Representations of Teacher Quality, Quantity, and Diversity in a National Mathematics and Science Program

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Abstract
Growing awareness of the importance of teacher quality in mathematics and science has stimulated a variety of national reports and funded initiatives for the purpose of improving teaching and learning in K-12 schools. This study examined the work of awardees in one federally-funded program that included a focus on increasing the number, quality, and diversity of mathematics and science teachers. Secondary data sources were used to understand representations of mathematics and science teacher quality, quantity, and diversity reported by awardees, and to identify interventions awardees implemented to influence teacher quality, quantity, and diversity. Results indicated a primary focus on the development of teacher characteristics such as subject knowledge, pedagogical knowledge, and instructional practices. Seven common interventions were implemented across the program to influence the quality of individual teachers and the quantity and diversity of the teacher population. Three prevalent themes in the secondary documents included: a) awardees' knowledge of and implementation of research-based professional development practices; b) a shift in emphasis to include specialized subject knowledge preparation for elementary teachers, in addition to the traditional emphasis on subject knowledge for middle and high school teachers; and c) involvement of STEM faculty and Teacher Leaders in various collaborative relationships, in activities at all levels (K-12) and in both mathematics and

science. Intervention efforts to influence teacher quantity and diversity were in their initial stages and limited in scope. These findings are discussed with reference to the impact of the program on the quality, quantity, and diversity of mathematics and science teachers.

Introduction

Teacher quality in mathematics and science has a significant impact on the teaching and learning process (Ferrini-Mundy & Schmidt, 2005; Hiebert et al., 2003; Lindquist, 2001; Silver & Kenney, 2000). As policy, such as the No Child Left Behind Act of 2001 (NCLB, 2002) and research, including the TIMSS international comparisons of student performance (Hiebert et al., 2003), converge around mathematics and science issues, it is clear that the importance of teacher quality in these content-specific areas is of national significance. Although the quality of mathematics and science teachers has gained national prominence in policy statements and educational reform efforts (Conference Board of the Mathematical Sciences, 2001; Council of Scientific Society Presidents, 2004; National Council of Teachers of Mathematics, 1991, 2005; National Research Council, 1996; National Science Teachers Association's, 2002, 2004), understanding the meaning of teacher quality is a complex issue.

Teacher quality includes not only the characteristics of individual teachers, but also the characteristics of the teacher population as a whole. When we refer to improving a teacher's subject-specific knowledge in a discipline such as mathematics or science, we are referring to the quality of individual teachers. When we refer to the examination of teacher turnover or teacher shortages in subject-specific areas or to the importance of a diverse teaching force, we are referring to the quality of the teacher population. Teacher quality, then, is a complex construct encompassing an array of different characteristics that are not easily defined, assessed, categorized, or measured.

In July 1999, U.S. Secretary of Education Richard Riley announced the appointment of the National Commission on Mathematics and Science Teaching for the 21st Century (the Glenn Commission) to investigate the quality of mathematics and science teaching and examine ways to increase the number and quality of mathematics and science teachers in K-12 schools. The resulting report, *Before It's Too Late* (National Commission on Mathematics and Science Teaching for the 21st Century, 2000), highlighted the importance of quality education in mathematics and science to prepare students to be competitive in an increasingly global society. This focus on teacher quality in mathematics and science has resulted in several national initiatives funded by the federal government, under the direction of agencies such as the National Science Foundation (NSF) and the Department of Education, to initiate *Math and Science Partnership Programs* for the purpose of improving mathematics and science teaching and learning in K-12 schools. The goals of the NSFs Math and Science Partnership (MSP) Program are stated as follows:

> 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).

The present study was designed to examine more closely the implementation of one of these goals; namely, the way in which awardees in the MSP Program "increase the number, quality and diversity of mathematics and science teachers…" (item #2). Our investigation focused on three major constructs: the quality of individual mathematics and science teachers, the quantity of mathematics and science teachers in the teacher population, and the diversity of mathematics and science teachers in the teacher population; and examined these constructs along two dimensions: representations and interventions. In the sections that follow we review the literature on teacher quality, quantity, and diversity; present findings based on secondary source documents provided by MSP Program awardees that illuminate their *representations* of teacher quality, quantity, and diversity within their work; and discuss the *interventions* identified by awardees to influence quality, quantity, and diversity specifically for mathematics and science teachers. These findings lead to a discussion of the implications of awardees' work on teacher quality, quantity, and diversity for mathematics and science education.

Research on Teacher Quality, Quantity, and Diversity

To establish a background against which to examine representations of teacher quality, we used Bolyard and Moyer-Packenham's (in press) review identifying six characteristics of mathematics and science teachers commonly examined for their relationship to student outcomes. These six commonly used characteristics included: 1) general ability, 2) experience, 3) pedagogical knowledge, 4) subject knowledge, 5) certification status, and 6) teacher behaviors, practices, and beliefs. We also used characteristics in the literature related to the teacher population. These characteristics included: attrition, migration, and retention (for teacher quantity) (Ingersoll, 2006a; Ingersoll, 2006b; Johnson, Berg, & Donaldson, 2005); and the demographic composition of the teaching force, the importance of having a diverse teaching force, and methods and strategies for improving teacher diversity (for teacher diversity) (Clewell & Villegas, 1998; Dandy, 1998; Darling-Hammond, Dilworth, & Bullmaster, 1996; Holloway, 2002; Jorgenson, 2001; Loving & Marshall, 1997; Newby, Swift, & Newby, 2000; Shen, Wegenke, & Cooley, 2003; Torres, Santos, Peck, & Cortes, 2004). Among these characteristics are variables gathered through assessment measures (i.e., responses to test items or teaching performance during an observation) and nonassessment measures (i.e., highest degree obtained or number of years of teaching experience) (American Statistical Association, 2007).

Teacher Quality: Characteristics of Individual Mathematics and Science Teachers

Subject knowledge is considered by many to be an important characteristic of mathematics and science teachers. Research indicates links between teachers' subject matter preparation and teacher effectiveness (Darling-Hammond, 2000; Darling-Hammond & Youngs, 2002; Rice, 2003; Wilson & Floden, 2003; Wilson, Floden, & Ferrini-Mundy, 2001), with the most consistent results showing positive links between teachers' mathematics knowledge and secondary students' mathematics achievement (Wilson & Floden, 2003). Goldhaber and Brewer (1997a; 1997b) found that teachers holding bachelor's or master's degrees in mathematics had a statistically-significant positive relationship to high school students' mathematics achievement (compared to teachers without advanced degrees or out-of-subject degrees). In science, they found holding a bachelor's degree in science (rather than having no degree or a BA in another subject) to have a statistically positive relationship with student achievement (Goldhaber & Brewer, 1997a). A later study found similar positive results for teachers having a mathematics BA or MA on secondary students' mathematics achievement, but no significant relationship between a science degree and secondary students' science achievement (Goldhaber & Brewer, 2000). Studies of the relationship between the number of courses taken in the subject and student achievement have found generally positive results for mathematics (Chaney, 1995; Monk, 1994). In science, results are generally positive but depend upon the area of science studied (e.g., physical, earth, or life sciences) (Chaney, 1995; Druva & Anderson, 1983; Monk & King, 1994).

