerships are started with funds coming from an external sponsor such as a federal agency or a foundation (Kingsley, 2008). However, although they may develop the desired features to operate successfully during the funding period, the partnerships may become dormant or even dissolve unless they can identify and obtain new external funds.

In contrast, if partnerships are to continue beyond external funding periods, they must develop some independent incentives that also have been repeatedly recognized in previous studies of partnering experiences, in both the public and private sector (e.g., Tushnet, 1993; Wills and Kaufman, 1997; Reardon, 1999; Knight and Wiseman, 2000; Harms et al., 2001; Holland, 2001; Epanchin and Colucci, 2002; Brinkerhoff, 2002; Neufield and Guiney, 2003; Philips, Rivo, and Talamonti, 2004; Harmon et al., 2007; Amey, Eddy, and Osaki, 2007; and Shepherd, 2008). Among these relationships include:

- Mutually increasing growth or expansion by the partners (e.g., by expanding into new markets);

- The ability to solve common problems important to the partners but that no partner alone can solve; or

- The establishment of service relationships whereby one partner provides a service purchased by the other partner.

All three exemplify a similar principle—that partnerships need to produce *mutual benefits* for the partnering entities to remain partnered.

At the same time, existing studies of education partnerships, and especially those involving IHE faculty in STEM disciplines and K-12 districts, have not found such mutual benefits to be commonly present. Part of the reason may be the nature of the joint educational activities undertaken by a partnership, discussed next.

How IHE-STEM Faculty and School Districts Have Collaborated in the Past

Over the years, mathematics and science education has been the occasion for many instances of collaboration between IHE-STEM faculty and K-12 school districts. Two types of collaborative activities have commonly been reported and studied.

1. IHE-STEM Faculty and K-12 Students. One of the most frequent types of activity has involved IHE-STEM faculty working with K-12 students, in a variety of situations. First, the faculty have been part of informal science programs, with the faculty and students interacting in the context of science museum programs, summer camps, science clubs, and other afterschool programs (e.g., Rhoades, Walden, and Winter, 2004; and Bachman et al., 2008).

Second, the K-12 students have worked on research projects with the faculty, possibly even serving as interns in IHE laboratories and being able to use scientific equipment too sophisticated or expensive for high school classrooms (e.g., Canton, Brewer, and Brown, 2000).

As a third variant (e.g., Clark, 1996; and Turner et al., 2007), the IHE-STEM faculty have made guest lectures in K-12 schools—e.g., demonstrating laboratory experiments. The faculty also have helped schools to assess science fairs and competitions.

In all of these and other similar interactions, although the students (and therefore their host schools and districts) might have derived important educational benefits—including the motivation to pursue science and engineering careers[6]—the interactions did not necessarily produce strong benefits for the faculty or their academic departments. Rather, these types of collaborations relied heavily on the personal interests and commitments of the faculty members and may not have established much less maintained any formal inter-organizational relationships.

2. IHE-STEM Faculty and K-12 Teachers. A similar asymmetry appears to exist with a second commonly reported activity. In this activity, IHE-STEM faculty have provided professional development and other training to K-12 teachers. Such collaboration has occurred in many settings, including the offering of summer institutes, off-site workshops, mentoring assistance during the school year, and collaborative research projects and internships occurring in an IHE's laboratories (e.g., Dresner, 2002; Sandholtz, 2002; Galley, 2004; Drayton and Falk, 2006; and Liddicoat, 2008). These opportunities have been the occasion for covering intensive, content-based knowledge in mathematics or science.

The inservice training role can include the design and development of the training curriculum itself, and in many cases the training covers an existing or new curriculum that the teachers are to implement in their K-12 classrooms, including the use of hands-on materials such as science kits (e.g., Ginsberg and Rhodes, 2003; Elgin, Flowers, and May, 2005; Tomanek, 2005; Bearden, Culligan, and Mainardi, 2008; and Shepherd, 2008). Typically, the IHE faculty have initially offered workshops to help the teachers to know how best to use the kits. Later, the faculty then have been available to assist the teachers when they have been implementing the kits in K-12 classrooms.

