Participation by STEM Faculty in Mathematics and Science Partnership Activities for Teachers

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Reports, including *Rising Above the Gathering Storm* (National Academy of Sciences, 2007) and *Before It's Too Late* (National Commission on Mathematics and Science Teaching for the 21st Century, 2000), have highlighted the critical need for a mathematically, technologically and scientifically literate work force, and the important role that a high quality mathematics and science education plays in preparing citizens for an increasingly competitive global society. Many agree that one of the most significant methods for increasing America's talent pool is to improve K-12 mathematics and science education.

A variety of federal and state initiatives to support K-12 mathematics and science education have been the result of identifying this critical need. Agencies such as the National Science Foundation and the Department of Education have increased funding for partnerships that include science, technology, engineering, and mathematics (STEM) faculty in disciplinary departments at universities to work in collaboration with faculty in colleges of education and K-12 school systems to improve mathematics and science teaching and learning. Developing partnerships with institutions of higher education (IHEs), businesses, or other organizations is a popular avenue for many K-12 school districts to pursue in an effort to improve student learning (Borthwick, Stirling, Nauman, & Cook, 2003; Bullough, Draper, Smith, & Birrell, 2004).

Over the past seven years, the National Science Foundation has funded the Math and Science Partnership (NSF-MSP) Program as a research and development effort to support K-12 mathematics and science education through partnerships with IHEs and other organizations (National Science Foundation, 2007a). (See Appendix A for the NSF-MSP Program goals.) These partnerships engage IHE STEM and Education faculty with K-12 schools, teachers, and students.

Traditionally disciplinary faculty in IHE STEM departments have contributed to K-12 education by teaching content-specific courses for pre-service and in-service mathematics and science teachers at the IHE, rather than participating directly with teachers in K-12 schools. In Ginsberg and Rhodes' (2003) analysis of 32 National Network for Educational Renewal (NNER) institutions, with approximately the same number of research-oriented and teaching-oriented IHEs, they reported that "faculty" involved in

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Abstract

This study examines archival data from a federally-funded mathematics and science program (NSF-MSP) where partnerships in the program provided pre-service and in-service education for mathematics and science teachers. Of particular interest in the present study was the breadth of participation by IHE Science, Technology, Engineering, and Mathematics (STEM) faculty in the activities designed for teachers, and the relationship between the participation of IHE STEM faculty and the participation of all other providers of MSP teacher activities.

In this contextualized analysis, researchers examined breadth of participation for each provider in terms of topics (i.e., mathematics, science, technology), levels (i.e., elementary, middle, high), and categories of common teacher activities (i.e., pre-service teacher preparation activities, in-service teacher enhancement activities). It was hypothesized that IHE education faculty and K-12 teachers and leaders would be the providers most involved in the in-service activities for current mathematics and science teachers. It was also anticipated that IHE education faculty would be the providers most involved in pre-service activities for university students in mathematics and science teacher education programs, with IHE STEM faculty serving as the developers and instructors of mathematics and science courses in their STEM departments.

Findings indicated that, in terms of the breadth of participation in pre-service and in-service teacher activities among 14 provider groups, IHE STEM faculty participated most broadly across the activities, followed by IHE education faculty and K-12 teachers. Because IHE STEM faculty participation with K-12 teachers was an important goal of the NSF MSP Program, these findings reflect well on the efforts of the partnerships in the program. These results demonstrate that shifts were evident among participants in MSP partnerships, in relation to the typical roles and responsibilities of IHE faculty and K-12 school personnel providing teacher development.

The findings are significant because they indicate that, not only did partnerships in the NSF-MSP Program attain the goal of engaging IHE STEM faculty in activities with pre-service and in-service teachers, they engaged IHE STEM faculty across a breadth of teacher activities. The scope of IHE STEM faculty participation included each topic area, all K-12 levels, and various categories of teacher activities. Because teacher development in mathematics and science education is not the primary role of STEM faculty in most IHE disciplinary departments, these findings show the unique nature of STEM faculty participation that was achieved in the NSF-MSP Program.

partnerships with schools rarely meant the involvement of STEM disciplinary faculty. The NSF-MSP Program purports that there are many ways, in addition to teaching IHE content courses, that STEM faculty can support mathematics and science education and teacher development. In fact, many mathematics and science partnerships are based on the notion that mathematicians and scientists can make a variety of contributions to teacher education. The present study was designed to explore this notion.

This investigation examines the work of partnerships in the NSF-MSP Program to "Engage and support scientists, mathematicians, and engineers at local universities and local industries to work with K-12 educators and students" (National Science Foundation, 2007b). It is common for IHE faculty in colleges of education to work in collaboration with K-12 schools to support educational initiatives, but less common for IHE STEM disciplinary faculty to be engaged in this work. Because the NSF-MSP Program calls for IHE STEM faculty engagement with teachers, the present inquiry focused on identifying the breadth of participation by IHE STEM faculty in mathematics and science partnership activities for teachers, and the relationship of IHE STEM faculty participation with the participation of other providers in the partnerships.

Previous research on IHE STEM faculty participation has provided descriptive information and tabulations on characteristics of IHE providers (including IHE STEM faculty, IHE Education faculty, and IHE others), using broad teacher development categories, as well as focusing on specific teacher development activities (Frechtling, Miyaoka, & Silverstein, 2006; Zhang et al., 2007). Other research has examined subsets of the MSPs and the teacher development providers, including analyses of 21 selected MSP projects examining the role of IHE STEM faculty in course and curricular changes (Shapiro et al., 2006), 8 case studies of MSP partnerships where there was a high level of STEM faculty participation (Zhang et al., 2007), and an examination of the work of research mathematicians with in-service teachers in 15 targeted mathematics MSP partnerships (Alligood, Moyer-Packenham, & Granfield, in press). The present analysis advances these previous studies by examining data from 34 partnerships over two years. In contrast with the previous research, we focused on IHE STEM faculty participation within the context of all providers' participation in pre-service and in-service teacher development activities (not just IHE providers). This contextualized analysis examined IHE STEM faculty participation using a detailed level of categorization of activites in terms of topics (mathematics, science, engineering, technology, content, pedagogy, and leadership), in terms of levels (elementary, middle, and high school), and in terms of categories of activities (e.g., in-service retention/enhancement for K-12 teachers, developing pre-service courses, pre-service recruitment targeting STEM students, etc.).

Partnering to Improve K-12 Mathematics and Science Education

Collaborative projects among K-12 schools, universities, and other organizations come in a variety of forms and take on a range of goals. Partnerships may seek to improve student achievement, implement a new curricular program, improve instruction, increase the numbers of mathematics and science teachers, or some combination of these. As a result of increased attention on mathematics and science education brought on, in part, by results of international comparisons of student performance (Stigler & Hiebert, 1999; U. S. Department of Education, 2007), the No Child Left Behind Act (2001), and the small numbers of students pursuing mathematics and science related majors and careers, many K-12 partnerships seek to improve student performance through improved pre-service and in-service teacher development efforts.

