Journal of Educational Research & Policy Studies
Fall 2009, Vol. 9, No. 2, pp. 23 - 42

NORMES

Research Mathematicians' Participation in the MSP Program

Kathleen T. Alligood
George Mason University

Patricia S. Moyer-Packenham
Utah State University

Patricia G. Granfield
George Mason University

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

Research Mathematicians' Participation in the MSP Program

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

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

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

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

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

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

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

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

Background on STEM Faculty Engaged in Education Work

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Methods and Data Sources

Sources

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

Analytic Approach

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

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

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

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

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

Results

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

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

Participation of Mathematics Researchers

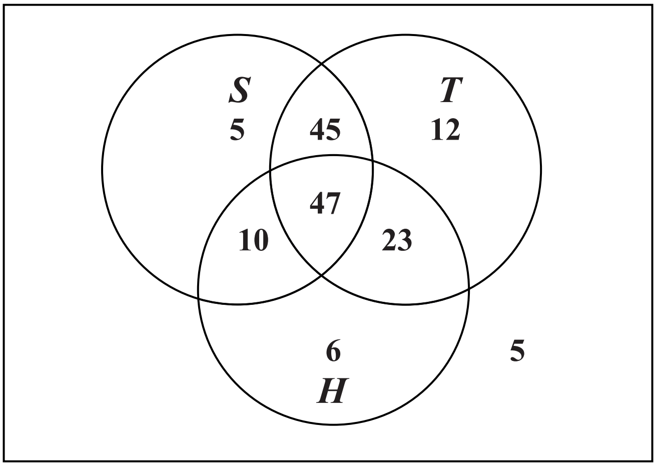
Figure 1(a) indicates how STEM faculty (as defined by Zhang et al., 2006, 2007) are engaged in K-12 teacher training activities based on a level of significant contribution to the partnership (160+ hours). The relationships are given as percentages of the total IHE faculty in the mathematics-targeted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

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

Mathematics Researchers' Involvement in Activities

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

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



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

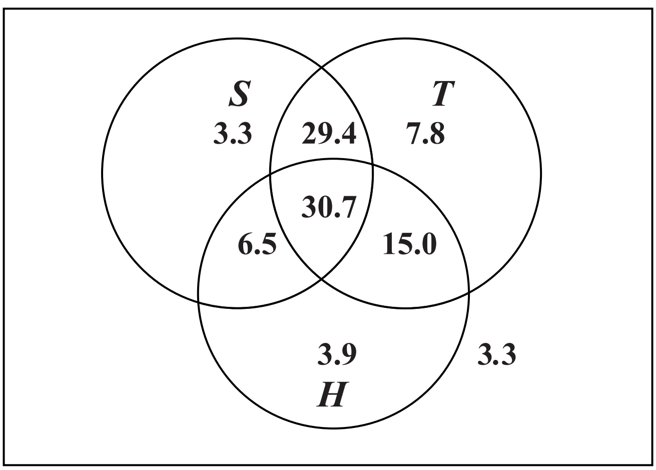
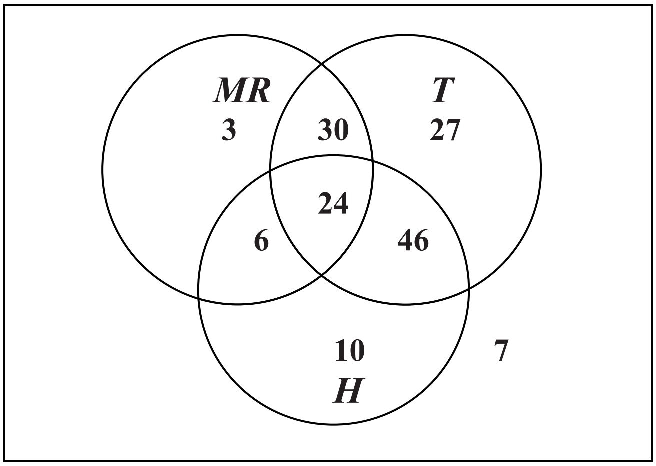


Figure 1. Faculty participation as defined by STEM researcher or STEM teacher (S).

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



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

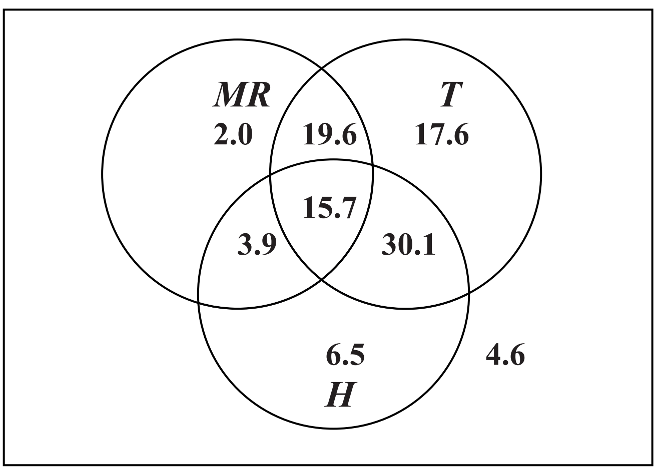


Figure 2. Faculty participation as defined by Mathematics Researcher (MR)..