Other curriculum topics have included training in the use of various educational technology tools and computer modeling software (e.g., McCombs, Ufnar, and Shepherd, 2007; and Riley and Thomas, 2008). Some of the curriculum topics also may be highly focused—e.g., covering engineering-related modules or a pre-engineering curriculum at the high school level (e.g., Clewett and Tran, 2003; Kline et al., 2006; Hjalmarson, 2006; and Reid and Feldhaus, 2007). Finally, in some collaborations, the training curriculum can be attuned to the state or district standards that the K-12 teachers need to follow.

[6] An earlier evaluation of NSF's informal science program that interviewed a sample of over 250 persons having science careers suggested that their motivations to pursue these careers commonly started with their exposure to informal science programs, rather than the formal science and mathematics courses offered in their schools (see COSMOS Corporation, March 1998).

Regardless of the content, these inservice collaborations again appear mainly to benefit the K-12 teachers. The participating IHE faculty, especially because they are in STEM discipline fields, may not derive any benefits for their own research.

Several exceptions are possible but have not commonly been the subject of study, so the experiences are not well documented. First, some discipline departments do recognize research on STEM education as part of the department's mission. Such departments therefore give research recognition to faculty who are able to convert their K-12 experiences into published studies on the educational theories or practices in their discipline. Second, non-profit and other intermediary organizations can establish inservice training on a fee-for-service basis, frequently calling upon STEM faculty to serve as paid consultants. In this manner, the arrangement creates the opportunity for mutual benefits for all participants. Third, the participating IHE-STEM faculty may come from community colleges or four-year colleges that emphasize teaching and learning, rather than discipline-based research publications, as the basis for the STEM faculty's professional advancement.

Nature of Collaborative Activities in the MSP Program

Extent of Collaborative Involvement. The MSP Program has been successful in gaining extensive involvement by IHE-STEM faculty during the MSPs' period of support from NSF.

Exhibit 2 shows the extent of this participation. "STEM faculty" were defined as those persons who listed their area of research as a mathematics or science field. "Education faculty" were defined as those listing their area of research as education, even though they also might have been teaching a STEM subject. The exhibit shows that, for all three cohorts of MSPs and for the two most recently reported years (2005-06 and 2006-07), the STEM faculty (mathematics and science fields combined) outnumbered the education faculty, though the total number of faculty declined somewhat over the two-year period.

Other studies of the MSP Program have reported the same finding regarding the large numbers and dominance of STEM faculty involvement in the MSP Program (e.g., Frechtling, Miyaoka, and Silverstein, 2006; Zhang et al., 2007; Moyer-Packenham, 2008; and Alligood, Moyer-Packenham, and Granfield, in press). These studies have shown that the STEM faculty involvement outdistanced not only the involvement by education faculty but also the involvement by all other types of MSP participants, including school administrators and university graduate students.

Exhibit 2

NUMBER OF IHE FACULTY INVOLVED IN MSP PARTNERSHIPS, ** 2005-06 AND 2006-07 (n = 47 MSPs)

PARTICIPANTS' PRIMARY RESEARCH* AREA		2005-06: 1. COHORT 1 No.	Pct.**	2. COHORT 2 No.	Pct.	3. COHORT 3 No.	Pct.	4. TOTAL 2005-06 No.	Pct.	2006-07: 5. COHORT 1 No.	Pct. **	6. COHORT 2 No.	Pct.	7. COHORT 3 No.	Pct.	8. TOTAL 2006-07 No.	Pct.
MATH	Tenured	46	13.5	81	18.6	29	18.5	156	16.7	41	14.1	67	16.3	27	16.7	135	15.6
	Non-Tenured	19	5.6	17	3.9	11	7.0	47	5.0	12	4.1	12	2.9	6	3.7	30	3.5
	Subtotal	**65**	**19.1**	**98**	**22.5**	**40**	**25.5**	**203**	**21.7**	**53**	**18.2**	**79**	**19.2**	**33**	**20.4**	**165**	**19.1**
SCIENCE	Tenured	86	25.2	94	21.6	24	15.3	204	21.8	80	27.5	95	23.1	28	17.3	203	23.5
	Non-Tenured	60	17.6	42	9.6	20	12.7	122	13.1	43	14.8	48	11.7	15	9.3	106	12.3
	Subtotal	**146**	**42.8**	**136**	**31.2**	**44**	**28.0**	**326**	**34.9**	**123**	**42.3**	**143**	**34.7**	**43**	**26.5**	**309**	**35.7**
EDUCATION	Tenured	37	10.9	94	21.6	30	19.1	161	17.2	36	12.4	88	21.4	34	21.0	158	18.3
	Non-Tenured	93	27.3	108	24.8	43	27.4	244	26.1	79	27.1	102	24.8	52	32.1	233	26.9
	Subtotal	**130**	**38.1**	**202**	**46.3**	**73**	**46.5**	**405**	**43.4**	**115**	**39.5**	**190**	**46.1**	**86**	**53.1**	**391**	**45.2**
Grand Total***		341	100.0	436	100.0	157	100.0	934	100.0	291	100.0	412	100.0	162	100.0	865	100.0

