

# Engaging STEM Faculty In K-20 Reforms—Implications for Policies and Practices

*This article looks at policies and strategies that can be used to promote partnerships involving university science, technology, engineering, and mathematics (STEM) faculty and K-12 teachers, as well as the nature of such collaboration.*

## Introduction

The Math and Science Partnership (MSP) program at the National Science Foundation (NSF) is a major national research and development effort that supports innovative partnerships among institutions of higher education (IHEs), local K-12 school systems, and their supporting partners in order to improve K-12 student achievement in mathematics and science.<sup>1</sup> Deep engagement of science, technology, engineering, and mathematics (STEM) disciplinary faculty is a hallmark of the MSP program. The program posits that disciplinary faculty hold the content knowledge that K-12 teachers need and that, if faculty are substantially involved, teachers' disciplinary knowledge will be strengthened, resulting in improved student achievement.

Many reforms stress partnerships among institutions of higher education, K-12 schools and districts, and community-based organizations and businesses (Abbott et al., 1992). The MSP program and the U.S. Department of Education's Teacher Quality Enhancement effort have the

explicit goal of forming partnerships between K-12 districts and IHEs in order to create innovative solutions to persistent instructional problems and lead to improvement in both K-12 schools and IHEs. Educational partnerships between universities and public schools are not new. There are, however, three reasons for the current interest surrounding such partnerships. First, the politics of education reform have created the need for at least symbolic association among

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educational stakeholders. Second, increased accountability for student achievement, coupled with the need for better-prepared teachers, has placed pressures on public schools and IHEs to collaborate. Finally, K-12 schools and IHEs face similar problems, such as public criticism, lack of sufficient funding, limited public support or respect, low salaries, and faculty

shortages (Sirotnik & Goodlad, 1988). According to Teitel (1999), common interests have brought together a strong convergence on four goals: improvement of student learning, preparation of educators, professional development of educators, and research and inquiry into improving practices.

Although partnerships are easy to extol, they are difficult to achieve. One of the most prominent reasons for this difficulty is the institutional reward structure, which puts different emphasis on research, teaching, and service (Boyer, 1990). According to Diamond (1999), an appropriate and effective tenure and promotion system should be aligned with the institution's mission statement; be sensitive to differences among the disciplines and individuals; include appropriate, fair, and workable assessment; and recognize that action takes place at the departmental level in which the most specificity in documentation is required. Although many IHEs' mission statements recognize teaching, research, and service, there is often a mismatch

in reality between the mission of an institution and the priorities described for the tenure and promotion systems. As Boyer noted in 1990, “almost all colleges pay lip service to the trilogy of teaching, research and service, but when it comes to making judgments about professional performance, the three rarely are assigned equal merit” (p.15).

A 1996 survey of 50,000 faculty, chairs, deans, and administrators at research universities (Gray, Diamond, & Adam) showed that respondents often considered the balance between research and teaching on their campus to be inappropriate. A more recent national survey (Alshare, Wenger, & Miller, 2007) found that deans at teaching universities, on average, assigned percentages of 47/43/10 to teaching, research, and service activities for promotion and 48/42/10 for tenure decisions. In contrast, deans at research institutions assigned percentages of 59/33/8 to research, teaching, and service for tenure and 57/32/11 for promotion. The difference between teaching and research universities lies largely in the relative weights on teaching and research, but it is clear that service is a distant third in both cases.

Tenure and promotion is a powerful motivator to faculty (Colebeck, 1994). However, the increased prominence of the research enterprise and lack of rewards for public service have contributed to the socialization of faculty away from public service, even at institutions with strong service traditions (Jaeger & Thornton, 2008). As a result, faculty have been forced to exhibit market-like behaviors to secure competitive funds from government grants or the private sector and ignore teaching and service.

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Faculty and administrators are often prisoners of their own thinking, firmly holding values about faculty roles, scholarship, and institutional identity shaped by the current reward system that promotes a “publish or perish” culture (Senge, 1990, p.27). A 2005 survey of 729 chief academic officers found that two-thirds of respondents believed that faculty graduate school training and socialization toward traditional forms of scholarship served as a barrier to encouraging multiple forms of scholarship (O’Meara, 2005). Another reason that service is devalued may relate to a lack of means to assess quality in public service. In research, the universal language of exceptionality is the number of publications in top field journals, an easily countable and recognizable measure. McDowell (2001) claimed that public service and teaching were often overlooked in promotion, because proper evaluation of achievements in these areas was more difficult than mere counting.