Studies of such partnerships have found that they can have positive effects on teachers (in the form of higher quality professional development and increased opportunities to work collaboratively with peers) and on students (in the form of increased student achievement) (Bruckerhoff & Popkewitz, 1991; Dresner & Worley, 2006; Gut, Oswald, Leal, Frederickson, & Gustafson, 2003; Mariage & Garmon, 2003; Sandholtz, 2002; Vos, 2002). School, university, and business partnerships formed for the purpose of better preparing teachers have been found to provide meaningful opportunities for interactions between pre-service and in-service teachers (Bullough et al., 2004; Gut et al., 2003; Sutherland et al., 2005). Other partnerships form to recruit and prepare qualified mathematics and science teachers (Walters, 1993) and increase the numbers of minority mathematics and science teachers (Cavallo, Ferreira, & Roberts, 2005). Research indicates that the success of partnerships relies on building strong relationships and a strong sense of trust among partners (Bullough et al., 2004; Fisler & Firestone, 2006). Effective collaborations are characterized by mutual respect among the people involved, commitment to com-

	Mathematics N=585	Science N=441	Technology N=141	Engineering N=42	Content N=602	Pedagogy N=557	Leadership N=327
IHE STEM Faculty	444 (75.9)	316 (71.7)	124 (87.9)	40 (95.2)	448 (74.4)	406 (72.9)	246 (75.2)
IHE Education Faculty	365 (62.4)	269 (61.0)	102 (72.3)	24 (57.1)	367 (61.0)	343 (61.6)	201 (61.5)
IHE Administrators	189 (32.3)	179 (40.6)	64 (45.4)	26 (61.9)	195 (32.4)	177 (31.8)	105 (32.1)
Graduate Students	100 (17.1)	82 (18.6)	33 (23.4)	9 (21.4)	117 (19.4)	106 (19.0)	71 (21.7)
Postdoctoral Students	8 (1.4)	18 (4.1)	3 (2.1)	1 (2.4)	17 (2.8)	16 (2.9)	10 (3.1)
STEM Undergraduate Students	48 (8.2)	44 (10.0)	28 (19.9)	12 (28.6)	49 (8.1)	41 (7.4)	28 (8.6)
Pre-Service Undergraduate Students	38 (6.5)	33 (7.5)	16 (11.3)	5 (11.9)	38 (6.3)	33 (5.9)	25 (7.6)
K-12 District and/or School-Level Administrators/Staff	238 (40.7)	187 (42.4)	69 (48.9)	19 (45.2)	241 (40.0)	232 (41.7)	166 (50.8)
K-12 Teachers	345 (59.0)	271 (61.5)	92 (65.2)	22 (52.4)	373 (62.0)	355 (63.7)	214 (65.4)
K-12 Instructional Coordinators and Supervisors	236 (40.3)	199 (45.1)	70 (49.6)	19 (45.2)	253 (42.0)	244 (43.8)	166 (50.8)
K-12 Guidance Counselors	12 (2.1)	10 (2.3)	9 (6.4)	9 (21.4)	9 (1.5)	6 (1.1)	6 (1.8)
Non-Academic Mathematicians	42 (7.2)	23 (5.2)	19 (13.5)	3 (7.1)	40 (6.6)	35 (6.3)	35 (10.7)
Non-Academic Scientists	30 (5.1)	42 (9.5)	20 (14.2)	3 (7.1)	41 (6.8)	37 (6.6)	28 (8.6)
Non-Academic Engineers	11 (1.9)	16 (3.6)	9 (6.4)	3 (7.1)	14 (2.3)	13 (2.3)	12 (3.7)

Table 1. Breadth of Provider Participation by Topic

Note: Number and Percent = provider involvement in a topic divided by the total number of activities within the topic; Ns are provided for the total number of activities per topic.

mon and relevant goals, and adaptability (Kersh & Masztal, 1998).

Involving Mathematics and Science Disciplinary Faculty in Education Work

More recently, emphasis has been placed on the participation of science, technology, engineering, and mathematics (STEM) faculty and other professionals in K-12 school partnerships, particularly in activities designed for teachers. This has been influenced by recent calls for the reform of the preparation of mathematics and science teachers and the role of STEM faculty in that reform (Cole, Mahaffey, Ramey, Ryan, Swann, & Tomlin, 2002; Selden, 2005). For example, the 2001 Conference Board of the Mathematical Sciences (CBMS) report, *The Mathematical Education of Teachers*, discusses the need to make teacher education an important part of the work of mathematics departments and to foster cooperation among mathematics faculty, mathematics education faculty, and K-12 education. The report of the National Commission on Mathematics and Science Teaching for the 21st Century (2000), *Before It's Too Late*, also calls on faculty from mathematics and science IHE departments to play a substantive role in improving teacher preparation along with education faculty. Because reports on the participation of STEM faculty show that the reward structure and incentives in IHE STEM disciplinary departments can be a significant factor in the engagement of faculty from these departments in K-12 education work (Zhang et al., 2006, 2007), incentives may be necessary to move STEM faculty toward education work. In that regard, funding opportunities from private and federal programs have encouraged the participation of STEM faculty and professionals in K-12 school reform efforts. Two examples include the Ford Foundation's Ford Urban Mathematics Collaboratives program (Nelson, 1986) and the NSF Graduate Teaching Fellows in K-12 Education (GK-12) (NSF PR 07-555; www.nsf.gov). These examples demonstrate the belief that the knowledge and contributions of the STEM disciplinary faculty are important for education work, and therefore, it is crucial to find meaningful ways to engage STEM faculty in that work.

Teachers and Scientists

Partnerships between teachers and scientists are often designed to engage teachers in the work of scientists in the field. For example, partnerships may engage teachers in summer field work experiences with scientists from IHEs and federal agencies (Dresner, 2002; Dresner & Worley, 2006; Dresner & Starvel, 2004), provide teachers with opportunities to participate in yearlong research projects with scientists (Drayton & Falk, 2006), pair graduate students in science fields with high school science teachers to design classroom activities (Siegel, Mlynarczyk-Evans, Brenner, & Nielsen, 2005), pair

	School Levels		
Providers	Elementary N=375	Middle N=589	High N=499
IHE STEM Faculty	255(68.0)	430(73.0)	386(77.4)
IHE Education Faculty	229(61.1)	370(62.8)	319(63.9)
IHE Administrators	139(37.1)	197(33.4)	144(28.9)
Graduate Students	80(21.3)	113(19.2)	101(20.2)
Postdoctoral Students	18(4.8)	17(2.9)	15(3.0)
STEM Undergraduate Students	18(4.8)	39(6.6)	46(9.2)
Pre-Service Undergraduate Students	21(5.6)	33(5.6)	36(7.2)
K-12 District and/or School-level Administrators/Staff	132(35.2)	247(41.9)	205(41.1)
K-12 Teachers	237(63.2)	361(61.3)	315(63.1)
K-12 Instructional Coordinators and Supervisors	151(40.3)	249(42.3)	208(41.7)
K-12 Guidance Counselors	1(0.3)	8(1.4)	5(1.0)
Non-Academic Mathematicians	13(3.5)	40(6.8)	36(7.2)
Non-Academic Scientists	18(4.8)	40(6.8)	28(5.6)
Non-Academic Engineers	6(1.6)	16(2.7)	12(2.4)

Table 2. Breadth of Provider Participation by School Level

Note: Number and Percent = provider involvement in a level divided by the total number of activities within the level; Ns are provided for the total number of activities per level.

secondary teachers and research scientists in workshop experiences to learn about inquiry instruction (Canton, Brewer, & Brown, 2000), or connect university scientists to the K-12 community through the use of videoconferencing (McCombs, Ufnar, & Shepherd, 2007).

Benefits of teacher-scientist partnerships have been found for teachers, scientists, and students (Siegel, Mlynarczyk-Evans, Brenner, & Nielsen, 2005). Often, these projects focus on the development of teachers' knowledge and encourage them to learn for their own benefit (Drayton & Falk, 2006). As a result, teachers gain content knowledge, increased motivation and confidence, and an understanding of the nature of science (Canton, Brewer, & Brown, 2000; Dresner, 2002; Dresner & Starvel, 2004; Dresner & Worley, 2006; Siegel, Mlynarczyk-Evans, Brenner, & Nielsen, 2005). Studies indicate that participation in such projects may result in changes in teachers' instruction and have positive effects on the environment in college and K-12 classrooms (Canton, Brewer, & Brown, 2000; Dresner, 2002; Dresner & Starvel, 2004). Teachers value the opportunity to collaborate with other teachers and science professionals while developing a network of scientists and teachers (Dresner, 2002; Dresner & Worley, 2006). There is also evidence that teachers feel an improved sense of status from having worked with research scientists (Dresner & Worley, 2006).

For students, school-scientist partnerships can enrich their learning and provide role models in the field. Results of a study partnering biology graduate students with a high school teacher to design classroom lab activities found that the participation of the research scientists contributed to the authenticity of the work and helped students understand the nature of scientific inquiry (Siegel, Mlynarczyk-Evans, Brenner, & Nielsen, 2005). Another study found that students whose teachers had participated in an inquiry workshop with scientists indicated higher levels of satisfaction with inquiry activities in the classroom (Canton, Brewer, & Brown, 2000). In addition, partnerships with scientists can allow students and teachers to engage in richer, more sophisticated investigations by providing access to individuals with advanced techniques and to use equipment too expensive or sophisticated for a high school lab (Powell & Stiller, 2005).