* IHE participants indicate both their primary research area and primary instruction area, but this analysis only examines the data for primary research area.
** There are no Institutes in Cohort 1.
*** Excluded from the analysis were IHE participants who classified their primary research area as "Not Applicable" (used mainly by 95 administrators in 2005-06 and 82 in 2006-07) or as "Other" (90 in 2005-06 and 84 in 2006-07). In total, for 2005-06, 195 survey participants are excluded from MSP-PE's analysis, and for 2006-07, 166 survey participants are excluded from MSP-PE's analysis; these excluded participants are not included in this exhibit. These data only represent the first three cohorts.
Source: MSP-MIS, Annual IHE Participant Survey for Comprehensive and Targeted MSPs and Annual Survey for IHE Institute Participants.

Prospects for Sustainability. To create a stronger institutional basis for sustaining the involvement of STEM faculty in the MSPs' activities—and therefore to continue the interorganizational partnerships—one of the MSPs' important objectives has been to promote changes in IHE tenure and promotion policies. The goal has been to give collaboration with K-12 systems greater recognition in tenure and promotion decisions, relative to the emphasis on discipline-based research.

A few MSPs are making some headway in this direction (e.g., Kutal et al., 2009). However, even when the overall policies have moved in the preferred direction, how individual tenure and promotion cases will be affected will be unclear until a sufficient number of cases has occurred. As an alternative, other MSPs report making new tenure track appointments in STEM departments where the candidates have education-related accomplishments built into their agreements, but these situations only have occurred with a few of the MSPs.

Not surprisingly, two studies of IHE-STEM faculty participation specifically occurring in the MSPs have offered rather bleak outlooks for creating the desired changes in tenure and promotion policies (Zhang et al., 2007; and 2008; and Kingsley, 2008). Barriers still need to be reduced or removed, and the main positive influences still seem to derive from the availability of external funds, or what one of the two studies has called "policy inducements" (Kingsley, 2008, p. 13). As further noted by this study (Kingsley, 2008, p. 19):

> *"...the level of engagement for university actors supported through soft money grants and contracts is quite high and, in most cases, vital to the life of the partnership."*

This apparent fact of life has revealed itself in the MSPs' strategies for sustaining themselves beyond the period of NSF funding. Most of the MSPs have searched for new sources of external funds as their main strategy (e.g., University of Wisconsin-Milwaukee, 2008).[7] The potential sources include grants from ED-MSP[8] as well as funds from other federal or private organizations.

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[7]In fact, from a reverse perspective, many of the MSP partnerships already had been in place prior to the MSP Program, operating with other external funds, including funds from other NSF programs. The MSP awards then became the "new" source of external funds that enabled a partnership to continue.

[8]The U.S. Department of Education runs a counterpart program, known as the "Mathematics and Science Partnerships," with funds distributed on a formula basis to state education agencies, who then solicit proposals from the school districts in the state. Successful applicants, who must be partnered with IHE-STEM faculty, then can receive modest awards for up to three years.

Occasionally, the IHE or district partners have made outlays from their own budgets to support the continuation of an MSP. Thus, for instance, a few of the IHE partners have made their own modest outlays and established new centers for research in science and mathematics education. The IHEs hope, however, that the centers will attract new external awards to augment the universities' own outlays. Similarly, district partners have directed some of their existing professional development funds to support their teachers in participating in the MSPs' inservice training in mathematics and science.[9]

Nevertheless, whether an MSP has obtained new external funds or whether its partners have made their own outlays, the resulting continuations are likely to operate at a lower level of activity than under the NSF funding, because the amount of new funds is likely to be lower than that of the original NSF awards. Moreover, the post-NSF funding is still likely to be transient, with new external awards still having their own expiration dates and partners' outlays still vulnerable to future budget cutbacks.