Studies of mathematics and science teachers' *pedagogical knowledge* have reported positive effects of education training on teachers' knowledge and practices (for example, see Adams & Krockover, 1997; Gess-Newsome & Lederman, 1993; Valli & Agostinelli, 1993). Studies examining the relationship between degrees in education as a measure of teachers' pedagogical knowledge and student outcomes have been mixed. At the secondary level, studies indicate that coursework taken in subject-specific pedagogy is positively related to secondary students' achievement, particularly in mathematics (Chaney, 1995; Monk, 1994). Wilson and Floden (2003) note that much of the research focuses on teacher education programs rather than specific courses or experiences.

Research also examines the relationship between *teachers' behaviors, practices, and beliefs* and student outcomes. Peterson, Fennema, Carpenter, and Loef (1989) found a significant relationship between first-grade teachers' pedagogical content beliefs about addition and subtraction and student achievement. In science, the use of hands-on laboratories (Burkam, Lee, &

Smerdon, 1997) and inquiry-based teaching practices (Von Secker, 2002) were significantly related to secondary students' science achievement. Other studies show associations between characteristics of high school science teachers and better classroom discipline (Druva & Anderson; 1983), and kindergarten teachers' instructional practices and student gains in mathematics (Guarino, Hamilton, Lockwood, & Rathbun, 2006).

Mathematics and science teachers' *certification status* is frequently used as a measure of the effects of knowledge gained from teacher preparation (Darling-Hammond, Berry, & Thoreson, 2001). Researchers compare those who are fully certified and those who hold provisional or emergency certification (Evertson, Hawley, & Zlotnik, 1985; Fetler, 1999; Goe, 2002; Goldhaber & Brewer, 2000). Several studies indicate an advantage in favor of fully certified teachers on measures of student achievement and teacher performance evaluations (Darling-Hammond, 2000; Evertson, Hawley, & Zlotnik, 1985; Fetler, 1999). Mathematics student achievement has also been found to be positively associated with having a teacher who is certified in-field (Hawk, Coble, & Swanson, 1985; Goldhaber & Brewer, 1997a, 1997b). Several studies show no significant differences or mixed results when comparing the teaching performances of regularly versus alternatively certified teachers on subject area and professional knowledge tests (Hawk & Schmidt, 1989), performance ratings (Hawk & Schmidt, 1989; Lutz & Hutton, 1989; Sandlin, Young, & Karge, 1992), teaching concerns surveys (Houston, Marshall, & McDavid, 1993; Sandlin et al., 1992), and teacher observations and student achievement (Miller, McKenna, & McKenna, 1998).

Researchers frequently investigate years of teaching *experience* as a teacher quality characteristic with several studies reporting positive relationships between teachers' years of experience and effectiveness (Ehrenberg & Brewer, 1995; Ferguson, 1991; Fetler, 1999; Goldhaber & Brewer, 1997b; Greenwald, Hedges, & Laine, 1996; Hanushek, 1992, 1996; Murnane & Phillips, 1981). Hawkins, Stancavage, and Dossey (1998) found statistically-significant associations between teacher experience and 4^{th}- and 8^{th}-grade students' mathematics achievement. Rivkin, Hanushek, and Kain (2005) found students of beginning teachers performing significantly worse than those of experienced teachers in mathematics. In science, Druva and Anderson's (1983) meta-analysis of 65 studies found student outcomes in science positively related to teachers' experience. However the relationship was not particularly strong. Other studies examining the relationship between teacher experience and student achievement have reported mixed or no results (Ferguson & Ladd, 1996; Hill, Rowan, & Ball, 2005; Rowan, Correnti, & Miller, 2002).

General ability refers to teachers' general intellectual academic and verbal abilities, often including evidence of language and mathematical proficiency. Studies generally report a positive relationship between measures of teachers' general and verbal abilities and their effectiveness (Ehrenberg & Brewer, 1994; Ferguson, 1991; Ferguson & Ladd 1996; Greenwald, Hedges, & Laine, 1996; Hanushek, 1971; Strauss & Sawyer 1986). Other studies indicate mixed or negative results (Ehrenberg & Brewer, 1995; Guyton & Farokhi, 1987; Hanushek, 1992; Murnane & Phillips, 1981).

Teacher Quantity: Turnover and Retention of Mathematics and Science Teachers

The entry and exit of teachers into and out of the profession has been characterized as a "revolving door." Ingersoll (2001) argues that this situation is not a result of shortages of teachers or teacher retirements, but rather *teacher turnover*, defined as departure of teachers from their teaching jobs. Statistics indicate that the current teaching force will lose almost half of its professionals in the next few years and one in five new teachers will not remain in teaching long enough to reach their fourth year (Johnson & Birkeland, 2003).

Two important elements of teacher turnover are *teacher attrition* (leaving the profession) and *teacher migration* (moving from one school to another) (Johnson et al., 2005). When schools report a *shortage* of mathematics and science teachers, they are often referring to both of these elements. Over time, research has shown that about 15 percent of America's 3 million teachers leave their schools or leave teaching each year, and after 5 years, 46 percent of teachers leave the teaching profession (Ingersoll, 2006a; 2006b). These numbers are even more startling for new teachers, who leave at a rate of almost 50 percent after four years, and for teachers in small, urban, poor schools, where the turnover rates are 26 percent each year.

Schools searching for mathematics and science teachers already know how difficult it is to find replacements with annual turnover rates for mathematics and science teachers at about 16 percent and 15 percent respectively, compared to 9 percent for social studies and 12 percent for

English (Ingersoll, 2006b). A closer examination of turnover for mathematics and science teachers shows that reasons for leaving teaching include pursuing other jobs (28%) and retiring (11%). While 40 percent of mathematics and science teachers who leave do so because of dissatisfaction, only 29 percent of all teachers in the general population report leaving teaching because of dissatisfaction. For mathematics and science teachers, dissatisfaction most frequently includes poor salary, poor administrative support, poor student motivation, and student discipline problems (Ingersoll, 2006a). Recruiting more and more teachers will not address these problems. Schools must design induction and retention plans that take into account school working conditions if they want their mathematics and science teachers to stay in teaching.