Although the current tenure and promotion system seems deeply entrenched, it has not always been this way. Boyer (1990) pointed out that the missions of universities have changed throughout the years — moving from teaching, to service, and

then to research, in response to shifting priorities both within the academy and beyond. However, at the very time the mission of American higher education was expanding after World War II, the faculty reward system was narrowing to its current status. Fortunately, some colleges and universities have attempted to change the existing tenure system (Chait, 1998). Two approaches have been successful in encouraging faculty engagement in K-20 partnerships. One approach is to elevate the status of service, which is often how faculty involvement is defined. Another approach is to redefine scholarship to include teaching, discovery, integration, and application of knowledge.

In addition to changing the tenure and promotion system, Boyer (1990) argued that universities should also create flexible and varied career paths for professors throughout a lifetime in order to counter burnout or stagnation. He observed that late-career professors may experience a peak in status and recognition, and that it is at this time that demands for their service from outside their institution often grow. The argument for career flexibility relates to variations in the disciplines, since patterns of productivity vary from field to field. STEM faculty, for example, are often most productive in their youngest years. In the STEM fields, it is common to devote most of one’s early career to specialized research and then turn to integrative questions. At this later stage, faculty might take time to read in other fields, write interpretive essays or textbooks, or collaborate with a colleague on another campus. Still later, the faculty member may focus on an applied project.

Drawing on a larger study that examines the effects of STEM faculty engagement in MSP, this article specifically looks at the tenure and promotion policies in a sample of IHEs involved in MSP. Recognizing that tenure and promotion policies may be slow to change, we also examine strategies that were used by selected MSP projects to engage STEM faculty in K-20 educational reforms in the absence of major policy changes at the university level.

### Methodology

The findings are based on case studies of eight MSP projects. The eight case study projects were selected from a pool of 48 projects, primarily because, based on their proposals, these projects were expected to include high levels of STEM faculty participation. Two of the eight projects focused on mathematics, three on

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science, and three on both mathematics and science (Table 1). Among the lead institutions, four are classified under the Carnegie classification system as Research University (very high research activity), one as Research University (high research activity), one as Doctoral/Research University, and two as Master's College or University (larger program). Six of the IHEs are public and two are private. Geographically, they are located in the East, Midwest, South, and West. The number of IHEs within a partnership varies from 1 to 10. The number of

K-12 districts ranged from 2 to 29, with an average of 10.

In addition to document reviews of tenure and promotion policies, we conducted annual site visits to the eight projects in order to describe faculty engagement over four years and to identify changes that occurred. Site visits often included interviews (with project leadership, STEM faculty members, department chairs, in-service teacher leaders and teachers, principals, and district content/curriculum specialists) and classroom observations of STEM faculty and K-12 teachers with whom STEM faculty have worked. The interview questions were linked to respective research questions that reflected both the roles of the respondents and the maturity of the project. The semi-structured, open-ended question format allowed for additional questions or probes to be used as deemed necessary

**Table 1:** Characteristics of the case study sample

Aspect	P1	P2	P3	P4	P5	P6	P7	P8
<b>Content focus</b>	<b>M</b>	<b>S</b>	<b>M/S</b>	<b>M/S</b>	<b>M/S</b>	<b>S</b>	<b>M</b>	<b>S</b>
<b>Institution type of lead partner</b>								
<b>Carnegie classification</b>								
Research University (very high research activity)			X		X		X	X
Research University (high research activity)	X							
Doctoral/Research University				X				
Master's College or University		X				X		
<b>Ownership</b>								
Public	X	X	X		X	X	X	
Private				X				X
<b>Location</b>								
East				X		X		X
South	X							
Midwest					X			
West		X	X				X	
<b>Total number of IHE partners</b>	2	5	1	2	5	4	10	1
<b>Total number of K-12 district partners</b>	15	29	3	10	8	2	10	17

P = Project; M=Mathematics, S=Science.  
Source: MSP MIS; case studies.

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by the interviewer. We conducted observations, including those of non-participants, in classrooms and at a variety of meetings. The annual site visits were conducted by teams of two that consisted of a researcher and a STEM disciplinary faculty member from a non-MSP university. The inclusion of a STEM faculty member as co-site visitor helped to establish a rapport between respondents and researchers, and it also provided insight that allowed the data to be interpreted in a more culturally sensitive way.

