Abstract Title: Assessing the Impacts of the MSPs: K–8 Science

MSP Project Name: Assessing the Impacts of the MSPs: K–8 Science

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120 word summary:

What the field knows about professional development strategies to deepen the content knowledge of teachers is surprisingly limited given the extent of efforts in this area. One challenge for the field is understanding what strategies or features matter most. Another challenge is that the vision for science education described in the *National Science Education Standards* requires teachers to understand science concepts, how scientific knowledge is generated, and how students learn science. AIM is addressing these challenges by developing instruments that can be used in research about professional development and its impacts, conducting a quasi-experimental cross-MSP study to add to the empirical knowledge base, and developing an existence proof of the efficacy of one model of professional development.

- Section 1: **Questions for dialogue at the MSP LNC**.

What types of science learning experiences are likely to impact teacher and student content knowledge?

- Section 2: **Conceptual framework**.

The MSP program is premised on the idea that strong teacher content knowledge is necessary for improving student learning of mathematics and science. Yet, what the field knows about professional development strategies to deepen the content knowledge of mathematics and science teachers is surprisingly limited given the extent of efforts in this area. Research has provided some evidence that professional development with a focus on teachers' content knowledge is more likely to influence changes in classroom practice and support student achievement, compared to programs that focus on more generic topics (Cohen and Hill, 2000; Kennedy, 1999).

One challenge for the field is understanding what strategies or features of content-focused PD matter most. Both Cohen and Hill (2000) and Kennedy (1999) found that an emphasis not just on content knowledge, but also on student learning of the content, were related to measured student learning. A series of studies conducted on the effectiveness of mathematics and science education professional development supported with Eisenhower program funds (Desimone, Porter, Garet, Yoon, & Birman, 2002; Garet et al., 1999; Garet, Porter, Desimone, Birman, & Yoon, 2001) found that teachers who participated in activities that emphasized content knowledge, active learning, and coherence with other improvement programs were more likely to report enhanced knowledge and skills, and changes in their teaching practice than teachers who did not participate in such programs. The studies also found that these emphases were more

common in professional development that had a longer time span, had a greater number of contact hours, and encouraged collective participation of teachers within a school, grade level, or course. It is important to note, however, that these studies relied on teacher self report in determining gains, rather than more objective measures.

The MSP KMD project conducted a systematic review of the literature on deepening teacher mathematics/science content knowledge to pull together what is known about professional development with this aim from empirical study. Nearly 2,000 relevant items published since 1990 were identified. However, a large number of these items were advocacy or opinion pieces, not research; others were eliminated from further analysis because they did not include assessments of teacher content knowledge, e.g., they used teacher self report of knowledge gains as the dependent variable, or examined teaching practice outcomes with the assumption that gains in teacher content knowledge were responsible.

Standards of evidence were applied to the small subset of studies (n=26) that used objective measures to examine the impact of professional development on teacher mathematics/science content knowledge in order to identify their contributions to the knowledge base. This effort underscored several limitations in the current empirical knowledge base. The review had intended to use the frame of disciplinary content knowledge, ways of knowing, and pedagogical content knowledge for analysis, but the studies typically did not define what they meant by teacher content knowledge in sufficient detail, nor clearly measure particular aspects of knowledge. The studies also tended to have very sparse documentation of their interventions; consequently, even if there was convincing evidence that a program was effective, we have only a vague idea about what the program entailed.

The standards of evidence review also revealed substantial weaknesses in the research designs of many of the studies, greatly limiting what could be learned. For example, many of the studies lacked comparison groups, making it difficult to attribute any measured gains to the particular treatment of interest. Similarly, many of the studies were based on volunteer teachers, or interventions provided by their developers, so the results may not readily generalize to other teachers or other professional development providers. Finally, in many cases, the studies used idiosyncratic instrumentation, without providing evidence of validity or reliability (Heck, Smith, Taylor, and Dyer, 2007).

The MSP projects struggle with many of the same challenges in studying the impact of their efforts to deepen teacher content knowledge, including the scarcity of high-quality instruments, difficulties in identifying appropriate comparison groups, unique professional development contexts with results that may not generalize more broadly, and dealing with small sample sizes that limit the power of their analyses.

Another challenge for the field is that the vision for science education described in the *National Science Education Standards* (NRC, 1996) requires teachers to understand science concepts, how scientific knowledge is generated, and how students learn science. The *Standards* describe learning science as "something students do, not something that is done to them" (p. 20), emphasizing the use of scientific inquiry as a strategy to help students "develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural

world" (p. 23). This vision calls for greater involvement of students in hands-on/minds-on activities and less emphasis on teachers presenting information to students, studying fewer topics, each in greater depth.