Desirability of Identifying a Functional Basis for Sustaining the Partnerships. As suggested earlier by the literature on successful interorganizational partnerships, a lasting relationship should not depend on the continued availability of external funds. Partnering organizations need to derive mutual benefits of some sort from their partnership work. If they do, the relationships may become self-sustaining. In this sense, a partnership will have sustained itself as a result of a functional relationship that produces its own rewards.

The education activities undertaken by an MSP define the range of functional possibilities. Unfortunately, at first glance, the STEM faculty's involvement in the MSPs seems to be dominated by activities involving K-12 students or the training of K-12 teachers—neither of which, as previously pointed out by the extant literature—readily produce mutual benefits. For instance, at an annual conference sponsored by the MSP Program in January 2007 (see the conference summary by Frank and Shapiro, 2007), many MSPs reported the involvement of their IHE-STEM faculty in these two kinds of activities as the primary mode of participation. To this extent, and given the experiences with the earlier kinds of partnering arrangements described in the literature, the prospects for continuing the MSPs' partnerships on a sustaining basis, absent continued external funding, still might not appear encouraging.

At the same time, the importance of identifying any possible functional relationship, from the perspective of potential mutual benefits, warranted more detailed inquiry. The goal was to determine more carefully the full array of the MSPs' activities and to

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[9]One of the most sizeable outlays was for $2.8 million from an MSP's partnering district, accompanied by an additional $10 million from the state agency, to continue the MSP's activities over a new five-year period.

re-confirm whether any of them offered a basis for sustaining the MSPs apart from receiving additional external funds.

Information about the nature of these activities came from three sources. First and most important, the program evaluation team made site visits to all 47 MSPs from 2006 to 2008, conducting interviews and reviewing documents and archival records. Second, the MSPs submit annual reports and their own evaluation reports to NSF, and these have been the subject of ongoing review. Third, data related to STEM faculty involvement as reported by the MSPs into the MSP Program's management information system (MIS) also were extracted.

The information from all three sources suggested that the activities could be placed into eight categories. Exhibit 3 contains an illustrative and brief MSP profile for each of the eight categories. The activities are as follows.

MSPs' Collaborative Activities. Of the eight types of activities, Categories 1 and 2 (*involvement with K-12 students* and *community education*) deal with STEM faculty working directly with K-12 students or in conducting events such as family science nights, and Categories 3 and 4 (*inservice training for K-12 teachers* and *IHE-based courses for K-12 teachers*) deal with activities involving K-12 teachers. These four initial categories therefore mimic the dominant two modes of collaboration previously identified in the literature. To this extent, the first four categories do not appear to offer new insight into the prospects for sustainability.

Category 5 (*assistance to districts*) has a similar shortcoming, again providing benefits for the district partners but not necessarily for the STEM faculty. In this activity, the STEM faculty may assist school districts in developing curriculum standards and frameworks as well as assessment tools. At a classroom level, the faculty at a few MSPs have actually helped to define and link lesson plans with classroom assessments.

Categories 6, 7, and 8 reverse the direction of the benefits, largely providing some benefit for IHE partners but not necessarily for the district partners. Category 6 (*preservice training*) involves IHE-STEM faculty offering undergraduate mathematics or science courses that can be taken by prospective K-12 teachers. For some MSPs, the STEM and education departments have coordinated these offerings so that the STEM courses are integral to the education departments' preservice programs. In this situation, the STEM faculty and departments may derive a benefit by having greater enrollments in their courses. However, because the students are not yet members of any school district and can eventually be employed at a number of locations, any particular district would not be likely to have a reciprocal benefit, except for the small set of local communities where an IHE and a district serve as "feeders" to each other, as described earlier.