The literature guided some of the coding and analysis of interview notes and documents (Patton, 1990), but codes emerged primarily from the data. The data analysis followed the

process of 1) developing preliminary coding categories from the research questions and confirming or modifying those categories as information was gathered, 2) reducing the data to manageable chunks of information for identifying themes or patterns of response, and 3) drawing conclusions by comparing within-case and across-case themes and patterns (Miles & Huberman, 1994). Essentially, we used two forms of triangulation. Within each project, evidence was triangulated from interviews and observations. Across projects, evidence was compared and contrasted in the context of each project.

## Results

The number of STEM faculty involved in the eight case study projects varied considerably, from 8 to 50 with an average of 22 per project (Table 2). The majority of the participants were tenured or tenure-track faculty. Faculty participation usually involved two to eight weeks over the summer, depending on the length of the summer institutes. For projects that required commitment during the school year, the extent of involvement varied markedly—from two days a month to 50 percent of the participants' time. STEM faculty devoted considerable time in the areas

of in-service and pre-service teacher training, curriculum development, project management, and research.

Although the majority of the participating STEM faculty were highly motivated, they still needed additional incentives to sustain a high level of motivation; that is, self-motivation is not enough, especially when projects require extensive multi-year involvement from the faculty. In fact, the issue of incentives may be even more critical to further expansion of STEM faculty engagement, especially as the current IHE reward structure and tenure policies are not conducive to MSP-like activities.

## IHE Tenure and Promotion Policies Related to MSP Activities

Tenure and promotion policies were among the main foci of our investigation, because they are often considered one of the biggest hurdles to creating K-20 partnerships. Our focus was not only on how such policies were articulated at the university (macro) level but also how they were implemented at the department (mezzo) level and how they were perceived by the STEM faculty themselves (micro-level). We found that research and sometimes teaching were the principal paths to

**Table 2:** Extent of STEM faculty involvement in MSP in the case study projects

Aspect	P1	P2	P3	P4	P5	P6	P7	P8
Number of STEM faculty involved in development/ delivery of MSP activities	8	29	50	14	36	10	21	14
Percent tenured or tenure track	100%	72%	78%	57%	64%	100%	81%	57%
Amount of involvement								
Percent more than 40 hours	100	95	30	100	100	83	92	88
Percent more than 160 hours	38	74	14	64	35	83	77	31

P = Project.

Source: MSP MIS IHE Institution Survey 2005-06; case studies.



tenure and promotion. Considered to be a distant third path, service or outreach, sometimes referred to as “other contributions,” was used to define MSP involvement in most cases. In order to survive in a highly competitive IHE environment, large research universities sought to maintain their edge, and smaller colleges strived to become research universities. Nevertheless, service and/or outreach were not completely ignored. Of the eight lead IHEs, the policies of seven contained language recognizing service and/or outreach and five recognized publications that pertain to teaching and learning.

It was widely acknowledged that tenure and promotion policies were key to encouraging STEM faculty participation, and one may hope that this realization would lead the universities to review and modify policies so as to create an environment more conducive to faculty engagement. Unfortunately, our eight case policy projects showed little change at the university level in these areas over the last four years. Most MSP projects were not designed to change IHE tenure and promotion policies and practices. Only one of the eight case studies articulated influencing the reward structure for IHE faculty as a goal. That project planned to convene a 15-member Council for Math, Science and Education in order to address the larger issues that plague education reform, systemic problems, and specific issues arising from the project’s operation. Potential issues included reward structures for IHE faculty and K-12 teachers, institutional change, and sustainability. However, this activity never really started. In fact, of all 48 MSP projects in the first three cohorts, only one project has made

significant change in the university’s tenure and promotion policies.

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Despite official recognition at the university level, university policies were often implemented differently at the department level where “the change is really taking place.” In at least two instances, department policy statements noted that the department generally avoids major service demands on untenured faculty and that leadership in outreach/service is not part of the criteria for tenure. However, sections of the policy statements on appointment to full professor mentioned the need to demonstrate significant accomplishments within the department, university, and professional societies, as well as outreach to the community, including civic duties related to mathematics and science education. It was not surprising that most of the faculty members participating in the MSP project were tenured, so the younger, less established ones did not have to “sacrifice” time that could otherwise be spent conducting research. In fact, one MSP project director was told that tenure-track faculty were “off limits.” Many respondents observed the same basic pattern. Junior faculty are required to focus on research and teaching first. Then, once tenure is achieved, the balance

of responsibilities may change, and faculty may begin to either focus entirely on research or become engaged in teaching or service. As a result, tenured faculty have much more freedom to decide how they allocate their time and resources.