Research on teacher induction shows that when a first-year teacher has a full induction experience (including collaboration with a mentor in the same subject field, teacher networking and beginners seminars with other new teachers, reducing new teachers' course preparations, providing a teacher's aide, face time with school administrators, regularly scheduled common planning and release time for the mentor and new teacher to observe and analyze teaching), there is a statistically significant impact on the retention of that teacher (Smith & Ingersoll, 2004). Unfortunately only one percent of new teachers receive this type of comprehensive support (Smith & Ingersoll, 2004).

High teacher turnover in mathematics and science has many costs. Research shows that teacher turnover increases the variation in student outcomes across grades and cohorts in a school, with differences in mathematics achievement significantly related to teacher turnover (Rivkin et al., 2005). Unfortunately for students, the highest turnover rates are in the poorest schools where mathematics and science teachers are needed most (Neild, Useem, Travers, & Lesnick, 2003). There are also financial costs to schools in recruiting, hiring, induction, and professional development (Texas Center for Educational Research, 2000). A 2000 study found that schools in Texas spend over $329 million dollars each year as a result of a 15.5 percent teacher turnover rate. Other estimates report that, across the Nation, $2.6 billion is lost annually because of teacher turnover (Alliance for Excellent Education, 2004).

Diversity of the Teaching Force

The student population in America's schools is increasing in diversity in terms of race and ethnicity; however, the diversity of the teacher population has not followed this trend (Dandy, 1998; Newby et al., 2000; Shen et al., 2003; Torres et al., 2004). Data from a nationally representative sample of public school teachers indicates that schools have made slight increases in the racial and ethnic diversity of the teaching force in the years between 1987-1988 and 1999-2000; however, during this time, the number of male teachers decreased (Shen et al., 2003). Although there are increases in the numbers of diverse teachers in the new teacher population, retention of new teachers could prevent these gains from impacting the diversity of the teaching population over time (Darling-Hammond et al., 1996; Kirby, Berends, & Naftel, 1999; Shen et al., 2003).

Barriers to increasing diversity in the teaching force include too few minority students prepared for post-secondary education as a result of inadequate K-12 education, small numbers of minority students enrolling in teacher education programs, and financial and economic considerations (Clewell & Villegas, 1998). Another barrier cited is competency testing (either as part of the requirements for a teacher education program or for licensure) for which research indicates higher failure rates for minority students than for White students (Darling-Hammond et al., 1996; Kirby et al., 1999; Latham, Gitomer, & Zimonek, 1999). While there is some evidence to indicate that testing requirements negatively impact the diversity of the teaching force, there is also evidence that they are not the source of the problem, as the majority (81%) of the overall population of teacher candidates taking the tests is white (Latham et al., 1999).

The importance of a diverse teaching force. The importance of increasing the diversity of the teaching force is described as necessary in order to reduce gaps in achievement between white and nonwhite students (Darling-Hammond et al., 1996). Arguments focus on the need and importance of role models and teachers who can relate to students' backgrounds and experiences (Loving & Marshall, 1997; Riley, 1998). The pedagogical benefits of a diverse teaching force include the advantages teachers of color may have in successfully building relationships and relating to students from minority groups by using their personal experiences to connect with learners (Clewell & Villegas, 1998; Darling-Hammond et al., 1996). There are a limited number of large-scale studies on the relationship between same-race teachers and minority (and general) student achievement (Torres et al., 2004). Results indicate mixed evidence for a direct correlation between teacher diversity and student academic performance (Ehrenberg, Goldhaber, & Brewer, 1995).

Strategies that impact teacher diversity. There are several recommendations to improve minority teacher recruitment and retention. These include: improving the K-12 educational experiences of minority students; early identification of potential future teachers; recruitment of teacher education candidates at the community and junior college levels; implementation of programs that support minority teacher candidates throughout the education, initial certification, and induction processes (including mentoring programs); recruitment of candidates from non-traditional populations (second-careers or paraeducators); and recruitment of candidates from liberal arts majors and undergraduates having no declared major (Clewell & Villegas, 1998; Darling-Hammond et al., 1996; Holloway, 2002; Jorgenson, 2001; Loving & Marshall, 1997; Newby et al., 2000). Early identification programs expose qualified high school or middle school students to teaching through cadet or tutoring programs. These efforts raise awareness of and interest in teaching as a profession and support and encourage students to prepare for and enter the profession (Loving & Marshall, 1997; Newby et al., 2000). Programs designed to encourage para-educators to become teachers have been found to play a role in diversifying the teaching force (Haselkorn & Fideler, 1996), and there is evidence that these programs have higher retention rates than many traditional teacher education programs (Dandy, 1998; Haselkorn & Fideler, 1996).

Other studies indicate that alternative certification programs may serve as a source for recruiting minority teachers (Kirby et al., 1999; Shen, 1998). Findings of one study indicate that alternatively-certified teachers are more likely to be female, be teaching in elementary schools, and express less desire to continue teaching in the long term (Shen, 1998). Therefore, while alternative certification might contribute to diversity in terms of race and ethnicity, it does not in terms of gender (Shen, 1998). Shen (1998) further found that while alternatively certified teachers are more likely to teach mathematics and science, alternatively certified minority teachers are less likely to hold a bachelor's in mathematics, science, or engineering than alternatively certified white teachers.

As our review of the research on teacher quality, quantity, and diversity indicates, several characteristics of individual teachers and of the teacher population are influential in the relationships between mathematics and science teachers and the students they teach. The purpose of the present study was to examine data from the National Science Foundation's Math and Science Partnership (NSF-MSP) Program in an effort to determine how awardees in the program represented characteristics of teacher quality, quantity, and diversity, and what interventions awardees implemented to influence those characteristics within their awards. The following research questions guided this analysis: a) What are *representations* of mathematics and science teacher quality, quantity, and diversity among awardees in the MSP Program? and b) What *interventions* do awardees implement to influence teacher quality, quantity, and diversity characteristics within their awards?

Methods

Data Sources

The data sources in this study came from funded partnerships in the National Science Foundation's Math and Science Partnership (NSF-MSP) Program awarded between FY2002 and FY2004. The NSF describes the following four components of the MSP Program:

- Comprehensive Partnerships implement change across the K-12 continuum in mathematics, science, or both.
- Targeted Partnerships focus on improved student achievement in a narrower grade range or disciplinary focus in mathematics and/or science.
- Institute Partnerships develop mathematics and science teachers as school- and district-based intellectual leaders and master teachers.
- Research, Evaluation, and Technical Assistance (RETA) activities assist partnership awardees in the implementation and evaluation of their work (National Science Foundation, 2007).

