WRITTEN TESTIMONY OF SUZANNE M. WILSON

CHAIR, DEPARTMENT OF TEACHER EDUCATION
UNIVERSITY DISTINGUISHED PROFESSOR
MICHIGAN STATE UNIVERSITY

**BEFORE
THE HOUSE SCIENCE, SPACE AND TECHNOLOGY COMMITTEE
SUBCOMMITTEE ON RESEARCH AND SCIENCE EDUCATION**

HEARING ON

WHAT MAKES FOR SUCCESSFUL K-12 STEM EDUCATION? A CLOSER LOOK AT SUCCESSFUL STEM EDUCATION APPROACHES

12 OCTOBER 2011

Thank you Chairman Brooks, Ranking Member Lipinski, and the other members of the Subcommittee, for this opportunity to discuss the Federal government's role in K-12 STEM education. I am pleased to add my perspective on the Committee's questions, drawn from nearly 35 years in academia as first a high school mathematics teacher, then, teacher educator and education policy researcher, and now as chair of the Department of Teacher Education at Michigan State University, where I also conduct research on the effects of teacher preparation, professional development, and education policy. I also note that I was commissioned to prepare a review of the literature for the National Research Council's (2011) Board on Science Education and Board on Testing and Assessment workshop on *Highly Successful K-12 STEM Education in School.* I have also served on several NRC panels, including the one that issued the report on teacher preparation and Congressionally mandated (*Preparing Teachers*, 2010), and am a newly appointed member of the Board on Science Education. I also chaired the National Academy of Education's (2009) White Paper committee on teacher quality, which was also undertaken in response to the requests of several senators.

My expertise is in the area of teacher quality policies and practices, specifically teacher preparation, induction (early career support), and professional development. I will keep my comments focused on that domain.

<u>The Critical Role of STEM Teacher Preparation, Induction, and Professional Development</u>

While there is currently considerable debate about where and how teachers should be prepared, there is little question that STEM education depends on the sound preparation of K-12 teachers. Research clearly shows that it takes between 3-8 years to become an effective teacher, which underlines the importance of strong early career support (often called induction). And given the lackluster performance of US schools in STEM education overall – as well as the push for higher and more demanding standards -- there seems little question that we need equally strong professional development to build the capacity of practicing teachers. Further, there seems little debate about the need for all teachers to have sufficient content knowledge, as well as knowledge and skill in working with and adapting instruction for one's particular students, selecting and using appropriate curriculum materials, assessments, and other resources.

However, beyond that, there is much less agreement on who should prepare teachers, how that preparation should be structured and organized, and how to differentiate between the initial preparation of teachers and support they receive over their careers. This has resulted in what some have called a "non-system" of teacher support in this country: There are over 1200 teacher education programs at universities, another 130 "alternative routes," and at least as many induction programs. Every one of the over-15,000 school districts in the U.S. has multiple professional development programs sponsored by school districts, foundations, federal grants, universities, informal institutions, and other agencies. While there are similarities across some of these programs, there is considerable variation in content and quality.

However, we know that high quality teacher support needs to be anchored in clear and concrete vision of both what we want our K-12 students to learn and the instruction and other factors that lead to that learning. The NRC (2011) report, *Successful K-12 STEM Education: Identifying Effective Approaches in Science, Technology, Engineering, and Mathematics* accurately notes that effective STEM instruction:

> . . . students successively deepen their understanding both of core ideas in the STEM fields and of concepts that are shared across areas of science, mathematics, and engineering. Students also engage with fundamental questions about the material and natural worlds and gain experience in the ways in which scientists have investigated and found answers to those questions. In grades K-12, students carry out scientific investigations and engineering design projects related to core ideas in the disciplines, so that by the end of their secondary schooling they have become deeply familiar with core ideas in STEM and have had a chance to develop their own identity as STEM learners through the practices of science, mathematics, and engineering.

These are ambitious – and in the case of technology and engineering, new, ideas for what all students should learn and do in schools. Unfortunately, this kind of instruction is rare in US K-12 schools. And because our future teachers come through those schools, there are many teachers, especially elementary teachers, who themselves have never experienced that kind of instruction. I also note that although the problem is exacerbated for prospective elementary teachers, the majority of prospective middle and high school teachers seldom have an opportunity for first hand experience with the "practices of science, mathematics, and engineering."

Breaking this cycle requires improved teacher preparation (both in terms of the quality and quantity of teachers' engagement with relevant disciplinary content and in terms of professional coursework and experiences), subject-specific support during induction, professional development that targets teachers' needs and systematically builds on prior STEM learning, and professional communities in schools where teachers and administrators collectively focus on their students' learning. It would also entail considerable research to identify both the effective instructional strategies, educational resources, school supports, and teacher development programs that would inform those changes.