We did see some incremental changes in practices at department levels. For example, one lecturer worked with the MSP from the beginning. She had her five-year review and was certain that her work with the project was responsible for a “larger than normal” salary increase, because the review committee highlighted that work in their written report. In another project, two participating faculty received tenure and were promoted to the rank of associate professor. Both credited their involvement with the project as having played a positive role in the promotion and tenure decisions. However, we also heard stories that outstanding MSP participants were denied promotions due to a lack of research.

Tenure and promotion policy and practice changes in the departments were more likely to take place when department chairs were involved in MSP. One PI, who was also the department chair at a research university, said “as long as I am chair, it will play positively in terms of tenure and review.” That was not true, however, with all projects. Another PI who has been the chair of the department said that there had never been any intention to change the promotion and tenure criteria in his department to recognize service more favorably.

In addition, efforts were made to redefine MSP activities in terms of research or teaching. For example, up to the second year of our study,

MSP or STEM education-related research was identified only as an area of STEM faculty activity in one of the eight case study projects. Our latest round of visits found that at least five projects have faculty conducting STEM education research. The actual implementation can be layered and complex, as shown below.

- In his evaluation of faculty members, a math department chair who has been directly involved in the project from the beginning defined MSP as “multi-disciplinary and collaborative work.” The college considered it in tenure and promotion decisions, because it combined multiple components. In addition to outreach, research in mathematics education was counted as “application of math” similar to its applications in engineering or statistics. However, few participating faculty members had yet based their research agenda on their MSP activities. The chair added “if they do that, I will argue for it ... I’d prefer to count it as research contribution, because it is more highly regarded in the community.”
- In another case, a department chair was not directly involved in the project but had provided moral support and space. Although we heard that research on the scholarship of teaching was recognized at the university, the chair’s comment showed that the influence of those activities on advancement decisions was still ambiguous. He stated, “It is difficult. Although service is valued,

research weighs heavily. We have not totally figured it out. It is tricky to contextualize. People are always suspicious about publications, and it has to be on a case-by-base basis with more justification.” The chair continued, “There is a lot of sympathy. The ongoing focus has to do with the proportion of academic involvement in the outputs. The administration is reasonably receptive.”

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Another area of change was in hiring practices through the creation of tenure-track positions for teaching faculty or STEM education researchers in the STEM departments. For example, a department chair noted that there had been a new faculty slot added for STEM education. “Right now, there is not a critical mass, but I am not surprised to see it develop into a new sub-program. It will fit in the department nicely.” Similarly, for another project, the department hired a tenure-track STEM educator who will spend 80 percent of his/her time in disciplinary research and 20 percent in education research. The chair noted, “This would have been

laughed away five years ago,” but he felt that people were starting to understand. For the third project, two STEM education faculty were hired at the lead institutions, which may be the result of MSP or increased awareness within departments of the need for STEM education insights.

Several departments in another project have made hiring discipline/education faculty—e.g., doctorates in physics education and mathematics education—a priority. In one instance, a department chair asked his faculty to make a choice between beginning a search for a biosciences education faculty member or a marine biologist. The educator position was chosen. Departments that elected to move in this direction have found it to be an “exceedingly difficult and competitive” undertaking due to both the lack of people with these credentials and the increasing number of IHEs attempting to attract those who are available.

The ultimate goal of these policies and practices is to influence faculty so that they will be more attracted to service or to the scholarship of teaching and/or engagement. When asked whether they would be rewarded at their institutions for participating in an MSP-type activity, a minority of the STEM faculty thought that participation was viewed positively; most felt it was either tolerated or ignored. Some felt that the most that could be hoped for was for deans and department chairs to broadcast a message indicating “there is no reward for doing this, but it is okay for you to do it.” Most faculty members believed that teaching and service would never make up for the lack of research. However, it also appeared the distinction was not necessarily set in stone. One faculty member told us,

"It would be up to me to characterize it and present it to the university." In his case, MSP work, especially the professional development piece, was defined by the department as service, and pre-service teaching and curriculum design fell under teaching and curriculum development. However, if the MSP work came out in peer-reviewed journals, it would be classified as scholarship.