Partnering with K-12 schools has also been shown to have impacts on research scientists. Participating scientists have reported gaining instructional skills and increased knowledge of K-12 education (McCombs, Ufnar, & Shepherd, 2007). There is also evidence that scientists' participation in school partnerships can influence their beliefs about teaching elementary science and may impact their own instructional practices (Ballone-Duran, Czerniak, & Haney, 2005).

Teachers and Mathematicians

Some school partnerships involve mathematicians working with K-12 teachers. For example, the Vermont Mathematics Initiative is a program designed to focus on deepening elementary teachers' learning of mathematics (Galley, 2004, April 7). The three-year program requires teachers to attend a two-week session each summer and three weekend sessions each semester. At the end of the program, teachers can earn a master's degree. University mathematicians run the program and teach all classes. Preliminary evidence of the program's effectiveness indicates that participating teachers developed increased enthusiasm for the discipline of mathematics.

The Ford Foundation Urban Mathematics Collaboratives have provided opportunities for teachers to work with university and private sector mathematicians in a variety of ways, including: collaborating with partners from businesses and universities to design improved K-12 mathematics programs; participating in internship opportunities with mathematicians in industry; and engaging in complex mathematics work with university mathematicians (Nelson, 1986). Results of a case study from one project, the Cleveland Collaborative for Mathematics Education (C2ME), indicated that teachers' involvement in the program allowed them to play a part in the decision-making process in an effort to improve mathematics teaching and learning (Bruckerhoff & Popkewitz, 1991). Further, teachers appreciated the opportunity to work with university and private sector mathematicians and become part of a larger mathematical community. Teachers felt they were on an equal level with the mathematicians as they pursued a common goal.

Respected mathematician, Hyman Bass (2005), has advocated mathematicians being engaged in education work. In the Bulletin of the American Mathematical Society, Bass (2005) discussed the contributions of eminent research mathematicians, such as Felix Klein and Hans Freudenthal, who have made significant contributions to mathematics education work. In the AMS paper, Bass (2005) discusses how important it is for research mathematicians to develop an understanding of K-12 mathematics education that allows them to see how their own mathematical knowledge might contribute solutions to problems in mathematics education. A profile of one of the partnerships in the MSP Program, where over 15 research mathematicians have been actively engaged in K-12 education work, shows evidence that the mathematicians in the partnership have come to recognize and value the work of teachers and have a better understanding of the mathematics that is taught in K-12 schools (Alligood, Moyer-Packenham, & Granfield, in press).

MSP Research on IHE STEM Faculty

Prior studies on the work of IHE STEM faculty in the MSP Program provided a framework for our research questions in the present study. For example, 1,160 faculty responded in 2004-05 on the NSF-MIS IHE Participant Survey; of those, 706 were STEM faculty, 303 were education faculty, and 151 were other IHE personnel (Frechtling, Miyaoka, & Silverstein, 2006). Similarly, on the 2005-06 IHE Participant Survey, of 1,122 total faculty respondents, 720 were STEM faculty, 309 were education faculty, and 93 were other IHE personnel (Zhang et al., 2007). These data inform the present study in terms of the number of IHE faculty participants in MSP activities, and the proportional relationships among the IHE STEM faculty participants with the IHE education faculty and other IHE participants. Their results indicate that over twice as many IHE STEM faculty participated in MSP activities as compared with IHE education faculty. These results also show that 29% of STEM faculty, 45% of education faculty, and 54% of other IHE faculty spent more than 200 hours on MSP activities, in general, and that there was a significant difference between the hours of participation of mathematics faculty and science faculty (in favor of mathematics faculty) (Frechtling, Miyaoka, & Silverstein, 2006). These results are informative, but they are also limited, because they do not examine relationships among IHE STEM faculty and *all* other providers of pre-service and in-service teacher development activities (they focus only on the IHE faculty).

Additional studies on the work of IHE STEM faculty have focused on their participation in relation to four general categories: pre-service activities, in-service activities, activities with K-12 students, and management activities (Frechtling, Miyaoka, & Silverstein, 2006). Other reports provide tables showing the participation of faculty in specific MSP activities, based on individual survey items from the NSF-MIS IHE Participant Survey (Zhang et al., 2007). Again, the results from these prior analyses are useful; however, we believed that grouping the pre-service and in-service teacher activities into *categories of common activities* could identify trends in the types of activities in which individuals were involved in the MSPs. As Frechtling, Miyaoka, and Silverstein report, their analyses are "descriptive, rather than interpretive or evaluative" (Frechtling, Miyaoka, & Silverstein, 2006, p.

	Activity Categories						
Providers	In- Service Retention/Enhancement for STEM Teachers	In- Service Retention/Enhancement for K-12 Teachers	New Policies in Pre-Service	General Pre-Service Recruitment Activities	Pre-Service Recruitment Specifically Target STEM Students	Pre-Service Preparation—General Improvement Activities	Pre-Service Preparation—Developing Courses
	N=138	N=263	N=15	N=48	N=73	N=98	N=83
IHE STEM Faculty	82 (59.4)	182 (69.2)	12 (80.0)	39 (81.3)	58 (79.5)	65 (66.3)	73 (88.0)
IHE Education Faculty	66 (47.8)	157 (59.7)	9 (60.0)	25 (52.1)	28 (38.4)	69 (70.4)	67 (80.7)
IHE Administrators	17 (12.3)	87 (33.1)	9 (60.0)	21 (43.8)	16 (21.9)	39 (39.8)	37 (44.6)
Graduate Students	18 (13.0)	52 (19.8)	2 (13.3)	7 (14.6)	16 (21.9)	17 (17.3)	19 (22.9)
Postdoctoral Students	1 (0.7)	8 (3.0)	1 (6.7)	0 (0.0)	1 (1.4)	4 (4.1)	4 (4.8)
STEM Undergraduate Students	1 (0.7)	12 (4.6)	0 (0.0)	7 (14.6)	16 (21.9)	13 (13.3)	7 (8.4)
Pre-Service Undergraduate Students	1 (0.7)	5 (1.9)	0 (0.0)	3 (6.3)	13 (17.8)	15 (15.3)	5 (6.0)
K-12 District and/or School-Level Administrators/Staff	69 (50.0)	134 (51.0)	1 (6.7)	11 (22.9)	16 (21.9)	31 (31.6)	13 (15.7)
K-12 Teachers	100 (72.5)	175 (66.5)	3 (20.0)	17 (35.4)	35 (47.9)	58 (59.2)	31 (37.3)
K-12 Instructional Coordinators and Supervisors	79 (57.2)	138 (52.5)	1 (6.7)	6 (12.5)	13 (17.8)	27 (27.6)	11 (13.3)
K-12 Guidance Counselors	2 (1.4)	4 (1.5)	0 (0.0)	4 (8.3)	2 (2.7)	0 (0.0)	0 (0.0)
Non-Academic Mathematicians	7 (5.1)	21 (8.0)	0 (0.0)	1 (2.1)	2 (2.7)	3 (3.1)	8 (9.6)
Non-Academic Scientists	9 (6.5)	21 (8.0)	0 (0.0)	2 (4.2)	2 (2.7)	4 (4.1)	4 (4.8)
Non-Academic Engineers	1 (0.7)	10 (3.8)	0 (0.0)	0 (0.0)	1 (1.4)	3 (3.1)	1 (1.2)

Table 3 . Breadth of Provider Participation by Activity Category

Note: Number and Percent = provider involvement in an activity category divided by the total number of activities within the category; Ns are provided for the total number of activities per category.

2). In the present student we sought to provide some interpretation to the participation of IHE STEM faculty in relation to other providers. In addition, our research task was encouraged by prior researchers who note the importance of answering questions such as: "How does IHE involvement differ in elementary, middle and high school contexts?" and, "Are STEM faculty more likely to engage in activities that involve students and challenging curriculum at the high school level?" (Frechtling, Miyaoka, & Silverstein, 2006, p. 21).