Main Points

Before elaborating, I present four main points that frame my comments:

- ✓ We have high aspirations for mathematics and science learning, and some new ideas about what children should learn about technology and engineering.

- ✓ Many of our teachers have never experienced, as students, the learning we envision in those domains for their students.

- ✓ We have a massively incoherent system and very challenging contexts for instructional improvement.

- ✓ Yet we do know some things about improving instruction (including preservice and prospective teachers' training). And there are concrete things we can do to address the challenges that lay before us.

Challenges Facing STEM Initial Teacher Preparation

There is a growing consensus that initial preparation of teachers needs to include substantial study of the relevant disciplines. This is not identical to disciplinary majors, as the K-12 school subjects are not always taught in college majors. Thus, teacher preparation needs to be designed to explicitly address the content that will be taught. The development of the Common Core State Standards will help in this regard, as they clearly lay out the focal content that teachers will need to know how to teach. There is also consensus that teachers need professional knowledge that goes beyond subject matter, and that the process of learning to apply that knowledge in practice requires focused attention to a core set of teaching practices, over time, in structured and well-designed field experiences.

That said, teacher preparation currently faces several challenges:

- ✓ One overarching challenge has been the lack of a common curriculum that all teachers will teach. This has contributed to the diffuse nature of initial teacher preparation across the country since programs do not know what content or curriculum their graduates need to be prepared to use. The development of the Common Core State Standards might potentially help in this regard.

- ✓ Not surprisingly, therefore, there also exists no common curriculum for the preparation of teachers. And there is no agreement on what initial teacher preparation should focus on as opposed to the support of practicing teachers. This results in both variations in the content of what new teachers learn in their programs and an approach similar to the "a mile wide and an inch deep" characterization of U.S. mathematics education offered by William Schmidt and his colleagues in the TIMSS study.

- ✓ Another challenge, specific to elementary school, is that teachers are expected to teach all subjects. Most universities limit the maximum credits required for an undergraduate degree; given the need to prepare all elementary teachers to teach all subjects, and the increasing number of mandates about what they need to know (special education, English Language Learners, the arts, all academic subjects, etc.), most prospective elementary teachers have limited exposure to STEM disciplinary content. Specifically, the average elementary teacher might take two mathematics courses, two science sources (neither of which engages them in genuine science inquiry), no engineering courses, and if they take a technology class it is likely about *instructional* technology, not technology generally.

- ✓ At the middle and high school levels, recruitment into STEM teaching continues to be a challenge, especially in terms of long-term solutions that can be institutionalized. Programs with financial incentives or benefits at the front end (subsidized preparation, for example) have uneven track records for preparing teachers who stay in the profession. In an age of shrinking resources, it is unclear how programs or schools will secure funding to continue those programs.

- ✓ Middle school STEM teacher preparation continues to be serious challenge. The most recent research by William Schmidt and colleagues suggests that middle school mathematics teacher preparation programs in the U.S. are wildly uneven. State certification laws also vary, and many middle school teachers were originally prepared as elementary teachers (and therefore have limited disciplinary content preparation (see above)).

To address these challenges, we must establish specific standards for teaching practice and build a professionally valid licensure system. Assessments would focus on teachers' content knowledge, their actual skill with the instructional practices most important for student learning, and their persistence in working to make sure that every one of their students learns. These assessments would be different from the ones we currently have in this country which do not, for the most part, focus on the ability to teach.

To prepare teachers for these standards, we need to engage prospective teachers in disciplinary study directly related to the school subjects they will teach. We also need to integrate more content concerning engineering and technology into the teacher preparation curriculum, without making the curriculum wider and thinner. In terms of professional preparation, we need to design a system of high-quality rigorous training that is centered on practice. This system would require three components:

1. A curriculum focused on the highest leverage instructional practices <u>and</u> specialized knowledge of the academic content that teachers teach;
2. Close practice and feedback in clinical settings so that teachers can be deliberately taught and explicitly coached with the skills to reach a wide range of learners.
3. Highly credible and predictive assessments of professional knowledge and skill so that no one enters a classroom without demonstrated capacity for effective performance as a beginning teacher.

In addition, we might want to consider alternative staffing patterns in elementary schools so that teachers can specialize in particular content.