As we kept probing STEM faculty about changes in university tenure and promotion systems, we found little movement in their views. One STEM faculty member observed that "any consideration of coupling the three areas (research, teaching, and service) as equal is moving slower than a glacier." Changes regarding institutional reward and tenure policies will continue to be slow and can be controversial, even among the participating STEM faculty. As one noted, "I am ambivalent about it. Achieving tenure through outreach will create different attitudes. I don't think outreach should be an easy way to get tenure." One co-PI said that IHE policies have not changed, but a foothold has been established in the university for thinking about MSP-style involvement. "Policies, no; mind sets—there has been a change."

### **Project Strategies to Engage STEM Faculty**

Although tenure and promotion policies are critical to engaging STEM faculty, most MSP projects were not specifically designed to tackle that issue directly. In addition, changes in university policies can be slow to take place. Nevertheless, there were a number of effective strategies projects used to increase STEM faculty engagement in the absence of major changes in institutional tenure and

promotion policies. Motivation for STEM faculty to become engaged in a multi-year project like MSP appeared to hinge on two necessary and entwined conditions. The first condition was extrinsic and clear. Projects needed to provide adequate course release and/or stipends for participating STEM faculty. The second condition for STEM faculty engagement was an intellectual connection. That is, the project needed to make the case for the need for substantive STEM faculty work with K-12 teachers. This was an intrinsic and, perhaps, underestimated condition. Using evidence from the case studies, we synthesized these strategies into two categories: providing extrinsic incentives and providing intrinsic incentives.

### **Extrinsic incentives**

All eight projects offered stipends, and five provided release time as extrinsic incentives. These incentives were established at the beginning of the projects and have remained consistent over the period of MSP. If the STEM faculty were involved in summer institutes, the stipends often were for one or two months. However, one PI was adamant that offering support for a minimum of three months would make it easier to secure faculty commitment. For one project, stipends were larger during the first project year, when courses were being developed, and smaller for other years, when only modifications and adjustments were needed.

Involvement during the school year was normally compensated by release time and/or stipends. Of the three projects that did not provide release time, two were projects whose primary activities took place in the summer. In the third project, faculty participation was originally planned to occur in

the summer. However, many teams decided to conduct at least some of the activities during the school year, and the incentive scheme was not revised, so faculty continued to be reimbursed with stipends but not release time.

Providing stipends during the school year can be complicated. University policies on faculty consulting or "overload" may require a considerable amount of paperwork or restrict the amount of compensation that a faculty member may receive in the form of stipends. The rate for stipends may also vary. Some faculty members were willing to take a few hundred dollars for their contributions, whereas others requested that federal government consulting rates be used as a reference point.

Compared to stipends, release time was more difficult to get, especially in IHEs that were more teaching oriented. One course release per term seemed to be the norm. For one project, MSP teaching counted as part of the teaching load; in others, release time had to be negotiated. For example, a department chair had to make a strong case with the administration to arrange for course buy-outs for faculty, because, in his institution, release time was normally possible only in research-related situations. Practices often varied within a project. It was often the case that, while faculty from a lead institution might receive a course buy-out, members from non-lead institutions did not receive any course release.

Although we recognize the importance of extrinsic incentives, we do not ignore the element of altruism. In fact, many participating STEM faculty suggested that they got involved primarily because they were concerned about public education and wanted to serve the local community

and make a difference or because they simply enjoyed teaching. As one PI observed, “It is less about incentive and more about people interest.” We came across cases in which faculty members had no idea or did not care about how much they got paid for the involvement. There were also cases in which faculty did not seek course release, because they enjoyed teaching so much. “Teaching teachers is the best part—the reward,” one STEM faculty added.

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However, most STEM participants acknowledged that both stipends and release time were attractive, and they, naturally, “appreciate the extra money.” Some noted that the idea of servicing the community may appeal to the more established faculty, while the monetary incentive was more appealing to the younger, less established, non-tenure-track faculty. For community college faculty who have much heavier teaching loads, stipends and release time seem to be more crucial. In general, faculty felt that their involvement was supported generously by the projects, although one PI argued that there was not enough support (money or release time) for faculty involvement and “the good nature of faculty is always needed to make up for any insufficiency.”

### **Intrinsic incentives**

In addition to providing summer stipends and course release, projects employed a number of strategies to appeal to intrinsic motivations. These strategies include selective recruitment of faculty, professional development, effort to promote collaboration, and projects’ sensitivity and flexibility to faculty needs.