The present study examined data from 48 awards in three of these categories, including: 12 Comprehensive Partnerships, 28 Targeted Partnerships, and 8 Institute Partnerships. RETA awards were not included in the analysis due to the nature and scope of their work in "assisting" the other award categories.

Each partnership was required to address the quality of the mathematics and science teaching force and to document its progress towards the teacher quality goals and benchmarks it established. Awardees submitted Annual and Evaluation Reports describing this progress, and posted papers, presentations, and webpages in electronic media forms. These secondary documents were the primary source of data for the analysis. In the present analysis, researchers reviewed 132 Annual and Evaluation Reports provided to the NSF, with the length of each report ranging from 15 to 707 pages. These reports, along with awardees websites, published papers, and presentations, were the secondary source documents for the analysis. Data reviewed for this paper were obtained from documents available to researchers between January 2005 and February 2006.

Procedures

The examination was conducted using qualitative methods for a document analysis of secondary data sources (Miles & Huberman, 1994; Patton, 1990) and was used to identify awardees' narrative descriptions of characteristics and interventions influencing mathematics and science teacher quality, quantity, and diversity (Bogdan & Biklen, 1998). The methods of analysis employed both a content analysis, using a categorical system for organizing the information (Fraenkel & Wallen, 1993), and a concept analysis, to understand the meaning and usage of terms (McMillan & Wergin, 2002). The unit of analysis was the individual award. Because of the complex nature of awardees' reports, the research team used hand coding (rather than electronic software) to better preserve the context and content of the information contained in the reports. A team of six readers conducted the analysis, and 30 percent of the documents were read by two different readers to ensure reliability. Awardees' reports to the NSF were available to researchers in an electronic format that was password protected. Project websites, publications, and conference papers were generally available through internet access.

Three-Phase Analysis

Researchers analyzed data sources in three phases. During the first phase, researchers identified broad themes to guide the initial reading of the reports, based on reviews of the literature. Additional themes and sub-themes emerged during the readings. During this phase, researchers read through reports in their entirety and searched awardees' websites, publications, and conference presentations for supporting information. Readers used an analytic protocol to code information and write summaries. The protocol included a table for documenting the presence of themes, a section for writing detailed summaries, and a reference section to record page numbers and appendices from which the information was extracted so researchers could return to the documents to review information in its original context. Researchers met weekly to cross check themes and compare coded categories.

There were several challenges in organizing the large volume of report data: some awardees included extensive information about activities in comparison with other awardees that included little information; information was scattered in numerous places throughout reports, which required extensive reading to connect common themes; and, information was sometimes presented in a way that was unclear to a reader outside the award, using terms such as "the faculty," "the teachers," or "the school," without specifically identifying the faculty, teachers, or school to which the description was referring. Researchers cross-referenced different sources to piece together information.

During the second phase of the analysis, two Ph.D.-level researchers read and coded all of the written summaries, using open and axial coding to examine themes and define categories (Strauss & Corbin, 1998). The main purpose of axial coding was to gain a better understanding of the categories by identifying properties and dimensions around their "axis." Researchers focused on an individual theme, such as Teacher Leadership, and read all of the written summaries on that theme using a constant comparative method (Strauss, 1987). During this process, researchers determined major categories and sub-categories, wrote descriptions of the categories, and extracted examples from the reports.

During the third phase of the analysis, researchers used the categories in a key-word search process through the reports for the purpose of categorical aggregation (Stake, 1995). Using the search tool on Adobe Acrobat Reader, researchers used a variety of key words to conduct exhaustive searches for information on the properties of the categories. By the end of the third phase, researchers created documents with lists of examples from awardees' reports for each category related to teacher quality, quantity, and diversity, and compiled a list of frequencies across the 48 awards.

In an effort to synthesize the narrative results for presentation, researchers developed a categorical organization framework for ease of comparing the prominence of major themes among the representations and interventions identified by awardees. This framework uses the following categories: Category 3 (C3) = representations and interventions discussed and identified by 70 - 100% of the 48 awardees; Category 2 (C2) = identified by 40 - 69% of the 48 awardees; Category 1 (C1) = identified by 10 - 39% of the 48 awardees; and Category 0 (C0) = identified by 0 - 9% of the 48 awardees. These categories were determined by grouping the frequencies of representations and interventions, and first removing the bottom 0 - 9% (or 0 to 4 awards) in each grouping. When occurrences were reported in 0 - 9% of the awards, these occurrences were determined to be a rare or unique activity among the awards in the program (C0). The next sets of occurrences were sectioned into thirds. In the lowest third of occurrences were those items that were reported in 10 - 39% of the awards (or 5 - 18 awards, C1). In the middle third of occurrences were those items that were reported in 40 - 69% of the awards (or 19 - 33 awards, C2). In the top third of occurrences were those items that were reported most frequently across the awards in the program by 70 - 100% of awards (or 34 - 48 awards, C3). These categories were assigned to give the reader a sense of the portion of awards reporting each theme across the entire MSP Program. Throughout the results, this categorization is used to identify the most common representations and interventions of teacher quality, quantity, and diversity that are part of the work of the awardees in the MSP Program.

Results

Researchers identified a variety of major themes of teacher quality that centered on characteristics of individual teachers, characteristics of the teacher population, and interventions reported as influences on teacher characteristics. The framework in Figure 1 represents a general organization of these themes from the reports. All of the 48 awards provided descriptive information on increasing the quality of individual mathematics and science teachers and on increasing teacher quantity. Fewer awards provided descriptive information on increasing teacher diversity.

The results are organized around two major themes that address our research questions: 1) what awardees identify as *representations* of mathematics and science teacher quality, quantity, and diversity, and 2) *interventions* awardees implement to influence teacher characteristics. The first section of the results reports representations of teacher quality, quantity, and diversity identified by awardees. The second section discusses interventions awardees implemented to influence teacher characteristics. Examples from awardees' documents are presented to provide a context for the themes. The categories (i.e., C3, C2, C1, and C0) shown in parentheses are used as a way to group and identify the frequency of given representations and interventions. These themes, along with their examples, provide insights into the substance of awardees' work in the MSP Program.

Figure 1
Major Themes in Awardees' Documents

REPRESENTATIONS
of Teacher Quality

Individual Characteristics	Population Characteristics
Subject Knowledge	Quantity (numbers of teachers)
Pedagogical Knowledge	Diversity (race/ethnicity)
Behaviors/Practices/Beliefs	

↑ ↑ ↑ ↑

INTERVENTIONS
Influencing Teacher Quality Characteristics

Inservice Training/Prof. Development	Preservice Training
Teacher Leadership	Linking Teachers with STEM Faculty
Recruiting	Stipends/Compensation
Induction	

Representations

Awardees described various representations of teacher quality, quantity, and diversity. Representations of the quality of individual teachers frequently described by awardees included: subject knowledge, pedagogical knowledge, and behaviors, practices, and beliefs. Representations of the quantity and diversity of teachers included: numbers of teachers and race/ethnicity, respectively. These results are summarized in Table 1.