Exhibit 3

EIGHT TYPES OF PARTNERING ACTIVITIES INVOLVING IHE-STEM FACULTY AND SCHOOL DISTRICTS

Type of Activity	Illustrative Examples from the MSPs' Annual Reports and MSP-PE's Site Visit Notes
1. Direct Contact with K-12 Students	Each summer, the MSP sponsored two camps for middle and high school students: an engineering and science camp for about 30 students and a science institute for about 100. STEM faculty served as co-instructors for the courses.
2. Community Education	The MSP organized parents' workshops. The content was aligned with the state's standard course of study and therefore with teachers' professional development. Math faculty from community colleges helped to offer the workshops, and 4,500 parents attended the workshops over a three-year period.
3. Inservice Training for K-12 Teachers	The MSP's lead IHE offered a two-week summer institute for existing teachers. The institute provided teachers with ways of infusing mathematics into science curricula. Over 500 teachers from the entire region participated in the summer institute.
4. IHE Courses for K-12 Teachers	To improve the qualifications of existing K-12 teachers, the IHE's mathematics and education faculty established a new major in "school mathematics teaching" for an M.S. degree in the College of Science and Mathematics. Mathematics faculty taught the college courses to the K-12 teachers. Of the 25 IHE faculty involved in the program, 19 are from the STEM disciplines.
5. Assistance to Districts	The MSP helped its partnering district to adopt quarterly assessments for grades 3-9. The assessments supported teachers in examining student work in a more structured and purposeful manner. The MSP also helped to develop new pacing guides to accompany the district's newly-adopted K-8 mathematics textbooks.
6. Preservice	Within the arts and sciences school of the MSP's lead IHE, STEM faculty developed a three-course sequence covering physics, life sciences, and earth sciences. These preservice courses balance science education and pedagogy, using inquiry-based instructional strategies.
7. IHE Research	As part of their involvement with an MSP, engineering faculty conducted studies to determine the impact of inquiry-based pedagogy among university students. The results have been published in a number of papers geared to engineering education.
8. IHE Institutional Change	An MSP conducted case studies of eight faculty members who modified their instructional practices in their own undergraduate courses, as a result of having been exposed to the MSP's K-12 pedagogical principles.

Categories 7 and 8 also point toward the IHE environment. In Category 7 (*IHE research*), the STEM faculty may receive subgrants or subawards from the MSPs, to conduct their own research related to education in their STEM disciplines. In Category 8 (*IHE institutional change*), a typical item under this category includes the STEM faculty's efforts to modify the pedagogical practices in their own undergraduate or graduate courses (not necessarily limited to preservice or inservice courses).

The pedagogical changes are offshoots of IHE faculty members having learned about K-12 pedagogical practices through their MSP exposure. Such practices include pursuing a student-centric rather than didactic mode of teaching or emphasizing inquiry-based methods, and the experiences have been documented by a number of the MSPs (e.g., Donovan and Landel, no date; Holdan and Maxwell, 2004; Komives, 2006; and Pomeroy, 2009). This influence of the K-12 pedagogy on IHE instructional practices was largely unanticipated by the MSP Program and has been viewed as a pleasantly surprising outcome (e.g., Zhang, 2008). Nevertheless, in both Categories 7 and 8, the partnering districts would not necessarily derive benefits from these developments.

Many STEM and education faculty participated in these eight types of activities during either 2005-06 or 2006-07 (see Exhibit 4). About half of the participation has been directed at the K-12 students, communities, teachers, and district activities under Categories 1 through 5. The exhibit also shows that no distinctively different patterns arise when comparing the participation by STEM faculty and education faculty.

This more detailed examination of the MSPs' partnering activities still does not suggest opportunities for deriving mutual benefits on an activity-by-activity basis. Each activity appears to produce benefits for one partner but not the other. Taken together, however, the collection of all of the activities may provide the needed balance. Unfortunately, few if any of the MSPs have pursued the entire collection as the basis for forming their partnerships. Most MSPs have focused their efforts on only a few of the activities—some MSPs even being limited to one or two of the activities only. Therefore, the expectation of arranging the entire collection of activities may not be realistic.