### **Selective recruitment**

One department chair stressed the importance of combining “money talking” and enlightened self-interest when engaging faculty. It often fell upon the project leadership to actively engage STEM faculty. “The PI needed to beat down doors at the university to get more scientists involved,” said one co-PI. Several respondents pointed out the importance of finding STEM faculty with genuine interest in education who were willing to extend themselves rather than to say, “I have all the answers.” Engaging in K-20 reforms is not for every STEM faculty member. Some case study projects mentioned the importance of selective recruitment. “There are STEM faculty who I love and respect, but I wouldn’t let them near the project,” said one MSP project leader. Although it is difficult to generalize, one common element was that many of the STEM faculty in the case studies initially became involved with K-12 schools because they had children in them or their spouses were K-12 teachers.

Many respondents noted that it takes a “certain type of personality” to be effective in K-20 partnerships. An ideal STEM faculty participant often has the following traits: 1) possesses a high-quality disciplinary background and credibility, 2) is a good STEM higher education instructor and interested in

how to teach more effectively, 3) has a dedication to changing the lives of students, 4) is open-minded to trying new approaches, 5) is able to deal with people who are coming from different content-level foundations, 6) is willing to work in teams, and, on a lighter note as per one PI, 7) is “in touch with their inner adolescent.” A project evaluator summarized that the key to engaging STEM faculty was to use time well, compensate them with money and opportunity to collaborate, and make them feel that their voices are heard. Otherwise, “they will vote with their feet.”

While most projects recognized the importance of building partnerships early on, some projects had a steep learning curve throughout the years about the value of providing professional development for STEM faculty and demonstrating sensitivity and flexibility to faculty needs. In general, projects that made a substantial case for reform—that is, they laid the intellectual groundwork for new roles and models of STEM faculty engagement with K-12 teachers early on—reaped the benefits as the project progressed. Project leadership was critical in establishing such groundwork. Meaningful and prolonged STEM faculty engagement hinged on the balance of the two motivating conditions or, as one respondent put it, “the practical piece and the learning piece.”

### **Professional development**

MSP has high expectations of STEM faculty as an agent of change. However, just having a PhD in a STEM discipline is insufficient for the task, because doctoral systems are designed to produce researchers, not educators. As one PI, a chemist, bluntly pointed



out, “STEM faculty are typically clueless. They don’t understand the content needs of K-12 teachers. They don’t know where to start. And once they’ve gotten started, they don’t know where to go.”

Professional development for STEM faculty was an area of considerable growth over the years for MSP projects. Almost all case study projects had provided some forms of professional development for their STEM faculty, even though some was less intentional and intensive than others. For example, the training could be periodic (e.g., monthly) meetings or debriefings after workshops during which faculty discussed among themselves and/or with other participants general issues such as course content, methods of presentation, texts, and program requirements, or specific issues on research, curriculum development, and assessment. Other professional development was more systematic and intensive. Two examples of intentional professional development follow:

- One project organized biweekly seminars involving participating STEM faculty, education faculty, and graduate students. In each seminar, participants discussed the books and literature they read about best practices regarding the types of courses that need to be offered in teacher preparation programs and in-service professional development programs and the ways in which these courses should be taught. According to the PI, the biweekly seminar was the key to success, because participants forged common language, knowledge, and experience with each other. A senior STEM faculty said,

“This is the methods class that I’ve never had before.”

### **Although tenure and promotion policies are critical to engaging STEM faculty, most MSP projects were not specifically designed to tackle that issue directly.**

- Another project devoted an entire summer to providing professional development for STEM faculty members and teacher leaders on pedagogy and exemplary middle school curriculum materials *before* the teams were assigned to work with schools. Faculty contributed by assessing the curricula with regard to its effectiveness in identifying the kind of thinking needed in college, addressing the problems that students had in moving from the concrete to the abstract, and improving the scientific sophistication of the lead teachers. They learned from teacher leaders about school contexts, student diversity, and state curriculum standards and assessments.