Table 1
Frequency of Representations Reported by Awardees that Characterize Teacher Quality, Quantity, and Diversity

Constructs	Representations	Frequency
Teacher Quality		
	Subject Knowledge	C3
	Test Scores	C2
	Certification, Degrees, Courses	C2
	Pedagogical Knowledge	C3
	Surveys	C2
	Observations	C2
	Certification, Degrees	C2
	Behaviors, Practices, Beliefs	C3
	Surveys	C2
	Observations	C2
	Teacher Experience	C2
Teacher Quantity		
	MSP Award Quantity	C3
	Teachers Recruited/Participation	C3
	Hours/Days Teacher Training	C2
	Teachers Retained	C1
	University-Level Quantity	C2
	Preservice Enrollment	C2
	Program Completion	C1
	School-Level Quantity	C2
	Teacher Mobility	C2
	Teachers Retained	C1
	Teachers Hired	C1
Teacher Diversity		
	Demographic Data/Race and Ethnicity	C2
	Minorities Recruited	C1
	Minorities Receiving Scholarships	C1

Note: *N* = 48 awards. C3 = representations identified by 70 - 100% of the 48 awards; C2 = representations identified by 40 - 69% of awards; C1 = representations identified by 10 - 39% of awards; and C0 = representations identified by 0 - 9% of awards.

Representations that characterized teacher quality. Awardees reported various representations to characterize the quality of individual teachers.

Essentially these representations were a way for awardees to operationalize teacher quality characteristics within their award activities. Subject knowledge (C3), pedagogical knowledge (C3), and behaviors, practices, and beliefs (C3) were identified most frequently among awardees as characteristics of individual teacher quality. Awardees use of representations for teachers' subject knowledge, pedagogical knowledge, and behaviors, practices, and beliefs was consistent with the research literature on characteristics of teacher quality. A lesser number of awardees discussed teacher experience (C2) and general ability (C1) as a representation of teacher quality. This is a divergence from the research literature where teacher experience and general ability are frequently used as representations of teacher quality.

We further unpacked subject knowledge, pedagogical knowledge, and behaviors, practices, and beliefs to determine what represented these constructs for awardees. In terms of subject knowledge, the most common representation was a score on a test of mathematics or science subject knowledge (C2). Tests included standardized tests, tests developed by awardees themselves, or tests developed by Research Evaluation and Technical Assistance (RETA) awards in the MSP Program. Another common representation of a teachers' subject knowledge was the teacher's subject preparation, including subject-specific certification, degrees, and courses taken in mathematics or science content (C2).

In terms of pedagogical knowledge, the representations reported by awardees differed from subject knowledge in type and frequency. The most frequently-used representations of pedagogical knowledge reported by awardees were responses on surveys, observations of teaching, and teachers' certification or degree (all designated as C2). Surveys and observations documented teachers' knowledge of state and national standards, use of standards-based curricula, and use of reform-oriented teaching methods and materials. Unlike subject knowledge, where scores on tests were a frequently used representation of teacher knowledge (C2), scores on tests were one of the least likely representations of pedagogical knowledge (C0). A discussion of the specific instruments used by awardees to assess teacher knowledge is presented in another publication of the MSP Program Evaluation (MSP-PE) (Moyer-Packenham, Bolyard, Kitsantas, & Oh, in press).

The most common representations of mathematics and science teachers' behaviors, practices and beliefs were responses on a survey and behavioral observations (both C2). Surveys and observation protocols were designed to document changes in teachers' beliefs and classroom practices. Other representations of teachers' behaviors, practices, and beliefs that were described with less frequency included responses to interview questions and written documents (both C1).

Representations that characterized teacher quantity. All of the awards reported some form of information on teacher quantity. Awardees represented teacher quantity in three main sub-categories: *MSP Award Quantity*, *University-Level Quantity*, and *School-Level Quantity*. MSP Award Quantity included data collected on participants in MSP Award activities; University-Level Quantity included data collected on participants involved in courses and programs of a participating university; and School-Level Quantity included data collected on participants from the participating schools. In the sub-category, MSP Award Quantity, most awardees collected data on the number of teachers participating in award activities (C3). Other data in this sub-category tracked numbers of hours or days of training completed by teachers (C2), and numbers of teachers continuing in MSP activities from year to year (C1). The sub-category University-Level Quantity was represented by the number of preservice enrollments in university programs (C2) and the number of teachers completing university programs (C1), where the university programs were part of the activities of the award. In the sub-category School-Level Quantity, the most common representation was numerical and descriptive information about the mobility of teachers in schools where those teachers were also award participants (C2). Awardees described teachers and district contacts retiring, teachers leaving or being laid off from the school system, and the termination of school positions. With less frequency, awardees described the retention of teachers in participating MSP schools (C1) and numbers of MSP participants hired by school systems (C1).

Representations that characterized teacher diversity. While teacher diversity (i.e., race/ethnicity) was discussed frequently in award documents, many of these included general statements such as, "teacher diversity is one of the project's key features" or "increasing diversity is an important goal." Awardees reported a desire for increasing the number of minority students in teacher training programs or increasing minority hires in school districts; however, some reports lacked detailed information on how the award would document an increase in the diversity of its participating teachers. Of the awards that did provide this information, many were tracking demographic data that focused on changes in the diversity of the mathematics and science teachers participating in the award (C2). Some awards discussed increases in the number of minorities recruited to award activities (C1) and minority students receiving scholarships (C1) as representations of increases in teacher diversity. Information on gender appeared in few reports (C0).

Interventions

Awardees discussed a variety of interventions designed to influence teacher characteristics within their partnerships. Some interventions influenced one area (quality, quantity, or diversity) more than another, but to some degree the interventions impacted multiple areas and characteristics. The most common interventions reported by awardees are grouped by the frequency with which they appeared in awardees' documents and presented in Table 2. These interventions include: Inservice Training/Professional Development (C3), Preservice Training (C3), Teacher Leadership (C3), Recruiting (C3), Linking STEM Faculty with Teachers (C2), Stipends/Compensation (C2), and Induction (C1). The following sections further unpack the most common interventions by providing examples from awardees' activities.