Results from a national observation study (Weiss, Pasley, Smith, Banilower, & Heck, 2003) suggest that most elementary science lessons taught in the United States address content included in the *Standards*. However, they are unlikely to enhance students' understanding of important science content or their ability to engage successfully in the processes of science as described in that document. Observed lessons that were "traditional" in nature often failed to engage the students with science concepts, emphasizing vocabulary and factual information instead. Observed lessons that were more "reform-oriented" avoided those kinds of problems, but the instruction tended to focus simply on conducting the activities, without helping students make sense of the intended science content.

Since the national standards documents were published, research in the cognitive sciences has provided much new knowledge about the mechanisms by which people learn. This research and its implications for science education have been summarized in the National Research Council's How People Learn (National Research Council, 2003) and How Students Learn: Science in the Classroom (National Research Council, 2005). These documents describe students as active processors of information, placing heavy emphasis on the ideas and understandings that students bring to the classroom and how they construct new knowledge. Their initial concepts and skills affect how they process content and how they view the nature of science. For students to learn science content, learning theory posits that they must be motivated to learn and intellectually engaged in activities and/or discussions focusing on what they already know. Further, learning theory suggests that students will best understand science content and the scientific process if teachers encourage them to use evidence to support their claims and help them make sense of new, developmentally appropriate ideas in the context of their prior thinking and their understanding of related concepts.

AIM's hypothesis is that professional development that engages teachers with evidentiary phenomena (instructional experiences that provide evidence for a concept), a model for instruction based on learning theory, and explicit reflection on the learning process is more likely to lead to classroom instruction that embodies the vision of the *Standards* and is based on learning theory, and ultimately to students having a deep, conceptual understanding of important science ideas (AIM: K–8 Science's definition of student success). To this end, AIM is seeking to address the challenges described above by developing high-quality instruments that can be used in research about professional development and its impacts, conducting a cross-MSP study to add to the empirical knowledge base, and developing an existence proof of the efficacy of this model of professional development

- Section 3: **Explanatory framework**.

AIM has three main components for addressing its research questions. The first is developing the instruments necessary to address our research questions. AIM has been developing pairs of teacher and student assessments in four content areas: Evolution and Diversity; Force and Motion; Populations and Ecosystems; and Properties of and Changes in Matter. For each content

area, AIM will have two pairs of assessments, one for upper elementary grades and one for middle school grades. The content domains for the assessments are defined by strands of the *Science Framework for the 2009 National Assessment of Educational Progress* (National Assessment Governing Board, 2008) rather than by the contents of any particular professional development or instructional materials. All of the assessments focus on measuring conceptual understanding of the content and distractors are based upon common misconceptions. Assessment item development utilizes an iterative process that includes item writing/revision, cognitive interviews, review by content experts, and large-scale piloting. Each assessment yields an IRT-scaled ability score.

AIM has also developed a professional development provider log to capture data on the extent to which teachers' professional development experiences align with learning theory and take an evidence-based approach. In addition, AIM has developed a teacher questionnaire that captures data about factors that are likely to influence classroom practice, how closely that practice aligns with learning theory, and the extent to which instruction is evidentiary based.

The second component of AIM is working with MSP projects to collect data for a cross-project study. This aspect of the project provides MSPs with data they can use in their own research and allows AIM to take advantage of the naturally occurring variation in professional development approaches to further the field's understanding of which approaches to deepening teacher content knowledge are most effective in which contexts. AIM will use scores from the teacher content knowledge assessments as dependent variables in a multilevel regression analysis. The teachers' MSP professional development experiences will be coded into a set of factors that will be entered as the independent variables. This quasi-experimental study will allow us to examine the strength of the relationships between the different characteristics of the professional development and teacher content knowledge gains. A similar analysis of student assessment scores will examine the how different classroom practices relate to student knowledge gains.

The third component of AIM is creating an existence proof for a model of professional development explicitly aligned with learning theory. AIM is partnering with a local consortium of districts to run a week-long workshop for elementary teachers. The workshop will provide teachers with opportunities to engage with evidentiary phenomena and have explicit discussions about learning-theory based science instruction. Because the partner districts have an established PLC structure, AIM will work with the districts to provide additional learning opportunities during PLC meetings. Because this work will take place locally, in addition to examining the impacts of the professional development on teacher content knowledge, AIM will be able to intensively study the classroom instruction of participating teachers and examine how variations in instruction relate to student learning.

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