

Strengthening the Mathematical and Scientific Education of Teachers (MSET)

Background and Purpose

Teachers' knowledge of the disciplinary content they teach matters (Haycock, 1998; Goldhaber and Brewer, 1996). The research of the past decade or so has led us to realize that substantial understanding of mathematics and science is needed to teach even elementary topics well. When teachers teach topics on which they are well prepared, they encourage student questions and discussions, spend less time on unrelated topics, permit discussions to move in new directions based on student interest, and generally present topics in a more coherent way (Leder, 1990).

At the same time, there has been a growing understanding that the mathematical/scientific knowledge needed for teaching differs in some important ways from that required by those pursuing or engaged in other mathematics- or science-related professions. Teachers of mathematics/science need a deep understanding of their discipline -- to include "profound understanding" (Ma, 1999) of elementary mathematics/science -- so they can facilitate student learning of mathematics/science as a reasoned, coherent experience and communicate the elegance and power of their discipline.

To expect that teachers of K-12 mathematics/science will have learned in their preservice years all of the mathematics/science subject matter that they will teach is unrealistic. Teacher professional development must be a lifelong enterprise. For many K-12 teachers of mathematics/science, much of the subject matter mastery needed to teach well will necessarily be acquired through inservice teacher education. Over a teaching career that spans a number of years, a given teacher may have varied teaching assignments that encompass different grade levels (e.g., third grade in one year and fourth grade in the next) and different grade bands (e.g., upper elementary grades at one point in a career and middle school mathematics or science at another), as well as different content emphases within mathematics/science. Preservice education, at best, provides the foundations on which later learning will occur. The experience of being in the classroom -- like nothing else -- creates in teachers the desire, and indeed the need, to learn well the subject matter over which they have classroom responsibilities.

MSET derives its most important themes from the newly released report of the Conference Board of the Mathematical Sciences, *The Mathematical Education of Teachers* (CBMS, 2001), but extends those beyond K-12 mathematics to include elementary and middle school science, as well as high school biology, chemistry, and physics. MSET is therefore grounded in two general themes: (1) the intellectual substance in school mathematics and science; and (2) the special nature of the mathematical/scientific knowledge needed for teaching. Building further on the CBMS report for mathematics, MSET has a particular focus on middle grades mathematics and science: the more sophisticated content of middle school mathematics/science necessitates that mathematics/science specialists teach at these grade levels and that these specialists have a well-developed understanding of the subject matter they teach.

MSET will support:

- professional development materials and other resources for teachers that emphasize and address these general themes;
- professional development (inservice) and preparation (preservice) of K-12 teachers with an emphasis on mathematics and science content in the spirit of these general themes and with close connections to high quality, student-centered instructional materials and to classroom practice;
- development of resources and innovative delivery modes that enable the desired teacher development to occur within the context of the contractual school year and within a context that builds local communities of teachers as learners; and
- intense professional development of sufficient duration to enable practicing teachers of mathematics/science at the middle school grades to become mathematics/science specialists at those grade levels.

Centrality to Mission

MSET builds on the traditional strengths of NSF and its connections with the mathematical/scientific communities to provide a quality mathematical/scientific education for the K-12 teaching force. MSET stresses both the intellectual substance of mathematics and science, as well as the particular content domains that might be characterized as “school mathematics/science.” Mathematicians and scientists are particularly qualified -- indeed essential -- for the work required by MSET with current and prospective teachers. MSET requires partnerships and collaborations among disciplinary departments in IHEs, departments/colleges of education, and K-12 teachers of mathematics/science. Other partners might include industries, informal science centers, and laboratories with critical numbers of practicing scientists and mathematicians.

Need

The need for K-12 teachers to have a solid command of the subject-specific content they teach is well documented. Yet, almost 30% of those currently teaching middle or high school mathematics/science are “out of field” (i.e., without a major or minor in mathematics/science or mathematics/science education), and those teaching at the elementary grades have often completed only one or two mathematics courses and one or two science courses in their preservice years.

In addition, there has been a growing realization in recent years that the mathematics/science needed to teach well differs in some important ways from that needed in non-teaching mathematics- or science-related professions, thus serving to define content domains that might be characterized as “school mathematics/science.” Few teacher education curricula adequately provide for these differences at the preservice level. While inservice teacher education curricula make some inroads into the domains of “school mathematics/science,” they too fall short of what is needed, generally lacking the materials and often even the duration to provide the kind of coherent experience needed to address the general themes articulated above.

Quality

The quality of MSET will be ensured and assessed in multiple ways. Materials for teachers will undergo an extensive development process that includes review by experts in SMT and SMT education, pilot testing, and field testing with diverse groups of teachers. Teachers' growth in SMT content knowledge and especially in the domains of "school mathematics/science" will be assessed, and this will likely require the development of new instruments and protocols.

The quality of the professional development sessions will be assessed through professional development observations. Classroom observations will assess the quality of and track changes in teacher practice. Improvements in student achievement/outcomes will be documented.

Impact

MSET is expected to produce larger numbers of current and prospective K-12 teachers of mathematics and science with greater knowledge and understanding of the subject matter they teach, especially in the content domains of "school mathematics and science." But, equally important, MSET will contribute to the development of strategic, new tools: (a) professional development materials and other resources for teachers, and (b) instruments and protocols that assess teachers' content knowledge *per se*, as well as the effects of growth in teachers' content knowledge on teacher and classroom practice.

Other impacts include (a) increased numbers of middle school specialists in mathematics/science, and (b) greater capacity in the mathematics and science communities to work effectively with K-12 teachers of mathematics and science.