Interventions focusing on the quality of inservice and preservice teacher training. Inservice Training/Professional Development (PD) for individual teachers was discussed in all of the awards. These interventions included courses, workshops, institutes, and other teacher training activities, including those leading to certification and degrees in mathematics and science. New certification programs for teachers were reported in a number of awards (C2), most commonly as a way to develop certification and endorsement options to meet the "highly qualified" status or to obtain an add-on certificate or endorsement in addition to teacher licensure. For example, one certification program for elementary teachers included five mathematics content courses that were specially designed to increase subject knowledge. Other certification options for inservice teachers included a summer certification in secondary mathematics and National Board Certification. Most certification efforts focused on ensuring that those teaching mathematics and science were certified to teach those subjects. Many of these inservice training and professional development interventions were paired with teacher leadership.

All awardees described some form of teacher leadership in their documents (C3). Additionally, teacher leadership was described in all grade bands (elementary, middle, secondary), in both mathematics and science,

Table 2
Frequency of Interventions Reported by Awardees to Influence Teacher Characteristics

Interventions	Examples	Frequency
Inservice Training/ Professional Development	Courses, Workshops, Institutes (including those leading to Certification and Degrees); Increasing Subject Knowledge	C3
Preservice Training	New Course and Program Development (including those leading to Certification and Degrees); Increasing Subject Knowledge; Revising Student Teaching	C3
Teacher Leadership	Formal and Informal Roles (including Coaches, Mentor Teachers, Lead Teachers, Department Chairs, Curriculum Specialists, Master Teachers)	C3
Recruiting	Numbers Recruited to MSP and University Activities; Targeted Recruiting Activities for Minority Teachers	C3
Linking STEM Faculty with Teachers	STEM Faculty Teaching Courses, Providing Expertise, Designing New Programs	C2
Stipends/Compensation	Financial and Material Incentives (including stipends, tuition waivers, classroom sets of materials, manipulatives, science equipment, laptops and calculators)	C2
Induction	Mentoring New STEM Teachers	C1

Note: N = 48 awards. C3 = interventions identified by 70 - 100% of the 48 awards; C2 = interventions identified by 40 - 69% of awards; C1 = interventions identified by 10 - 39% of awards; and C0 = interventions identified by 0 - 9% of awards.

and in formal teacher leader positions within the award, school system, or university. Examples of teacher leadership roles included coaches, mentor teachers, lead teachers, department chairs, curriculum specialists, master teachers, and locally-based staff developers. In some cases awardees utilized teacher leadership roles already in place in the school system (i.e., department chairperson or curriculum specialist); while in others, teacher leadership roles were constructed as part of the award's activities. The largest responsibility of teacher leaders described by awardees was to provide professional development for inservice teacher training (C3). The professional development delivered by teacher leaders included using teacher networks and professional learning communities (PLCs), peer observations and feedback, peer coaching, peer support structures, and study groups (C2). To a lesser extent, teacher leaders engaged in curriculum work, helped to set and achieve school and MSP goals, and performed administrative tasks (all designated as C1). Training for leaders was reported in many awards (C3), with the most common attributes of leadership training being the development of the teacher leaders' subject knowledge, leadership skills, dispositions, and pedagogical strategies (all designated as C2).

Most of the inservice teacher training/professional development (PD) focused on developing teachers' knowledge in terms of content and pedagogy (C3). Efforts to improve or increase teachers' subject and pedagogical knowledge were commonly described as intertwined, with awardees using terminology such as *pedagogical content knowledge* (Shulman, 1986) and *mathematical knowledge for teaching* (Ball, 1991). A focus on subject knowledge is traditionally emphasized for high school teachers; however, awardees in this program emphasized subject knowledge for teachers at all grade levels.

Other PD activities included a variety of elements. Awardees frequently described the use of curriculum materials (C3) in their PD activities, including FOSS kits, Developing Mathematical Ideas (DMI), Great Explorations in Math and Science (GEMS), and standards-based NSF-funded curriculum materials. The use of inquiry science during PD activities was reported often (C2). Other PD work focused on assessment, such as developing various methods of student assessment, developing test items, and interpreting test item data (C2). PD seminars focused on analyzing students' thinking using student products and videotaped episodes of students working (C2). Awardees incorporated the use of mathematics and science standards documents (C2) in an effort to understand the contents of the standards documents and align standards with instruction. They also used technology and mathematics tools (including manipulatives) (C2).

In addition to the teacher quality interventions focused on inservice teachers, there were also teacher quality interventions focused on preservice teachers (C2), with the most common of these focusing on the development of new courses and new programs for preservice teachers that would lead to certification and degrees. Awardees created subject-focused preparation programs in mathematics and science at various levels throughout K-12, and alternative certification programs for mathematics and science majors. New course offerings specifically focused on increasing preservice teachers' subject knowledge (C1) (e.g., courses such as *Linear Algebra*, *Cells and Molecules*, and *Discrete Probability and Statistics*). Other awardees described revising student teaching programs and internships (C1).

Many preservice and inservice teacher quality interventions linked faculty in the fields of science, technology, engineering and mathematics (STEM) with K-12 teachers (C2). STEM faculty were identified as the providers and designers of multiple inservice and preservice teacher development activities among the awards, including those that were mathematics and science focused, those that focused on preservice recruitment, and those that were focused at the elementary, middle and high school levels (C2). (For a complete discussion of STEM faculty engagement, see Moyer et al., 2007). STEM faculty worked with education faculty, teachers, and teacher leaders to design, revise, and teach courses for teacher education programs, summer workshops, and in-service teacher programs in mathematics and science (C2). STEM faculty also served in management roles (such as directing project activities) or leadership roles (such as directing the development of a new course or course sequence for mathematics and science teachers) (C2). In some awards, STEM faculty served in advisory or "expert" roles, including attending professional development sessions to provide on-site support, participating in study groups, or being available for online discussions and mentoring (C1). The increased presence of STEM faculty in was reported as a means for increasing teachers' subject knowledge.

Interventions focusing on teacher quantity and diversity. All awardees reported recruiting as the most common intervention for influencing teacher quantity and diversity (C3). Some awardees' recruiting plans included a focus on diverse students with scholarship offers to minority students entering teacher training programs and other support structures to promote minority enrollment in programs leading to mathematics and science teaching careers (C1). STEM faculty involvement was common in the recruiting activities for preservice teachers (C2). As discussed previously, many awards utilized teacher leadership in their interventions. In addition to working to support the professional development of inservice teachers, teacher leaders also impacted teacher quantity and diversity. By serving as mentor and master teachers they were part of the recruiting and induction process for bringing new mathematics and science teachers into the profession, including those from minority populations, thereby influencing the quantity of new teachers and the diversity of the teaching force.