Other research on IHE STEM faculty in the MSP Program has focused specifically on the interaction of IHE STEM faculty with teachers. Using reports from 48 MSPs, researchers identified interventions, including linking IHE STEM faculty with K-12 teachers, described by awardees as influencing teacher quality, quantity, and diversity (Moyer-Packenham, Bolyard, Oh, Kridler, & Salkind, 2006). The results of this analysis indicated that IHE STEM faculty were most often described working with teachers in the following activities: teaching content courses or professional development workshops, designing new programs, recruiting pre-service teachers, and providing their expertise. Other researchers conducted a more focused analysis on the work of *mathematics researchers* (defined by the authors as IHE mathematicians whose primary field of research is mathematics) working in 15 mathematics-focused MSPs (Alligood, Moyer-Packenham, & Granfield, in press). When *mathematics researchers* were compared with non-mathematics researchers and all STEM faculty, the results showed differences among the three groups in terms of their participation in in-service teacher activities. For example, the mathematics researchers spent less time involved in partnership activities; however, the time they did spend was more focused on pre-service and in-service teacher activities than on the management of the partnership.

Although there appear to be large numbers of IHE STEM faculty participating in MSP activities in relation to other IHE individuals, without further analysis it is not possible to determine, from previous results, the breadth of IHE STEM faculty participation across topics, levels, and categories of teacher activities in relation to all participants in the MSP Program. The present study includes the examination of all providers with other variables not previously examined.

The Present Study

The present analysis advances inquiries on the IHE STEM faculty participation in the MSP Program by taking a broader perspective than previous work. To take this broader perspective, we examined a larger number of partnerships (34 MSPs) using data from two years of the NSF-MIS surveys (patterns of IHE participation have been consistent across a three-year period; Frechtling, Miyaoka, & Silverstein, 2006). We also broadened our research questions to include multiple groups (beyond IHE participants only) in an effort to contextualize the participation of IHE STEM faculty in relation to the participation of *all* providers of pre-service and in-service teacher development activities. We formulated our questions at a detailed level of categorization of activities to determine if IHE STEM faculty were engaged in a wide variety of activities, or if their participation was more narrowly limited to a few conventional activities. Our overall research questions focused on two broad inquiries: 1) What is the breadth of IHE STEM faculty participation in pre-service and in-service mathematics and science teacher activities in the MSP Program (where *breadth* is defined as "wide extent or scope" by the dictionary, and, for our purposes, broad participation across a number of and variety of activities within a particular category)? and, 2) What is the relationship of IHE STEM faculty participation to that of other providers in the MSP Program? These research questions were examined with respect to *topics* (mathematics, science, engineering, technology, etc.), *levels* (elementary, middle, and high school), and *categories of common pre-service and in-service teacher development activities* (e.g., in-service retention/enhancement for K-12 teachers, developing pre-service courses, pre-service recruitment targeting STEM students, etc.).

We considered these broad research questions in terms of the following sub-questions:

What is the breadth of IHE STEM faculty participation within topics (e.g., mathematics, science, technology)?

What is the breadth of IHE STEM faculty participation within levels (elementary, middle, high)?

What is the breadth of IHE STEM faculty participation within categories of common pre-service and in-service mathematics and science teacher activities?

What is the relationship of IHE STEM faculty

Providers	Topics						
	Mathematics	Science	Technology	Engineering	Content	Pedagogy	Leadership
IHE STEM Faculty	0.22***	0.01	0.18***	0.13***	0.16***	0.07	0.08*
IHE Education Faculty	0.16***	0.06	0.14***	-0.01	0.11**	0.11**	0.05
IHE Administrators	0.04	0.25***	0.15***	0.16***	0.05	0.01	0.01
Graduate Students	-0.06	0.01	0.07	0.02	0.07	0.04	0.08*
Postdoctoral Students	-0.17	0.11**	-0.02	-0.004	0.03	0.03	0.02
STEM Undergraduate Students	0.03	0.10**	0.22***	0.19***	0.03	-0.03	0.03
Pre-Service Undergraduate Students	0.06	0.09*	0.12**	0.06	0.05	0.01	0.07
K-12 District and/or School-Level Administrators/Staff	0.10**	0.11**	0.11**	0.04	0.08*	0.12**	0.23***
K-12 Teachers	0.03	0.08*	0.07	-0.03	0.17***	0.20***	0.13***
K-12 Instructional Coordinators and Supervisors	0.09*	0.18***	0.12**	0.04	0.18***	0.21***	0.23***
K-12 Guidance Counselors	0.06	0.06	0.18***	0.38***	-0.03	-0.09	0.01
Non-Academic Mathematicians	0.12**	-0.03	0.16***	0.01	0.08*	0.03	0.19***
Non-Academic Scientists	-0.06	0.20***	0.18***	0.01	0.09*	0.06	0.11**
Non-Academic Engineers	-0.05	0.12**	0.14***	0.08*	0.02	0.01	0.09*

Table 4. Phi Correlations between Providers and Topics

Note. These results indicate significant positive relationships only; * $p < .05$; ** $p < .01$; *** $p < .001$

participation to that of other providers within topics (e.g., mathematics, science, technology)?

What is the relationship of IHE STEM faculty participation to that of other providers within levels (elementary, middle, high)?

What is the relationship of IHE STEM faculty participation to that of other providers within categories of common pre-service and in-service mathematics and science teacher activities?

As the previous review demonstrates, there are a variety of partnership experiences between mathematicians and scientists and K-12 teachers, with many of these involving the K-12 teachers in experiences that improve their knowledge of mathematics and science. Only recently have mathematicians and scientists begun to work directly in K-12 schools with teachers, which may indirectly influence the knowledge of mathematicians and scientists about K-12 education and teaching. Based on the traditional roles and responsibilities of IHE STEM and education faculty and K-12 teachers and leaders, we hypothesized that IHE education faculty and K-12 teachers/leaders would have the highest breadth of participation in the in-service teacher activities across topics, levels, and categories, and that K-12 teachers/leaders would be involved across the breadth of the K-12 levels (elementary, middle, and high). We also hypothesized that IHE Education faculty and STEM faculty would have the highest breadth of participation in *pre-service teacher* activities, with IHE STEM faculty serving primarily as developers and instructors for content-specific courses in their STEM departments.

Methods

Data Source

The NSF Management Information System (MIS) contains archival data gathered using survey tools. The quantitative data from one MIS survey tool (*Annual Survey for Comprehensive and Targeted Partnership Projects*) was used in the present study. This survey contained information on all of the individuals who provided pre-service and in-service teacher development activities within the partnerships, as reported by project staff, including Project Investigators and Project Directors. (Using this survey to examine the participation of IHE STEM faculty diverges from prior research which has utilized the *IHE Participant Survey* and the *IHE Institution Survey*; Frechtling, Miyaoka, & Silverstein, 2006; Zhang et al., 2007). While the *Annual Survey for Comprehensive and Targeted Partnership Projects* collects information on who participated in each individual MSP activity reported, one limitation of the survey is that it does not collect information on the number of participants for each individual activity. Therefore, while we were able to analyze the breadth of participation of different providers across topics, levels, and categories of activities, we were not able to determine the numbers of individual participants for each activity based on the data gathered on this survey.

Thirty-four Comprehensive and Targeted partnerships submitted data to the MIS during the first and second years of data collection (we will refer to these as Wave I and Wave II). Following the Wave I and II survey administrations, responses were compiled in the MIS system and converted to SPSS and Excel file formats. The data collected from these 34 partnerships were used to answer our research questions. For individual items on the MIS, survey respondents selected a categorical response (either "yes" or "no") for pre-service and in-service teacher development activities for each of the following four variables: *providers, activities, topics and levels.*

Variables Included in the Analysis

Providers. The MIS instrument included 14 different selections for *providers*: 1) IHE STEM Faculty, 2) IHE Education Faculty, 3) IHE Administrators, 4) Graduate Students, 5) Postdoctoral Students, 6) STEM Undergraduate Students, 7) Pre-Service Undergraduate Students, 8) K-12 District and/or School Level Administrators/Staff, 9) K-12 Teachers, 10) K-12 Instructional Coordinators and Supervisors, 11) K-12 Guidance Counselors, 12) Non-Academic Mathematicians, 13) Non-Academic Scientists, and 14) Non-Academic Engineers. A generic "other" category listed on the survey was excluded from the analysis.