IHE-Based Courses for K-12 Teachers. Among the eight categories, the evaluation team's site visit data suggested that one of them, previously identified as Category 4 in Exhibit 3, be given yet another look. The site visits suggested that this activity appears to involve a combination not usually found among conventional collaborations between STEM faculty and districts: The STEM faculty design and offer formal courses within

Exhibit 4

PARTICIPATION IN MSP ACTIVITIES BY STEM AND EDUCATION FACULTY,* 2005-06 AND 2006-07 (n = 47 MSPs)

TYPE OF ACTIVITY	NUMBER OF PARTICIPANTS REPORTING THEIR INVOLVEMENT IN EACH TYPE OF ACTIVITY (Multiple responses possible from any given faculty member)							
	2005-06 (n=709)*				2006-07 (n=663)*			
	STEM (n=383)		Education (n=326)		STEM (n=332)		Education (n=331)	
	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.
1. Involvement w/ K-12 Students	124	10.9	83	7.4	91	10.2	82	7.4
2. Community Education	13	1.1	19	1.7	15	1.7	21	1.9
3. Inservice	291	25.5	223	19.8	222	25.0	228	20.4
4. IHE Courses	100	8.8	103	9.2	67	7.5	87	7.8
5. Assistance to Districts	132	11.6	116	10.3	79	8.9	109	9.8
6. Preservice	151	13.2	144	12.8	129	14.5	155	13.9
7. IHE Research	58	5.1	109	9.7	61	6.9	113	10.1
8. IHE Institutional Change	62	5.4	80	7.1	44	5.0	73	6.5
9. Other**	209	18.3	248	22.0	180	20.3	247	22.2
TOTAL*** PARTICIPANTS	1,140	100.0	1,125	100.0	888	100.0	1,115	100.0

* Number of faculty who reported spending 40 hours or more on their IHE's MSP during the year (see Appendix A)

** Category 9 (*other*) includes activities such as faculty members' attendance at their own MSPs' meetings or at the annual conferences convened by the MSP Program in Washington, DC. Five such conferences have been held, with the latest being in January 2009.

*** The number of participants exceeds the number of faculty because individual faculty could report participating in more than one type of activity.

Source: MSP-MIS, Annual IHE Participant Survey for Comprehensive and Targeted MSPs and Annual Survey for IHE Institute Participants.

their STEM departments, and these courses include enrollment by *existing* K-12 teachers (not just by preservice students).[10]

The combination differs from either the conventional inservice or preservice training. It differs from the more routine inservice arrangements in that the courses are a formal part of an IHE-STEM curriculum. As such, they involve an IHE's administrative approvals and arrangements that go beyond summer institutes, off-site workshops, or on-site mentoring experiences that dominate most inservice trainings for K-12 teachers—even though teachers may receive credits for participating in these latter events. At the same time, the combination differs from the conventional preservice training (Briscoe and Prayaga, 2004; and Townsend et al., 2003) in that the enrollees are existing K-12 teachers (although preservice students and undergraduates can be part of a course's overall enrollment).

Exhibit 5 contains brief profiles of eight MSPs reporting this type of activity. The profiles suggest that the IHE-STEM departments also have helped to develop new majors or degree programs, sometimes in conjunction with the education departments, in addition to offering the courses. The brief profiles suggest that existing elementary school teachers may more likely enroll when the courses are offered at the undergraduate level, whereas middle and high school teachers may more likely enroll when the courses are offered at the graduate level.

The combination of IHE-based offerings with enrollment by existing K-12 teachers is of interest because it may produce mutual benefits. One partner, the IHE and in particular its STEM departments, has enrichened its offerings and gained larger enrollments. The other partner, the district, has gained improved training for its teachers. Districts' existing professional development funds, not any external awards, support the training.

Data from the MIS offered more information about the volume of this activity in the MSP Program. The MIS asks participating IHE faculty to identify specific courses, if any, that they might have "developed, modified, or enhanced" as part of their MSP involvement. Where such courses are reported, the MIS also asks the faculty to identify the course by its name and course number.

[10]The role of IHE-based courses in the MSP Program is the subject of another study that is still ongoing (Shapiro et al., 2006). However, although the study provides a lot of detail about these courses and their institutional basis, the study has not yet specifically focused on the proportion involving STEM faculty, or whether the courses have been part of STEM or education departments.

Exhibit 5

STEM COURSES OFFERED TO K-12 TEACHERS: EIGHT ILLUSTRATIVE MATH AND SCIENCE PARTNERSHIPS

<u>Cleveland Math and Science Partnership</u>

At John Carroll University, one of the MSP's partnering IHEs, faculty in the mathematics, science, and education departments developed 11 new math and 10 new science graduate-level courses for existing middle grade teachers of math and science. STEM faculty taught those courses, which can lead to a master's degree offered by the College of Arts and Sciences with a specialization in mathematics and science for middle school teachers (grades 6th-8th). In 2007-08, 98 teachers from the partnering district participated.