<u>Challenges Facing Professional Development</u>

There is also a growing consensus among researchers regarding characteristics of high quality professional development, especially of effective science professional development. In particular, the *National Science Education Standards* (National Research Council, 1996) published professional development guidelines for teachers. Those standards emphasize the importance of professional development that focuses on subject matter, draws upon teachers' current practices and experiences, and is intensive and sustained. This resonates with the NRC report's findings, specifically the statement that:

> In any discipline, effective professional development should
>
> - focus on developing teachers' capabilities and knowledge to teach content and subject matter,

- address teachers' classroom work and the problems they encounter in their school settings, and
- provide multiple and sustained opportunities for teacher learning over a substantial time interval. (p. 21)

However, as the report authors note, the empirical evidence supporting these professional development characteristics is not always consistent and little research allows us to trace "the causal pathway from professional development to student achievement." Additionally, other factors pertaining to teachers and schools also appear to play a noteworthy role in each characteristic's importance.

STEM professional development programs in this country vary enormously in terms of their content and character and the challenges they face include:

- ✓ There is no agreed upon curriculum for professional development of STEM teachers. Professional development leaders often identify "big ideas" that transcend particular curricula: in science that might include the nature of science or scientific inquiry, or key concepts (like force and motion or natural selection) that seem foundational to scientific disciplines (like physics or biology). In mathematics, this might include fractions, patterns and functions, or reasoning and proof. But these big ideas are not selected in any systematic or deliberate way, and most professional development does not build on what teachers have already learned. Here too the Common Core State Standards might provide some guidance.

- ✓ Inconsistency and lack of predictability in terms of what teachers have learned prior to specific professional development. Thus, professional development leaders can have very experienced and brand new teachers in the same workshop, and those teachers can have little to high knowledge of STEM content.

- ✓ Lack of diagnostic information concerning what teachers need to learn. We do not tailor professional development in this country to the learning needs of the specific teachers in the class.

- ✓ Lack of centralized funding for professional development or plans to use funding in coherent ways. This includes a lack of integration and coordination of professional development concerning STEM education and other knowledge/skills teachers need to work on, including teaching STEM content to English Language Learners, or adapting STEM instruction to diverse student populations.

- ✓ School districts and states lack policies, practices, and resources that support the long term, sustained, collective focus that research suggests is necessary for high quality professional development.

In sum, professional development for STEM teachers is most often a patchwork of fragmented and disconnected experiences. The teachers who need the most support often do not pursue such opportunities. The NRC report authors note that:

> professional development alone is not a solution to current limitations on teachers' capacities. Instead, it is more productive to consider teacher development as a continuum that ranges from initial preparation to induction into the practice of teaching and then to systematic, needs-based professional development, including on-site professional support that allows for interaction and collaboration with colleagues. (p. 21)

To address these challenges, we need to radically change the way that states and school districts think about professional development. On-going teacher learning needs to be part of the mission of every school. Schools have to be structured and resourced so that teachers have clear instructional guidance, sound materials, a strong school leader, and time to work with other teachers on improving instruction and tailoring it to the specific children in that school. Professional development needs to be focus on the content teachers are responsible for teaching, and it needs to be tailored to the learning needs of the teachers involved. It needs to gradually become more and more sophisticated along the career paths of teachers.

Similar to initial preparation, the components of professional development would include:

1. A well articulated curriculum focused on the highest leverage instructional practices and specialized knowledge of the academic content that teachers teach, building on what teachers mastered during their initial preparation;
2. Close practice and feedback in their classrooms, including coaching.
3. Highly credible and predictive assessments of professional knowledge and skill so underperforming teachers can be identified and supported or, if they do not improve, removed.

The Current State of Teacher Assessment

Teacher assessment is under a great deal of scrutiny. In many current evaluation systems teachers receive almost universally high ratings. As many of these systems use a binary means of scoring (satisfactory or not), the systems also do not give teachers useful information to improve their practice. There has been a great deal of research and commentary on the quality of value added measures of teachers. However promising these methods might be, there are still several enormous challenges to the measurement and policy community related to these measures:

- ✓ Student achievement and gains are influenced by other factors besides the teacher, including, school factors such as class sizes, curriculum materials, instructional time; home and community supports; individual student needs and abilities, health, and attendance; peer culture and achievement; and prior teachers and schooling, as well as other current teachers. Most of these factors are not actually measured in value-added models. (AERA/NAE, 2011)

- ✓ Second, value-added estimates are based on test scores that "reflect a narrower set of educational goals than most parents and educators have for their students. If this narrowing is severe, and if the test does not cover the most important educational goals from state content standards in sufficient breadth or depth, then the value-added results will offer limited or even misleading information about the effectiveness of schools, teachers, or programs" (NRC, *Getting Value Out of Value-Added*, 2010).