Categories of common activities. The MIS instrument had 27 items for pre-service and in-service teacher development listed under three broad categories: pre-service recruitment, pre-service preparation, and in-service retention/enhancement. To create the *categories of common activities* variable, researchers reconfigured the three categories to create seven categories that were more specific. We first identified the intended audience (i.e., pre-service teachers, K-12 teachers, STEM students) for each activity item. Next, we identified the purpose of the activity in each item (e.g., new policies, retention, recruitment, preparation) by systematically focusing on various aspects of pre-service and in-service mathematics and science teacher development (Butler, Lauscher, Jarvis-Selinger & Bechingham, 2004; Zech, Gause-Vega, Bray, Secules, & Goldman, 2000). Following independent coding, we determined the seven *categories of common activities*.

The first category of common activities was named *"New Policies in Pre-Service"* and it included two items (e.g., *Establish and /or revise articulation agreements between 4 year institutions and community colleges*). The second category was *"In-Service Retention/Enhancement for STEM Teachers"* which consisted of four items (e.g., *Provide a peer coaching network for STEM teachers*). The third category with seven items was called *"In-Service Retention/Enhancement for K-12 Teachers"* (e.g., *Conduct targeted workshops/ institutes/ courses with K-12 teachers*). *"General Pre-Service Recruitment Activities"* was the fourth category with four items (e.g., *Conduct presentations at career fairs*). A fifth category with three items was named *"Pre-Service Recruitment Activities that Specifically Target STEM Students"* (e.g., *Invite STEM undergraduate/graduate students to help at (or participate in) K-12 special events*). The sixth category was identified as *"Pre-Service Preparation – Developing Courses"* and included three items (e.g., *Develop/revise pre-service courses to align with national and/or state standards*). The final category had four items and was named *"Pre-Service Preparation – General Improvement Activities"* (e.g., *Mentor pre-service students*). (The items in each category are presented in Appendix B.)

Topics. The third variable on the MIS instrument was topics. This variable referred to the different areas on which providers focused their activities. The seven topics examined in this analysis came directly from the MIS items. These included *mathematics, science, technology, engineering, content, pedagogy, and leadership*. A "none of the above" option was excluded from the analysis.

Levels. The fourth variable on the MIS instrument was levels. This variable referred to the three major levels commonly used to divide K-12 schools. The levels on the instrument included *elementary, middle* and *high*. A "none of the above" option was excluded.

Analytic Structure

To determine the "breadth" of IHE STEM faculty participation, we employed a contextualized analysis to interpret breadth in relation to the participation of the 13 other providers listed on the MIS instrument. As reported previously, we examined the 34 partnerships that submitted data in both Waves I and II. In the first part of our analysis, we determined the breadth of participation within activities, with particular attention to the relationships among providers in terms of their proportion of participation. The breadth of participation was based on the proportion of activities within each topic, level, and activity category in which a particular group of providers was involved in relation to the total number of possible activities within each topic, level, and activity category.

It should be noted that multiple providers from the same category of individuals could have participated in each single activity; however, the instrument reports categorical data only (i.e., whether a provider participated or not, "yes" or "no"), and does not provide the number of providers participating in each activity. Therefore, the numbers on the tables that follow in the results indicate numbers of activities, and *do not* indicate the number of individuals involved. For example, on the top left cell in Table 1, the number 444 indicates that IHE STEM faculty participated in 444 of the 585 total mathematics activities that were offered by the partnerships; it does not indicate that there were 444 IHE STEM Faculty participants. It is also important to note that, because multiple providers (i.e., STEM faculty, Graduate Students, and IHE Administrators) were frequently reported as all being involved in a single activity, the percents do not sum to 100 percent in each of the columns on the tables.

In the second part of our analysis, we examined the relationships among the providers and the topics, levels, and activity categories. Phi correlation coefficients were calculated to discern these relationships and to determine where there was a significant phi between the variables.

Providers	Levels		
	Elementary	Middle	High
IHE STEM Faculty	-0.07	0.09*	0.21***
IHE Education Faculty	0.05	0.18***	0.16***
IHE Administrators	0.13**	0.09*	-0.09
Graduate Students	0.08*	0.05	0.08*
Postdoctoral Students	0.14***	0.03	0.03
STEM Undergraduate Students	-0.12	-0.02	-0.09
Pre-Service Undergraduate Students	0.08*	-0.01	-0.09
K-12 District and/or School-Level Administrators/Staff	-0.07	0.16***	0.09*
K-12 Teachers	0.10**	0.13**	0.15***
K-12 Instructional Coordinators and Supervisors	0.04	0.18***	0.11**
K-12 Guidance Counselors	-0.12	-0.05	-0.08
Non-Academic Mathematicians	-0.11	0.09*	0.09*
Non-Academic Scientists	-0.05	0.09*	-0.02
Non-Academic Engineers	-0.05	0.07	0.02

Table 5. Phi Correlations between Providers and Levels

Note. These results indicate significant positive relationships only; * $p < .05$; ** $p < .01$; *** $p < .001$

Results

In the results that follow, we first present descriptive statistics based on the 34 partnerships that reported data in Waves I and II. Next, we present inferential statistics showing relationships among providers and the topics, levels, and activity categories.

Common Providers Based on Topics

Our first broad inquiry focused on the following research question: What is the breadth of the IHE STEM faculty participation in preservice and in-service mathematics and science teacher activities in the MSP Program? The first analysis under this research question considered participation across topics (e.g., mathematics, science, technology, etc.)? (See Table 1.) Overall, the providers participating across the greatest breadth of the topics were IHE STEM Faculty, followed by K-12 Teachers and IHE Education Faculty. In fact, across all seven topics, IHE STEM Faculty participated in 71.7% to 95.2% of the teacher activities within each topic. IHE STEM Faculty participated in most of the *engineering* (95.2%) and *technology* (87.9%) activities; and, they participated in 74.4% of the *content* activities and 75.9% of the *mathematics* activities.

IHE Education Faculty also participated across the breadth of the activities in each topic, ranging from participation in 57.1% to 72.3% of activities within each topic. IHE Education Faculty participated at their highest percentage in *technology* activities (72.3%) and mathematics activities (62.4%). K-12 Teachers also participated across a breadth of activities, ranging from 52.4% to 67.3% of the activities within each topic, with their highest participation in *pedagogy* (67.3%), l*eadership* (65.4%), and *technology* (65.2%) activities.

IHE Administrators were well represented in engineering, participating in 61.9% of the engineering activities. K-12 District and/or School-Level Administrators/Staff and K-12 Instructional Coordinators and Supervisors participated in 50.8% of the *leadership* activities. In terms of Non-Academics, Non-Academic Mathematicians participated in 7.2% of the *mathematics* activities; Non-Academic Scientists participated in 9.5% of the *science* activities; and, Non-Academic Engineers participated in 7.1% of the *engineering* activities. A trend in the findings from the first analysis suggests that, in all topic areas, IHE STEM Faculty participated across the greatest breadth of topics, followed by IHE Education Faculty and K-12 Teachers.

Common Providers Based on Levels

The second analysis under this research question considered breadth of participation across school levels (elementary, middle, high). (See Table 2.) IHE STEM Faculty participated in high proportions of the teacher activities at each school level when compared with the other 13 providers. IHE STEM faculty participated in 68% of the *elementary* activities, 73% of the *middle* school activities, and 77.4% of the *high* school activities). K-12 Teachers participated in 63.2%, 61.3%, and 63.1% of the *elementary, middle and high* school activities, while IHE Education Faculty participated in 61.1%, 62.8%, and 63.9% of the *elementary, middle and high* school activities, respectively. Other common providers of teacher activities at all three school levels included: K-12 Instructional Coordinators and Supervisors, K-12 District and/or School-Level Administrators/Staff, and IHE Administrators (approximately 30 to 40 percent of the activities across the three school levels).

As in the analysis examining the participation of providers within the topics, a similar trend existed among providers and school levels. That is, IHE STEM Faculty participated in a higher proportion of the activities across the elementary, middle and high school levels than any of the other providers. We anticipated that IHE Education Faculty and K-12 Teachers would show high participation as providers across activities in these school levels, particularly at the *elementary* level where it is much less common for IHE STEM Faculty to work with teachers.