Seriously engaged faculty did not view their involvement traditionally in terms of outreach or service roles but instead spoke of what they gained intellectually and professionally from participation. One project director reported that faculty “want professional development for themselves,” because they “want to learn these things.” Some examples of this intellectual engagement are

as follows: frequent mentions of foundational MSP readings such as *How People Learn*; references to the IHE faculty professional development they experienced prior to working with teachers; long-term collaboration with K-12 science and mathematics teachers and teacher leaders; insights from the field of science and mathematics education research; participation in a Lesson Study or the examination of student work with an emphasis on student understanding; change in their own disciplinary teaching as a result of the MSP influence; discussions about student preconceptions, cognitive load, and questioning strategies; mention of a forthcoming publication in a STEM education journal; and presentations at a National Association of Research in Science Teaching meeting.

### **Promoting collaborations**

Partnership formation plays a critical role in MSP program delivery and in fostering a climate to support institutional changes. The idea of partnership includes collaboration not only among IHEs and K-12 school districts, but also among the STEM faculty and other project participants. Importantly, STEM faculty typically work in an independent fashion and may not be comfortable in a collaborative environment in which people come from different backgrounds and have varying levels of content knowledge. Consequently, establishing and maintaining a true collaborative environment, especially setting up the framework, is critical to project success as well as to STEM faculty engagement.

In six of the eight cases, STEM faculty worked in teams with teacher leaders and/or education faculty, often in activities such as providing summer institutes for in-service teachers.

Essentially, many of these projects were built on the “co-learner model,” although STEM faculty roles varied from leading to supportive. Projects specified the type of roles to be filled by participants in some cases, while in others it was left entirely for the team to decide. Four examples follow.

- For one project, collaboration among participants was inherent in its operational model, which is known as teacher research teams. The team was composed of college disciplinary and education faculty, high school teachers, and undergraduate and high school student tutors. The hypothesis was that teachers will improve teaching skills on the job by working in teams with supportive instructional staff and content experts to conduct summer camps for high school students who failed the state exams. A number of features were built into the system to encourage cooperation, at least in theory. For example, faculty and high school teachers spent a week working as a team to prepare curricula for the summer program. They delivered the instruction as a team. At the end of each day, each team spent one or two hours debriefing and reflecting about the day.
- A second project was decentralized in 10 school-based teams. Each team included two IHE faculty, most of whom were STEM faculty. Other team members were teacher leaders, a principal, and a guidance counselor or school social worker. Working as colleagues one to two days

per month, IHE faculty and K-12 personnel tackled school issues in STEM education and learning.

- A third project had a very unusual arrangement. During the three-week summer institutes, faculty and K-12 teachers were required to be in residence. This aspect of the program was credited with having created a bonding and a professional learning community that could not have been achieved through other means.
- Another project brought together faculty from all levels—grade school, middle school, high school, community college, and university—by focusing on a dialogue about a particular mathematics or science concept. Although most participants felt that they were able to connect informally with STEM faculty and develop some valuable relationships, the activity was discontinued due to concerns that the episodic and “short-term” nature of the activity was not likely to influence teachers and students.

Bringing people together is one thing, but making it work is another. One PI pointed out that “willingness to work as a team is the toughest part.” Although many of the collaborators exhibited collegiality and camaraderie, some teams encountered problems. In some cases, the PIs had to change teams in order to resolve issues related to personality conflicts. In other cases, these problems were not resolved, and the affected members withdrew from the program. Fortunately, we observed an increasing ease in communications

between the STEM faculty and other members across projects over time.

**While most projects recognized the importance of building partnerships early on, some projects had a steep learning curve throughout the years about the value of providing professional development for STEM faculty and demonstrating sensitivity and flexibility to faculty needs.**

#### **Sensitivity and flexibility to faculty needs**

Projects have become increasingly aware that they must be sensitive to the priorities and needs of STEM faculty. Perhaps the number one issue is time. STEM faculty are often constrained by multiple and sometimes competing demands. For some projects, the fact that the majority of activities occurred in the summer reflected projects’ intentions that “research does not need to take a major hit,” although some faculty regarded summer as the optimal time to do research. One project’s experience is particularly illustrative. In the first year, STEM faculty expressed a concern about being stretched too thin by multiple responsibilities and time demands. The project changed strategy by requiring intense STEM faculty involvement only during the year in which their content area was featured in the summer institute.

Publication is another need of STEM faculty, and publications about

disciplinary education require support and mentorship. In an attempt to capitalize on the experience gained from MSP work, one project began to hold seminars about disciplinary journals that target STEM pedagogical research. With impetus from the project, the university established a research network promoting pedagogical research in STEM disciplines. Another project offered a writing seminar that provided faculty an opportunity to chronicle their research findings and document the curricula they had developed.