Other recruiting activities to increase the numbers of mathematics and science teachers included providing school-based experiences matching recruits with exemplary teachers (C1); developing recruiting tools, documents, recruitment videos, brochures, and information sessions about careers in teaching (C1); attracting university STEM students into teaching programs (C1); designing mentoring programs for high school students to recruit them into teaching (C1); engaging high school and university students in mathematics and science activities with younger students to promote interest in teaching as a career (C1); and forming after-school science and future teacher clubs in high schools (C1).

The most frequently-reported representation of teacher quantity was the number of teachers participating in award activities; therefore, stipends and compensation were viewed as an intervention to potentially increase participation and, thereby, increase teacher quantity for the award (C2). The types of stipends and compensation reported by awardees to increase teacher participation included: stipends for participating in inservice training and PD activities (C2), stipends for serving in new leadership roles (C1), tuition waivers or reimbursements for university courses (C1), and classroom sets of materials including mathematics manipulatives, science equipment, laptops and calculators (C1).

Teacher induction was described as an intervention to influence teacher quantity and diversity, but with less frequency than the other interventions previously discussed (C1). Induction activities were described as formal and informal events ranging in duration. Common induction experiences were described as on-site PD, new teacher workshops, and Saturday seminars (C1). Some induction experiences were provided by teacher coaches, through study groups, or as online mentoring, including one-to-one mentoring, as well as group induction activities for mathematics and science teachers (C1).

Limitations

One of the benefits of examining an entire group of awards for themes is also a limitation. While researchers gained valuable insights about the entire portfolio of awards, detailed descriptions of individual awards could not be highlighted. Because researchers believed that insights from the portfolio of awards may bring to the fore the value of the program as a whole, we chose this method of broad examination. Each award has its own evaluation in place and these individual evaluations may bring to light unique characteristics of the individual awards. Because this analysis provides a view of the awards as one entity, major shifts in teacher quality, quantity, and diversity work across the awards can be identified.

The descriptive and narrative nature of awardees' documents was a limiting factor in the analysis. Self-report documents prepared by awardees may not provide a complete and accurate account of the full scope or impact of awardees' activities. In some cases the use of terms was unclear, or a reference to a particular group or activity was incomplete. However, researchers in the present study believed that awardees had some choice in what to include in their documents. These selections were indicative of what awardees found of most importance to their work. The self-selection of information to include in the reports and the sections of the reports where information was expanded upon or limited were important data in and of themselves. While certain aspects of reporting were required across the program, there was still great latitude in the level of description awardees were required and permitted to submit as a report, as evidenced by the range in the length of their reports.

Discussion

These results provide a broad view of the work of awardees in a major mathematics and science program focused on influencing teacher quality characteristics. The findings illustrate how awardees represent teacher quality characteristics in their work and what interventions they report as influences on those characteristics. Several key findings emerge from our analyses.

Improving Individual Teacher Quality

Characteristics of individual teachers, in particular subject and pedagogical knowledge, are discussed extensively in the documents. Awardees' language on teacher knowledge emphasizes the importance of subject knowledge, and this emphasis is similar to recent policy and professional organization statements, as well as research (Darling-Hammond, 2000; Ferguson & Womack, 1993; Goldhaber & Brewer, 1997a; Monk, 1994; Wilson & Floden, 2003). In addition, there is an evident shift across this program of awards to place increased emphasis on the development of subject knowledge, not just for middle and high school teachers, but also for elementary school teachers, as evidenced by the course and program development for inservice teachers at the elementary level. This knowledge is specialized to the work of teachers at this level (Ball, 1991). While certification for elementary teachers does not currently require additional mathematics and science coursework, the emphasis in this portfolio of awards could indicate a future trend in the preparation and professional development of elementary teachers targeted toward specialized knowledge for teaching mathematics and science. In addition, the prominence of subject preparation at all levels among the awards places renewed emphasis on the importance of middle school teachers having strong preparation in mathematics and science content.

While much of the pure research in the general domain of teacher quality uses characteristics such as years of experience, general ability, and certification status as representations of teacher quality, awardees in the present study were more likely to focus on teachers' subject knowledge, pedagogical knowledge, and behaviors, practices, and beliefs. In the context of this awards program, these results are not surprising. The awards are funded based on a set of project-specific goals and plans for demonstrating and assessing progress towards those goals. It makes sense that awardees would focus on subject matter knowledge, pedagogical knowledge, and behaviors, practices and belief, because these are characteristics of teachers over which awardees' work may have some influence. Teacher quality is a complex construct. Awardees' use of multiple representations and interventions reveals their awareness of the complexity inherent in influencing these constructs. An awareness of this complexity also makes them better able to focus on documenting teacher growth as it relates to teachers' participation in the activities of the award.

The findings show that awardees have adopted research-based practices in the design of professional development experiences (Loucks-Horsley, Hewson, Love, & Stiles, 1998). For example, a large-scale empirical comparison on the effects of characteristics of professional development on teacher learning found significant positive effects on three core features: focusing on content knowledge, promoting active learning, and fostering coherence with other learning activities (Garet, Porter, Desimone, Birman, & Yoon, 2001). The study also found that structural features, including type of activity, duration of the activity, and collective participation, significantly affect teacher learning. In the present study, awardees demonstrate a strong emphasis on mathematics and science subject preparation and PD that contains active learning. Coherence and collective participation were fostered by using teacher learning networks in the same subject areas, grade levels, and schools. These characteristics indicated that awardees were knowledgeable about the types of interventions that have been shown to be effective in influencing growth in mathematics and science teachers.

Improving Teacher Quantity and Diversity

Tracking the quantity and diversity of the teachers engaged in these awards is documented at multiple levels across the program. While these data are a constantly moving target for awardees, most were able to report participation and demographic data on their teacher participants. In terms of influencing teacher quantity, some of the most commonly reported data were the numbers of participants recruited to the award and its activities. The research on teacher quantity indicates that teacher turnover is a primary reason that additional mathematics and science teachers are needed each year to fill vacancies in K-12 schools (Ingersoll, 2006a; 2006b). For this reason, awardees could place additional emphasis on induction, mentoring, and retention efforts for mathematics and science teachers so that these individuals remain in the teaching profession.

While some of the factors that cause mathematics and science teachers to leave the profession are out of the control of the awards (i.e., salaries, administrative support, student behavior, and student motivation) (Ingersoll, 2006a), there are a variety of retention strategies that can be implemented to offset these negative influences. One important reason for awardees to focus on retention efforts that influence the quantity of mathematics and science teachers is that support structures that are put into place now have the potential to last beyond the life of the award. These support structures could influence the retention of mathematics and science teachers in a school or a district long after the award funding ends. In addition, there are many potential findings that could emerge by viewing the collective efforts of these awards to influence mathematics and science teacher quantity. Across the program of awards, potential studies could examine retention efforts that are particularly effective under applied conditions, providing additional evidence on ways of retaining mathematics and science teachers.