Common Providers Based on Categories of Activities

The third analysis under this research question considered breadth of participation across categories of common pre-service and in-service mathematics and science teacher activities. This analysis specifically targeted pre-service and in-service teacher activities in the MSP Program, rather than general activities, to determine areas of participation with teachers for each provider. (See Table 3.) As the table shows, IHE STEM Faculty participated in the highest proportion of activities in five of the seven *activity categories*. These five categories included: *In-Service Retention/Enhancement for K-12 Teachers, New Policies in Pre-Service, General Pre-Service Recruitment, Pre-Service Recruitment Activities that Specifically Target STEM Students, and Pre-Service Preparation – Developing Courses*. In the remaining two categories, K-12 Teachers participated in 72.5% of the activities in the category – *In-Service Retention/Enhancement for STEM Teachers* (compared with the IHE STEM faculty participating in 59.4% of these activities), and IHE Education Faculty participated in 70.4% of the activities in the category – *Pre-Service Preparation – General Improvement* (compared with the IHE STEM faculty participating in 66.3% of these activities).

IHE Education Faculty continued to be among the top three most common providers in six of the seven activity categories (all but *In-Service Retention/Enhancement for STEM Teachers*). K-12 teachers were among the top three most common providers in four of the seven categories (*In-Service Retention/En-*

hancement for STEM Teachers, In-Service Retention/Enhancement for K-12 Teachers, Pre-Service Recruitment Specifically Target STEM Students, and Pre-Service Preparation – General Improvement). IHE Administrators played a more prominent role in this analysis as providers in 60% of the *New Policies in Pre-Service, 43.8% of the General Pre-Service Recruitment*, and 44.6% of the *Pre-Service Preparation – Developing Courses* activities. K-12 Instructional Coordinators and Supervisors and K-12 District and/or School-Level Administrators/Staff were providers in over half of the *In-Service Retention/Enhancement for STEM Teachers* and *In-Service Retention/Enhancement for K-12 Teachers* activities. This analysis continued to indicate the trend showing the breadth of participation by IHE STEM Faculty, IHE Education Faculty, and K-12 Teachers across the teacher activities. In addition, this analysis also indicated the participation of additional providers in a high proportion of activities within some specific categories, including IHE Administrators, K-12 Instructional Coordinators and Supervisors, and K-12 District and/or School-Level Administrators/Staff.

Relationships among Providers and Topics

Our next broad inquiry focused on the following research question: What is the relationship of IHE STEM faculty participation to that of other providers in the MSP Program? Based on the findings showing the breadth of participation of IHE STEM faculty, IHE Education faculty, and K-12 Teachers shown on Tables 1 through 3, we were curious to explore any significant relationships among these data. These relationships are presented on Tables 4 through 6.

The first analysis under this research question examined relationships between topics and the providers of activities within those topics. (See Table 4.) Because the variables were categorical, relationships among the providers and topics were determined using Phi correlation coefficients (ϕ). Overall, many statistically significant correlations emerged. These correlations throughout the topics indicate that providers were engaged in activities across a variety of topics. Primarily, significant phi correlations at the .001 level will be discussed in the text; however, the tables also show the statistically significant correlations at the .001, .01, and .05 levels. While the results that follow include numerous statistically significant correlations, these findings should be interpreted with caution based on the small sizes of the *n*s in several categories.

There were statistically significant correlations for the IHE STEM Faculty with *mathematics, technology, engineering*, and *content*. Similarly, there were statistically significant correlations for IHE Education Faculty with *mathematics* and *technology*, and there were significant correlations for K-12 Teachers with *content, pedagogy*, and *leadership*. IHE Administrators were significantly correlated with *science, technology,* and *engineering*. The only statistically significant correlation at the .001 level among students was between STEM Undergraduate Students with *technology* and *engineering*.

In terms of correlations among other K-12 school personnel, there were statistically significant correlations between K-12 Instructional Coordinators and Supervisors and *science, content, pedagogy* and *leadership*; and there were statistically significant correlations between K-12 District and/or School-Level Administrators/Staff and *leadership*. Interestingly, the relationship between K-12 Guidance Counselors and *engineering* was the strongest and most significant of the correlations between providers and topics (ϕ= .38, p < .001); K-12 Guidance Counselors were also significantly correlated with *technology*. With respect to non-academic professionals, Non-Academic Mathematicians were significantly correlated with *technology* and *leadership*; Non-Academic Scientists were significantly correlated with *science* and *technology*; and, Non-Academic Engineers were significantly correlated with technology.

Relationships among Providers and Levels

Our next analysis under this research question examined relationships between school levels and the providers of activities within those school levels (*elementary, middle, high*) using Phi correlation coefficients (ϕ). Several statistically significant correlations emerged in this analysis. (See Table 5.) The statistically significant correlations that existed were relatively scattered among the school levels, suggesting that the providers participated in an array of activities at different levels. A statistically significant correlation emerged, phi = .14, p < .001, between the *elementary* level and Postdoctoral Students. At the *middle* school level there were significant correlations (all *ps* =< .001) with IHE Education Faculty, K-12 District and/or School-Level Administrators/Staff, and K-12 Instructional Coordinators and Supervisors. The statistically significant correlations at the *high* school level were with IHE STEM Faculty, IHE Education Faculty, and K-12 Teachers.

Relationships among Providers and Activity Categories

The last analysis under this research question examined relationships between *activity categories* and the providers of activities within those categories, again using phi correlation coefficients (ϕ) to determine significant relationships. Several statistically significant correlations emerged. (See Table 6.) The statistically significant correlations at the .001 level for IHE STEM Faculty and IHE Education Faculty were with *Pre-Service Preparation – Developing Courses*. A statistically significant correlation (.001 level) for K-12 Teachers was with the category, *In-Service Retention Enhancement for STEM Teachers.*

Among the school personnel, K-12 District and/or School-Level Administrators/Staff and K-12 Instructional Coordinators and Supervisors were correlated (.001 level) with *In-Service Retention/Enhancement for K-12 Teachers*; in addition, K-12 Instructional Coordinators and Supervisors were correlated with *In-Service Retention Enhancement for STEM Teachers*. K-12 Guidance Counselors were statistically significantly correlated with *General Pre-Service Recruitment Activities*.

Pre-Service Undergraduate Students were statistically significantly correlated with *Pre-Service Recruitment Activities that Specifically Target STEM Students and Pre-Service Preparation – General Improvement Activities;* and STEM Undergraduate Students were correlated with *Pre-Service Recruitment Activities that Specifically Target STEM Students*. The one significant correlation with *New Policies in Pre-Service* was with IHE Administrators at the .05 level.

Discussion

The purpose of this study was to examine the breadth of IHE STEM faculty participation in pre-service and in-service mathematics and science teacher development activities in the MSP Program, and to contextualize IHE STEM faculty participation within the participation of all providers of teacher activities. Specifically, we examined the providers of different topics (e.g., science, mathematics, technology, etc.), levels (e.g., elementary, middle, and high) and teacher activity categories (e.g., new policies in pre-service, general recruitment activities, etc.). Our analysis included descriptive statistics (e.g., participation frequencies and percentages) and inferential statistics (e.g., phi correlations) to identify significant patterns of participation among 14 providers, including IHE STEM faculty. Several important findings emerged in this analysis.

Scope of Participation

The first major finding indicates that IHE STEM faculty, IHE Education faculty, and K-12 Teachers participated as providers across the breadth of *topics* and *levels* offered in the MSP Program; and additionally, IHE STEM faculty and IHE Education faculty participate as providers across the breadth of teacher *activity categories.* Overall, IHE STEM faculty were providers in the largest proportion of the teacher activities across topics, levels, and activity categories in the program. Because education faculty and K-12 teachers and leaders are frequently the providers of pre-service and in-service teacher activities, we were not surprised that they were among the top providers within the variables. We were also not surprised that IHE STEM faculty were participants in the teacher activities, since this was an explicit goal of the NSF MSP Program. What was surprising was that IHE STEM faculty, in these 34 partnerships, surpassed the other providers across all topics, levels, and activity categories overall. According to the partnerships' self-reports, they have successfully engaged the IHE STEM faculty as providers of pre-service and in-service teacher activities across all topics, levels, and activity categories in the MSP Program.