<u>East Alabama Partnership for the Improvement of Mathematics Education</u>

The MSP, through its two IHE partners—Auburn University (AU) and Tuskegee University (TU)—supported existing K-12 teachers to take graduate-level mathematics courses. The faculty teams also formed workgroups to review and approve new curricula for elementary and secondary mathematics education at TU and two revised and one new course in mathematics elementary education at AU.

<u>Focus on Mathematics</u>

The MSP initiated a fellows program for existing teachers to participate in a master's of mathematics for teaching program or to earn a certificate of advanced graduate study. Enrolling in 2004, the first cohort included 14 existing teachers, of whom 8 were to graduate in the fall of 2008.

<u>Milwaukee Mathematics Partnership</u>

Design teams, primarily composed of faculty from the University of Wisconsin-Milwaukee (UWM), developed new courses on various mathematics topics. Four of the courses became part of a new minor, and existing middle school teachers were eligible to enroll. By the summer of 2006, 53 teachers had enrolled, with 41 completing at least two courses. In addition, by 2006-07, 341 existing teachers had taken other graduate courses at UWM.

<u>North Cascades Olympic Science Partnership</u>

The MSP has supported its five IHE partners in collaboratively developing a common science education course sequence. At one of the partners—Western Washington University—25 undergraduate students and 27 existing K-12 teachers were the latest cohort of students enrolled in the course sequence.

<u>Partnership for Reform in Science and Mathematics</u>

The MSP helped one of its partnering IHEs—Georgia State University (GSU)—to offer five courses. The courses can lead to a mathematics endorsement, and 17 existing K-12 teachers enrolled in them during the spring of 2007. The MSP also supported other IHE faculty to redesign science and mathematics courses, to encourage students to pursue teaching careers.

<u>Teachers Assisting Students to Excel in Learning Mathematics</u>

The MSP supported the provision of mathematics methods courses co-taught by Cal State University faculty and district coaches. In 2005-06, eight K-12 teachers enrolled, to gain a higher level of mathematics knowledge and to move toward a credential to meet *No Child Left Behind* requirements.

<u>Vertically Integrated Partnerships, K-16</u>

The MSP supported four of its IHE partners—the University of Maryland-College Park (UMCP), the University of Maryland-Baltimore County (UMBC), Montgomery College (MC), and Towson University (TU)—to create new or redesigned undergraduate science courses. Both existing and aspiring science teachers have enrolled in these courses.

Source: MSP's Annual Reports; and MSP-PE Site Visits, 2006-08.

A tally of the responses to these questions shows that STEM departments have been highly involved in offering these courses (see Exhibit 6). Cumulatively during the three years from 2003 to 2006, the MSPs had 57 IHEs reporting many courses with many enrollees.[11] During this period, the overwhelming proportion of the courses were reported to be part of STEM departments or schools. To further confirm these data, a random check of the specific courses that were reported confirmed that they did in fact appear as part of STEM discipline department offerings in the respective IHEs' course catalogs.

Exhibit 6

MSP-SUPPORTED COURSE DEVELOPMENT, MODIFICATION, OR ENHANCEMENT, REPORTED BY 57* IHEs, 2003-06

		No. of Courses	No. of Enrollees	No. of IHEs (23 MSPs**)	No. of Courses per IHE
STEM Department or School	**Graduate Courses**	34	661	14	2.4
	Undergraduate Courses	223	37,304	43	5.2
Non-STEM Department or School	**Graduate Courses**	32	605	13	2.5
	Undergraduate Courses	40	3,473	17	2.4
	Total	329	42,043	87***	5.8***

* Data are from 39 Comprehensive and Targeted MSPs only (omitting the 8 Institute MSPs). The 57 IHEs represent a 95 percent response rate for those IHEs identified by their MSPs as participating in the partnership during 2003-06. All told, about 150 IHEs were initially listed as partners in the MSPs' original applications, but the partnership activities may not have been fully established during this time period.