Flexibility is also an important consideration. One project involved both mathematics and science faculty. The science faculty worked with education faculty on the instructional team and sought an increased variety of pedagogical strategies, such as differentiated learning for both pre-service and in-service teacher training. The mathematics faculty, however, chose to focus on other goals, because they felt that such an arrangement would make it hard to recruit content-focused colleagues. “We are being tapped by the MSP for what we know—content, and not for what we don’t know—school pedagogy,” one faculty member told us. The project did not try to impose one approach over another. Instead, difference between these two approaches appeared to be a “benign bifurcation.”

For another project, STEM faculty were frustrated that they could not integrate their experience into their professional lives after two years of MSP engagement. The project redesigned its faculty involvement plan and left it up to faculty to choose how they wished to participate. As a result, some focused on pedagogy, some on content, and others on research. Only two faculty members stayed with the

original concept of involvement. In general, STEM faculty took roles in the schools that best corresponded to their area of expertise, interests, and comfort levels.

## Conclusions

MSP projects employed a number of effective practices to support faculty involvement. Extrinsic incentives were universally used, whereas intrinsic incentives were sometimes underestimated.

- At the project level, both extrinsic and intrinsic incentives needed to be created. The former often involved providing stipends and release time for faculty members, and the latter often included providing professional development to faculty in order to enhance their understanding of K-12 perspectives and pedagogical issues, as well as building collaborations among participants and demonstrating sensitivity and flexibility to faculty needs.
- Extrinsic incentives were well understood, as evidenced by the finding that all of the case study projects offered stipends and five provided release time. These incentives were established at the beginning of the projects and remained consistent over time. The intrinsic piece—making the case and creating the intellectual connection for substantive STEM faculty work with K-12 teachers—was often underestimated. Although most projects recognized the importance of building collaborations early

on, many projects had a steep learning curve about the value of providing professional development for STEM faculty, as well as demonstrating sensitivity and flexibility to their needs.

- Traditional tenure and promotion structures and faculty perceptions about the status associated with different types of engagement were considered major barriers for faculty involvement in most MSP-like endeavors. Although the majority of the IHEs recognized service or outreach, these types of activities were generally considered to be a distant third in priority after research and teaching, and this presented a major roadblock to involving faculty from the STEM disciplines. As a result, the majority of participating STEM faculty already were tenured. Although tenure and promotion policies were critical to STEM faculty engagement, most MSP projects were not specifically designed to tackle those issues.

- Changing tenure and promotion policies was a slow process. We found that small steps had been made toward either elevating the status of outreach/service directly or redefining MSP activities in terms of research or teaching. However, faculty perceptions about tenure and the reward system remained the same.

Since most of the IHEs in the MSP are research universities and the participating STEM faculty are either tenured or on a tenure track, these findings are limited to these IHEs and faculty. However, the potential for STEM faculty involvement is much

larger than the level of involvement that is currently being realized. It may be worth considering the possibility that MSP would be more successful in recruiting faculty from IHEs that are less research-oriented, because STEM faculty from research universities are less likely to be interested in K-20 reforms. In contrast, STEM faculty from liberal arts colleges and regional state universities may be more inclined to engage in such efforts, because teaching and learning forms a more integral part of their mission, and, consequently, faculty from these institutions are more likely to reach out to K-12 teachers, as well as more likely to be recognized and rewarded for such efforts.

Another possibility is that the funding agencies would be best served by targeting a different type of STEM faculty, such as those who are not on a tenure track, because the pressure for tenure and promotion poses barriers to involvement in K-20 reforms. This is especially relevant when considered in light of the realization that the fast expansion of non-tenure-track faculty and part-time faculty is causing the landscape of IHE faculty to change rapidly (Schuster & Finkelstein, 2006). According to the Integrated Postsecondary Education Data System (IPEDS) Fall Staff Survey for 2003, 34.8 percent of all full-time faculty are off-track faculty, and they represent 58.6 percent of all newly hired full-time faculty. In addition, part-time faculty already account for half of the academic workforce. It is important to note the marked differences within the system. Research and doctoral institutions and the more selective liberal arts colleges, while increasingly resorting to contingent staff, still

retain a large majority of full-time tenured or tenure-track faculty. Nevertheless, without the pressure of obtaining tenure through research and publications, non-tenure-track faculty members may be a resource that could be more fully utilized in the future.

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