The large *numbers* of IHE STEM faculty participating in pre-service and in-service teacher activities reported previously has been shown as one positive outcome of the MSP Program (Frechtling, Miyaoka, & Silverstein, 2006; Zhang et al., 2007). According to a report by Frechtling, Miyaoka, and Silverstein (2006), IHE STEM faculty have outnumbered IHE education faculty for the past three years in the MSP Program (approximately a 2 to 1 ratio). But, while the large numbers of IHE STEM faculty engaged in the MSP Program could explain frequent participation in the teacher activities, there are two important areas that warrant further consideration: 1) the *breadth* of their participation goes beyond typical activities in which IHE STEM faculty are engaged and covers a broad, rather than a narrow, scope of teacher activities; and, 2) IHE STEM faculty are represented in a *greater proportion* of the activities *than every other provider* in almost every topic, level and activity category. This finding is tough to explain by simply saying that there are more IHE STEM faculty involved, and therefore, their involvement has a greater scope. It is an assumption to think

Providers	Activity Categories						
	In-Service Retention/Enhancement for STEM Teachers	In-Service Retention/Enhancement for K-12 Teachers	New Policies in Pre-Service	General Pre-Service Recruitment Activities	Pre-Service Recruitment Activities that Specifically Target STEM Students	Pre-Service Preparation—General Improvement Activities	Pre-Service Preparation—Developing Courses
IHE STEM Faculty	-0.13	-0.03	0.03	0.06	0.06	-0.04	0.13***
IHE Education Faculty	-0.11	0.02	0.04	-0.04	-0.14	0.10*	0.16***
IHE Administrators	-0.20	0.03	0.09*	0.07	-0.07	0.07	0.10**
Graduate Students	-0.07	0.03	-0.02	-0.03	0.03	-0.01	0.04
Postdoctoral Students	-0.06	0.02	0.04	-0.04	-0.03	0.04	0.05
STEM Undergraduate Students	-0.13	-0.09	-0.04	0.07	0.18***	0.08*	0.01
Pre-Service Undergraduate Students	-0.11	-0.13	-0.04	0.01	0.17***	0.16***	0.003
K-12 district and/or school-level Administrators/staff	0.12**	0.20***	-0.10	-0.09	-0.11	-0.06	-0.17
K-12 Teachers	0.14***	0.13**	-0.11	-0.13	-0.07	0.01	-0.15
K-12 Instructional coordinators and supervisors	0.19***	0.22***	-0.10	-0.14	-0.14	-0.09*	-0.17
K-12 Guidance	-0.01	-0.01	-0.02	0.14***	0.03	-0.05	-0.05
Counselors							
Non-academic Mathematicians	-0.02	0.07	-0.04	-0.04	-0.05	-0.05	0.06
Non-academic Scientists	0.01	0.07	-0.04	-0.02	-0.05	-0.03	-0.02
Non-Academic Engineers	-0.05	0.08*	-0.02	-0.04	-0.02	0.02	-0.03

Table 6. Phi Correlations between Providers and Activity Categories

Note. These results indicate significant positive relationships only; * $p < .05$; ** $p < .01$; *** $p < .001$

that *more* automatically equals greater scope. For example, one IHE STEM faculty member could be engaged in developing content specific courses; or ten IHE STEM faculty could be engaged in developing content specific courses. Adding more IHE STEM faculty does not necessarily broaden the scope of their activities. Therefore, the assumption that more IHE STEM faculty equates to broader coverage across all topics, levels, and activity categories must be considered, but it is not sufficient to explain the breadth of their participation in the present results.

The breadth of IHE STEM faculty participation has also been indicated by prior research. Alligood, Moyer-Packenham, and Granfield's (in press) research on 15 mathematics-focused MSPs specifically examined the work of mathematics researchers. They found that *mathematics researchers* spend less time on partnership activities than all STEM faculty, in general; however, the time they do spend is more focused on pre-service and in-service teacher activities than on the management of the partnership. In one case study, the mathematics researchers participated in a broad array of teacher activities, and they indicated that their enthusiasm for working with K-12 teachers was based on not being asked to "do education work" and on being able to maintain active research careers in their discipline.

In addition to the participation of IHE STEM faculty, the results also show participation across the breadth of the MSP Program by IHE education faculty and K-12 teachers. Prior analyses of IHE STEM and Education faculty have shown that there are over twice as many IHE STEM faculty as IHE education faculty in terms of their numbers (Frechtling, Miyaoka, & Silverstein, 2006; Zhang et al., 2007). While the IHE education faculty number half that of the IHE STEM faculty, their representation across the breadth of the MSP Program is also noteworthy. In fact, one might argue that because their numbers are much less than that of the IHE STEM faculty, their scope of participation across all teacher activities in the program is even more meritorious than that of the IHE STEM faculty.

In recent publications on the state of mathematics and science, many leaders have voiced the opinion that it is important for education faculty and STEM faculty to collaborate to design and provide more effective mathematics and science programs for K-12 schools (Drayton & Falk, 2006; Sutherland, Scanlon, & Sperring, 2005; Walters, 1993). STEM Faculty participation could influence a variety of long and short-term outcomes such as sustained high quality of K-12 teachers and high student academic achievement (Zhang et al., 2007). The present study's results suggest that the providers involved in these partnerships, both IHE STEM and Education faculty, have collaborated interdepartmentally to provide activities for K-12 teachers and IHE students.

Significant Relationships

The second set of major findings indicates that there are a number of significant relationships across the topics, levels, and activity categories. Out of 98 total phi correlations, 51 (52%) were significant for the *topics*. The high number of significant relationships shows that the providers were involved in a range of activities across topics, instead of focusing their participation in one specific area. The results indicate that mathematics, science, and engineering topics were more closely associated with IHE providers; whereas, the topics of content, pedagogy and leadership were generally more closely associated with K-12 teachers and leaders. The topic of technology cuts across boundaries and was significantly correlated for both IHE and K-12 providers.

There was a similar pattern with regards to the providers involved in the activities designed for different school levels. More specifically, out of a total of 42 different correlations, 27 (64%) were significant, again, implying that providers were involved in different activities for different school levels. The results of the correlations between providers and *school levels* show that most of the associations were strongest across the elementary school level for IHE Administrators, students (Graduate, Postdoctoral, and Pre-Service Undergraduate), and K-12 Teachers. The middle and high school levels were most associated with IHE and K-12 providers. In particular, the significant relationship at the .001 level for IHE STEM faculty with the high school level and at the .05 level with the middle school level provides insight into questions from other researchers on how IHE STEM faculty engagement may differ at different school levels (Frechtling, Miyaoka, & Silverstein, 2006).

Out of 98 total phi correlations in the analysis of the teacher *activity categories*, 37 (38%) were significant. The lower amount of significant relationships within this variable may be due to the lower number of activities within each category, making the relationships more difficult to detect statistically. Overall, the phi correlations again suggested that providers were involved in activities across the categories. As these results indicated, the associations of IHE STEM and education faculty are generally with pre-service course development at the IHE; while K-12 teachers and leaders are generally more closely associated with in-service activities for STEM and K-12 teachers. However, it is worth noting that, although many statistically significant correlations emerged, some of these relationships may have limited practical significance because the magnitude of the correlations is rather small.

Limitations

One of the greatest limitations in these data was that they were self-reported and collected in such a way that the actual number of participants in each provider category could not be matched with participation in the category. Therefore, we *could* determine whether or not a particular provider was represented as a participant in an activity, but we could not determine how many of each provider participated in the activity. Research shows that, when individuals complete a survey, they often over-report participation in project activities (Gall, Gall & Borg, 2006). The Project Investigators and Project Directors who reported on the activities of all 14 providers could have over reported the participation of any one provider. The data do not provide evidence that the STEM faculty and other providers actually engaged in the activities or to what extent they engaged in the activities. There are only partnerships' self-reports which could have been obtained by the Project Investigators and Project Directors by observing the activity of the providers or by the self-reports of the providers to the Project Investigators and Project Directors. Another limitation was that there was no outcome variable (e.g., impact of STEM instruction on teachers' classroom practices, impact of recruiting activities on student matriculation, academic achievement of students) to determine the impact of the providers on the pre-service and in-service teachers who participated in the activities. Therefore, a subjective approach is required when interpreting these results. However, based on the findings of the present analysis, further examinations could delve more deeply into inquiries focused on the extent of involvement in activities by IHE STEM faculty, connections between the activities provided for teachers and changes in their classroom practices, and connections between teachers' classroom practices and student learning.