** Eight additional MSPs reported new or modified courses but did not specify the courses.

*** The same IHE may offer both STEM and non-STEM courses and therefore appear more than once in this table.

Source: MSP-MIS, Annual IHE Survey for Comprehensive and Targeted MSPs.

At the same time, although the new and modified courses are listed in official IHE course catalogs, and although the courses are frequently accompanied by the development

[11] The data were reported for IHEs associated with the 39 Comprehensive and Targeted MSPs; no data were requested of the 8 Institute MSPs.

of new degree programs and majors, the data do not clarify whether the courses are permanent or only special-topic, one-time-only offerings. Similarly, the MIS data do not clarify the precise number of enrollees who are K-12 teachers as opposed to those who are either preservice students or full-time students at the IHEs.

Nevertheless, the presence of the courses and programs may be a positive sign for sustainability. As described in a related study (Shapiro et al., 2006), the approval of such new courses and programs generally requires a rigorous IHE review process, involving multiple faculty members and some committee or review panel. For public sector IHEs, the review process often involves external bodies such as the university system office or state higher education board. Overall, the heft and formality of the review process involves a "...substantial buy-in at a variety of levels at an institution" (Shapiro et al., 2006, p. 7), suggesting that the new courses and programs are likely to be continued to be offered for an indefinite period.

Furthermore, the fact that such developments are occurring in STEM departments also suggests that K-12 teachers are potentially being exposed to stronger mathematics and science content than in the absence of these initiatives. Although no evidence regarding the content of the courses exists, an illustrative list of course titles may suggest the stronger mathematics and science content of the STEM courses, compared to similar ones offered by the non-STEM departments and schools (see Exhibit 7).

Exhibit 7

ILLUSTRATIVE STEM AND NON-STEM COURSES IN MATHEMATICS AND SCIENCE

STEM Department, Mathematics:	**STEM Department, Science:**
1. Euclidean and Non-Euclidean Geometries	1. College Physics, I and II
2. Mathematical Problem Solving and Critical Thinking	2. Fundamentals of Chemistry
3. Structure of the Number System	3. Biological Science: Cells and Molecules
4. Differential Equations with Linear Algebra	4. Ecology of a Changing Planet
5. Technology in Teaching of Mathematics	5. Immunology
6. Research Methods in Mathematics, I and II	6. Biotechnology
Non-STEM Department, Mathematics:	**Non-STEM Department, Science:**
1. Math for Educators, I and II	1. History of Science
2. Abstract Algebra to School Mathematics	2. Environmental Experiences in the Schoolyard
3. Mathematics for Students with Special Needs	3. Teaching Human Biology
4. Mathematics for Science Teachers	4. Teaching of Science and Health
5. Measurement: Concepts and Strategies	5. Electricity and Magnetism
6. Mathematics Curriculum: Program Issues, Trends	6. Teaching Weather and Water

Source: MSP-MIS, Annual IHE Survey for Comprehensive and Targeted MSPs.

Sustaining the MSPs: A Continuing Challenge. The IHE-based courses for K-12 teachers could become a centerpiece for sustaining IHE-STEM partnerships with K-12 districts. Additional strengthening could come from agencies external to the MSPs that could make relevant changes affecting incentive systems.

First, agencies like NSF, who support STEM research, could revisit the incentives built into all of their R&D awards, not just those for the MSP Program. For instance, the award criteria for all NSF research grants could be augmented to include a funded research project's involvement in K-12 education. The current award criteria do cover a category known as "broader impact," but an insistence to work with K-12 systems could be more explicit, as well as distinct from the "broader impact" criterion. Large numbers of STEM faculty and graduate students would become involved in the IHE-based courses for K-12 teachers (as well as other collaborative activities).

Second, local K-12 systems could define their inservice training and re-certification requirements in terms of having their teachers enroll in and pass IHE-based courses as the preferred source of training. Large numbers of K-12 teachers would enroll in the IHE-based courses with the teachers also able to obtain advanced degrees and certification. At the same time, the K-12 systems would discourage the traditional forms of professional development that have taken the form of ad hoc institutes and workshops occurring outside of IHE departments.

Imagine that these two kinds of external changes themselves become routinized. Partnerships between IHE-STEM faculty and K-12 systems would not then need to be supported by specific projects. The partnerships would form a new professional culture whereby the IHE and K-12 participants were part of the same world rather than two different ones.

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