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

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

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

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

Profile of Mathematics Researchers in Schools

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

Table 1

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

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

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

Table 2

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

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

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

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

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

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

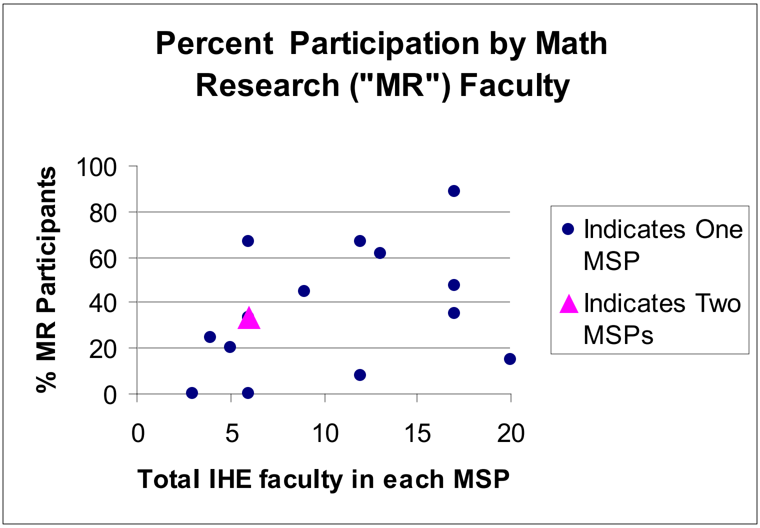


Figure 3. Participation by mathematics research faculty.

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

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

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

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

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

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

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

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

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

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

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

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

Discussion

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

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

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

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

continuing their research careers while participating in the NSF MSP activities.
- The lead university made interest and ability in teaching a priority in hiring MRs.
- The universities were partnered with an education institute which provided expertise in education, school relations, and the overall management of the partnership.

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

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

Acknowledgments

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

Any opinions, findings, conclusions, and recommendations expressed in this article are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Authors' Note. Some quoted material in this manuscript was obtained from confidential reports, and therefore, these quotations do not include page numbers for the source material to protect the anonymity of the participants.

References

Askey, R. (1999). Knowing and teaching elementary mathematics. *American Educator, 23*(4), 6-13, 49.

Askey, R. (n.d.). *Good intentions are not enough.* Retrieved from http://www.math.wisc.edu/~askey/

Bass, H. (2005). Mathematics, mathematicians, and mathematics education. *Bulletin of the American Mathematical Society, 42*(4), 417-430.

Ginsberg, R., & Rhodes, L. (2003). The work, support and recognition of university faculty in partner schools. *Journal of Teacher Education, 54*(2), 150-162.

Grobe, T., Curnan, S. P., & Melchior, A. (1990). *Synthesis of existing knowledge and practice in the field of educational partnerships.* Boston, MA: Brandeis University, Center for Human Resources.

Kahane, J. P. (1990). A farewell message from the retiring president of ICMI. *Bulletin of the International Commission on Mathematical Instruction, 29*, 3-8.

Kingsley, G., & Waschak, M. R. (2005). *Finding value and meaning in the concept of partnership*. Paper Presented at the MSP Evaluation Summit: Evidence -Based Findings from MSP's, September 2005, Minneapolis, MN.

Koppes, P. (2003). Sally says students need more than math "appreciation." *University of Chicago Chronicle, 22*(8), 1-2. Retrieved from http://chronicle.uchicago.edu/030123/math.shtml

Milgram, J. (2005). *The mathematics pre-service teachers need to know. "Ten myths about math education and why you shouldn't believe them."* Retrieved February 10, 2009, from http://www.nychold.com/myths-050504.html

Moyer-Packenham, P. S., Kitsantas, A., Bolyard, J. J., Huie, F., & Irby, N. (2009). Participation by STEM faculty in mathematics and science partnership activities for teachers. *Journal of Stem Education*, *10*(2), 17-36.

National Science Foundation. (2002). *Math and science partnership program: Program solicitation NSF02-061*. Retrieved from http://www.nsf.gov/pubs/2002/nsf02061/nsf02061.html

Roitman, J. (2000). Revising the NCTM standards. *Notices of the AMS, 47*(1), 5.

Shapiro, N., Benson, S., Maloney, P., Frank, J., Dezfooli, N., Susskind, D., et al. (2006). *Report on Course and Curriculum Changes in Math and Science Partnership (MSP) Programs,* prepared by the CASHÉ (Change and Sustainability in Higher Education) Project Team, University System of Maryland.

Westat. (2003). *National Science Foundation Math and Science Partnerships Program Management Information System.* Rockville, MD: Author.

Winkler, A., & Frechtling, J. (2005). Posted on MSPnet (1/25/06). *Evaluating new versus mature partnerships: How evaluation questions may change based on partnership longevity.* Retrieved from http://hub.mspnet.org/index.cfm

Wu, H. (1999). Basic skills vs. conceptual understanding: A bogus dichotomy. *American Educator, 23*(3), 14-19, 50-52.

Zhang, X., Frechtling, J., McInerney, J., Nyre, G., Michie, J., Miyaoka, A., et al. (2006). *Effect of STEM faculty engagement in MSP – a longitudinal perspective: A year 2 RETA report*. Rockville, MD: WESTAT.

Zhang, X., Frechtling, J., McInerney, J., Nyre, G., Michie, J., Miyaoka, A. et al. (2007). *A year 3 report for effect of STEM faculty engagement in MSP – a longitudinal perspective.* Rockville, MD: WESTAT.