Conclusion

The present study extends prior research by going beyond descriptive information on the numbers of IHE providers, to contextualize and interpret the breadth of participation of *all* providers (including IHE faculty and K-12 school personnel) of pre-service and in-service teacher development activities. While prior research indicated that IHE STEM faculty were well represented in the MSP Program, our analysis sought to determine if that representation reflected a breadth of participation in teacher activities, or if IHE STEM faculty participation was limited narrowly to a few activities, such as teaching content-specific courses for teachers.

As the results indicated, IHE STEM faculty, IHE Education faculty, and K-12 Teachers provided pre-service and in-service teacher activities across a broad scope of topics, school levels, and activity categories. The literature suggests that school-university partnerships are an effective way of addressing a variety of issues in education (Fisler & Firestone, 2006; Gut et al., 2003; Kersh & Masztal, 1998), particularly improvement in mathematics and science (Drayton & Falk, 2006; Sutherland et al., 2005; Walters, 1993). Recent calls for reform of mathematics and science teacher preparation have increased the focus on the potential role for STEM faculty in addressing those issues and influencing positive change. Further, funding opportunities have encouraged the participation of STEM faculty and other STEM professionals in work with K-12 education. Because K-12 education work is not a typical responsibility for IHE STEM faculty, it is unlikely that large numbers of STEM faculty will initiate these types of relationships without some type of incentive for their own academic work. Research suggests that partnerships between scientists and mathematicians and K-12 teachers can have benefits for teachers, in terms of increasing their content knowledge; and, they can benefit mathematicians and scientists by providing opportunities for them to learn new instructional techniques and develop a greater understanding of K-12 education. Perhaps these, and other, reasons are the underlying impetus for the broad scope of participation by the three providers most common among our results.

One goal of the NSF MSP Program was to encourage the participation of IHE STEM faculty in K-12 mathematics and science education activities for pre-service and in-service teachers. In fact, without this outcome, partnerships would not have met an important goal of the MSP Program. As these results indicate, not only were the IHE STEM faculty participants, but the breadth of their participation surpassed the other providers across a diversity of all topics, levels, and activity categories. Because the present results show the extensive scope of IHE STEM faculty participation, this can be viewed as a positive finding that reflects well on the partnerships in the NSF MSP Program.

Further study may reveal the long term effects of IHE STEM faculty participation on the pre-service and in-service teachers in the program. Outcome variables could produce findings that connect the work of IHE STEM faculty with teacher performance and achievement results for students in K-12 schools. For example, now that the program has achieved the goal of engaging the IHE STEM faculty in a broad array of teacher activities, what will be the impact on teachers' classroom practices and K-12 student achievement? This question, and many others on the work of the IHE STEM faculty with K-12 teachers, warrants further study.

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Appendix A

Program Goals of the National Science Foundation Math and Science Partnership Program

The National Science Foundation Math and Science Partnerships program has the following broad goals:

MSP serves students and educators by emphasizing strong partnerships that tackle local needs and build grassroots support to:

- Enhance schools' capacity to provide challenging curricula for all students and encourage more students to succeed in advanced courses in mathematics and the sciences;
- Increase the number, quality and diversity of mathematics and science teachers, especially in underserved areas;
- Engage and support scientists, mathematicians, and engineers at local universities and local industries to work with K-12 educators and students;
- Contribute to a greater understanding of how students effectively learn mathematics and science and how teacher preparation and professional development can be improved; and
- Promote institutional and organizational change in education systems – from kindergarten through graduate school – to sustain partnerships' promising practices and policies (National Science Foundation, 2007).

SOURCE: National Science Foundation (2007a).

Appendix B

Categories of the Activities on the MIS Annual Survey for Partnership Projects

1. *New Policies in Pre-Service*
   a. **Establish/provide alternative certification programs** (e.g., to encourage STEM undergraduates/career changes to pursue educational careers)
   b. **Establish and/or revise course articulation agreements between 4 year institutions and community colleges** (e.g., common course numbering to ease the 2 year to 4 year institution transfer)
2. *In-Service Retention/Enhancement for STEM Teachers*
   a. **Provide group induction supports for new STEM teachers** (e.g., a highly structured and sustained group induction process to support beginning teachers)
   b. **Provide a peer coaching network for STEM teachers** (e.g., emphasis upon experienced and veteran teachers, as well as beginning teachers)
   c. **Provide individual supports for STEM teachers** (e.g., provide a mentor for each beginning STEM teacher; IHE faculty "on-call" for classroom teachers, discipline-based e-mentoring)
   d. **Establish/provide STEM study groups** (e.g., lesson study groups; discipline dialogues)
3. *In-Service Retention/Enhancement for K-12 Teachers*
   a. **Conduct workshops/institutes/courses with K-12 teachers that increase <u>general</u> content and/or pedagogical knowledge** (e.g., summer science institutes; workshops on cognitive science and its impact on instruction; weekend professional development seminars)
   b. **Conduct <u>targeted</u> workshops/institutes/courses with K-12 teachers** (e.g., conduct a summer science institute that is specifically linked to the curriculum/text used at partner schools)
   c. **Design/offer STEM content courses specifically for elementary/middle/high school teacher certification programs**
   d. **Provide administrative supports for K-12 teachers** (e.g., release time for profession development; substitute teacher support; financial support for professional meetings; scheduling aid for special projects/field trips)
   e. **Provide instructional materials for K-12 teachers**
   f. **Provide externship opportunities for K-12 teachers** (e.g., teachers spend a year, semester, or summer working with a MSP business/industry partner related to their discipline)
   g. **Establish/provide adjunct position for K-12 master teachers at the partner IHEs**
4. *General Pre-Service Recruitment Activities*
   a. **Provide scholarships to undergraduate students** (e.g., to encourage STEM and minority undergraduates to pursue educational careers)
   b. **Conduct presentations at career fairs** (e.g., to encourage high school students, community college students, or career changes to consider educational careers)
   c. **Create/provide informative materials for potential STEM teaching candidates** (e.g., promotional video, promotional brochure)
   d. **Establish a regional plan for recruiting pre-service students that encompasses multiple MSP partners** (e.g., coordinate regional participation in recruitment)

5. *Pre-Service Recruitment Activities that Specifically Target STEM Students*
    a. **Create/provide teaching assistant positions for STEM undergraduate/graduate students** (e.g., to allow STEM undergraduate to experience formal instruction and to encourage teaching as a career)
    b. **Create/provide opportunities for STEM undergraduate/graduate students to tutor K-20 students** (e.g., undergraduate peer tutoring; tutoring in K-12 schools to allow STEM undergraduates to experience formal instruction and to encourage teaching as a career)
    c. **Invite STEM undergraduate/graduate students to help at (or participate in) K-12 special events** (e.g., Inven tion Conventions; Lego Logo Fairs; Science Nights) \
6. *Pre-Service Preparation—Developing Courses*
    a. **Develop/revise pre-service courses to align with national and/or state standards**
    b. **Develop/revise pre-service course content to align with local school district curricula**
    c. **Design/offer pre-service STEM content courses specifically for elementary/middle/high school teacher certification programs**
7. *Pre-Service Preparation—General Improvement Activities*
    a. **Provide opportunities for pre-service students to gain experience in K-12 classroom settings before formal student teaching** (e.g., an internship experience; teaching at a summer STEM camp; shadowing; tutoring)
    b. **Involve K-12 master teachers in pre-service program** (e.g., co-teach a pre-service course as an adjunct along side education faculty; co-teach a pre-service course with STEM faculty)
    c. **Invite pre-service students to take part in local school district in-service activities** (e.g., in-service summer institutes or ongoing LEA profession development)
    d. **Mentor pre-service students**

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