As with teacher quantity, influencing teacher diversity involves changing population characteristics rather than characteristics of individual teachers, and changing population characteristics takes time. Research on teacher diversity indicate a number of strategies for increasing the diversity of the teaching force over time. Some of these include: improving K-12 education for minority students, early identification, targeted recruiting, and support through various stages of teacher education (i.e., initial certification, induction, on-going professional development) (Clewell & Villegas, 1998; Darling-Hammond et al., 1996; Holloway, 2002; Jorgenson, 2001; Loving & Marshall, 1997; Newby et al., 2000). The most common efforts directed toward improving teacher diversity among these awards involved recruiting minority candidates and implementing support structures for minority candidates. However, these activities were reported by a lesser number of awards (C1, 10 - 39% of awards). While some awardees have selected research-based implementation strategies for influencing teacher diversity, wide-spread use of these strategies was not evident in the documents reviewed during this analysis.

Promising Interventions

The involvement of STEM faculty and Teacher Leaders was evident throughout the portfolio of awards, across subject areas and grade levels, and among preservice and inservice teacher development activities. The results showed STEM faculty most commonly involved as course instructors, program designers, and content experts, which capitalizes on the type of work STEM faculty do at the university, and in some cases, pulls them out of the university environment and into K-12 schools. For some this was unfamiliar territory, and STEM faculty struggled to identify where they "fit in." In addition, traditional university reward structures for STEM faculty often hinder their involvement in mathematics and science education work. However, as STEM faculty and educators worked through the design of the award's activities, they gained a better understanding of each other's work. A discussion by Hyman Bass in the *Bulletin of the American Mathematical Society* describes the long tradition of contributions of noted research mathematicians to mathematics education work (Bass, 2005). He highlights the importance of 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. As evidenced by these awards, many STEM and education faculty across the country are currently working together to improve mathematics and science education.

As the awards end, it will be interesting to examine how the collaborative relationships formed among STEM faculty, education faculty, and K-12 education will influence their future collaborative work in K-12 mathematics and science education. The MSP Program awards provided opportunities for university faculty and K-12 educators to understand each others' professions, pedagogy, and language. Continuing initiatives have the potential to build upon the work stated during the award. In particular, the mathematics and science teacher turnover challenges faced by the field of education are also faced in STEM fields in terms of those earning STEM degrees. Recent reports show that the proportion of students earning degrees in STEM fields has also declined, and that factors contributing to this decline include sub par teacher quality at the high school and college levels and poor high school preparation, among others (Ashby, 2006). These are interrelated challenges that face both STEM and education faculty, providing a common goal in the improvement of mathematics and science teaching at all levels K-16.

The findings suggest that awardees view teacher leadership as an important element in their intervention efforts for improving teacher quality, quantity, and diversity. While teacher leadership is a construct that has been examined in the literature for several decades (Hatch, White, & Faigenbaum, 2005; Rowan, 1990; Smylie, 1994), recently, there has been increased interest in teacher leadership, including broader views of the construct, and its effects on teaching and learning (Spillane, Halverson, & Diamond, 2001; York-Barr & Duke, 2004). Much of the existing literature on teacher leadership focuses on formal roles of leadership, characteristics of teacher leaders, and conditions that facilitate teacher leadership development; less research focuses on the effects of teacher leadership, particularly on other teachers and students (Smylie, 1995; York-Barr & Duke, 2004). The purposes of teacher leadership models in the literature include incentives to retain, reward, and motivate teachers; a means of improving teaching and learning by providing opportunities for teacher development, growth, and collaboration; and a means of utilizing organizational resources in order to support and sustain reform efforts (Mijus & Harris, 2003; Smylie, 1995, 1996; Webb, Neumann, & Jones, 2004; York-Barr & Duke, 2004). These were common elements in the descriptions of leadership activities of the awardees. An underlying assumption among awardees' was that teacher leadership was a vehicle for influencing teacher quality, quantity, and diversity in a systematic way. For example, when a science teacher leader with subject specific skills mentors a new minority science teacher, the teacher leader has the potential to influence the new teacher's subject and pedagogical knowledge (influencing teacher quality), and to mentor and support the new minority teacher through the first few difficult years of teaching (influencing teacher quantity and diversity).

Most of the existing research on the effects of teacher leadership has focused on the effects on teacher leaders themselves (York- Barr & Duke, 2004). Evidence of the effects of teacher leadership outside the individual leader is more unclear. An important element for future research on teacher leadership is a focus on how leadership influences teachers and students at the classroom or "micro level" (Coggins, Stoddard, & Cutler, 2003). The awards in the present study are in a unique position to contribute to this research. With many awards engaged in teacher leadership work, and many different leadership configurations among the awards, there is much opportunity for research that has been absent from the literature. The impact of mathematics and science teacher leaders on the quality, quantity, and diversity of teachers is certainly worthy of further study, and awardees in this program are in the position to conduct this potentially meaningful research.

Conclusion

Several important insights have emerged from this examination. Among the awards there is a renewed emphasis on the importance of subject preparation for mathematics and science teachers, and in particular, a shift in emphasis to include specialized subject knowledge preparation for elementary teachers. This shift may have future effects on the design of preparation and professional development programs for teachers at the elementary level. Awardees in this program focus on the growth of teachers in terms of those characteristics over which they have influence, and at the same time they recognize the complexity of influencing and documenting teacher change. The findings from their own research has the potential to inform educational research on effective practices for documenting teacher growth in applied settings. Efforts to influence teacher quantity and diversity are only in their initial stages for many awards, as these are population characteristics and changing the characteristics of a population takes time. The influence of Teacher Leaders and STEM faculty is prominent throughout the awards, as they are engaged in activities at all levels (K-12) and in both subject areas (mathematics and science). The foundation of collaboration developed during the activities of the awards, among university faculty and K-12 education, has the potential to continue to influence K-12 mathematics and science education for years to come. Through their work these awards have made gains toward improving the quality, quantity, and diversity of the mathematics and science teaching force. The value of these efforts will be revealed as awardees document and disseminate new knowledge from their initiatives and experiences.

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This research is part of the Math and Science Partnership Program Evaluation (MSP-PE), supported by Contract No. 0456995 from the National Science Foundation. The MSP-PE is led by COSMOS Corporation, with Robert K. Yin of COSMOS serving as Principal Investigator (PI) and Jennifer Scherer serving as one of three Co-Principal Investigators. Additional Co-Principal Investigators and their collaborating institutions (including discipline departments and mathematics centers) are Patricia Moyer-Packenham of George Mason University and Kenneth Wong of Brown University. Other collaborating institutions include Vanderbilt University and The McKenzie Group. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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