For the purposes of this committee's discussions, tests currently do not measure the "practices" of the disciplines, for instance, the ability of students to engage in scientific inquiry or reason mathematically. Nor do the tests measure students' continued interest in, commitment to, or engagement in STEM fields. Here one can see the interdependence of research on student and teachers. Without good research on student engagement and learning, any and all attempts to measure teacher effectiveness are hamstrung.

There is other work underway in teacher assessment as well, specifically in the area of creating observation protocols for measuring teacher quality. This would allow for more refined documentation of instruction. However, preliminary work suggests that training raters to score such protocols reliably continues to be a challenge.

The Role of the Federal Government in K-12 STEM Education

While our teacher preparation and professional development practices may appear inconsistent -- like the larger educational system they serve -- they were built from the bottom up, school-by-school, program-by-program; and were designed to serve locally managed and funded markets. This is not to say that they were or are immune to national issues; consider that with the Elementary and Secondary Act of 1965, and continuing even today, they have steadily worked at better serving students across lines of race, gender, and ability with the goal of achieving equality. At present, and for indisputably good reason, the national press in on for quality in addition to equality.

In terms of teacher preparation, induction, and professional development, the primary role of the federal government has been to produce resources to stimulate thinking about state and district level policies, programs, and practices, as well as to press for increased evidence of effectiveness. In particular, research and development work sponsored by the National Science Foundation and the Department of Education, including the Institute for Education Sciences has played a major role in influencing how we think about teacher preparation and professional development, as well as how we assess its effectiveness (see below). But that support has been limited, especially in the area of teacher preparation, and it has not been leveraged to catalyze coherence or the accumulation of knowledge.

What role might the federal government play to shape reform in STEM education? There are several avenues to pursue that could encourage more coherence and focus.

- ✓ Use the Common Core State Standards to focus the initial preparation of teachers. Because states control teacher licensure, this might include providing guidance and resources to states to align state policies with the CCSS.
- ✓ Federal investment in the development of resources might focus on programs and materials that also align with the CCSS so that teachers have strong instructional materials.
- ✓ Expand investment in the assessment consortia to include assessments that go beyond content knowledge in ways that align with the recommendations of the NRC report (these are essential for anchoring teacher assessment/evaluation).
- ✓ Create consortia for the development of <u>teacher</u> assessments that align with the knowledge/skill teachers would need to master to effectively teach to the CCSS.
- ✓ As all teacher preparation programs are pressed to tie their graduates to K-12 student outcomes, invest in strategies that would enable teacher preparation programs to track their graduates across states.

<u>The Role of the National Science Foundation in Teacher Preparation, Induction, and Professional Development</u>

The NSF plays a critical role in supporting both innovation and research on teacher support programs. It has played three roles: (1) the development of programs, practices, and tools (curriculum, assessments, etc.) for teacher development; (2) the development of networks (i.e., “systems” or “partnerships”) of stakeholders who collaboratively work in those programs and/or use those tools; and (3) sponsoring research on the effectiveness of some of those programs/practices/tools.

In the sprawling landscape of programs for teacher support, NSF-sponsored programs play an important role. Most of the time, funding is for four or five years, which allows for a program to be carefully planned and launched. NSF-sponsored programs are required to have a well-articulated theory-of-action, as well as plans for evaluations, so all such programs tend to be more carefully constructed and data driven.

However, the emphasis on launching innovation, however, means that many of those launched programs are not then studied over time in terms of their effects on students or teachers. And because the field lacks robust metrics for student and teacher effects, the limited budgets for evaluation do not allow for extensive research.

Another contribution that NSF-sponsored programs make to the larger field is in the development of professional development leaders. Even when funding ends, programs leave in their wake increased human capital that schools and districts tap into for their own local efforts.

Unfortunately, the three NSF foci (program development, networking, and research) are – at times – in competition with one another, so that the development of programs comes at the expense of empirical research on how teachers learn, what teachers need to know, or the effects of various programs on student engagement and achievement or on teacher knowledge, skill, and practice. It is important that NSF and IES continue to both support the development of innovative programs and fund ambitious basic and applied research on both how teachers learn and the effects of various programs.

Research Gaps in STEM Teacher Preparation and Professional Development

Several Congressionally-mandated efforts have made suggestions concerning the most pressing research areas. As the authors of the NRC's (2010) *Preparing Teachers: Building Evidence for Sound Policy* note:

> There is no system in place to collect data across the myriad teacher preparation programs and pathways in the United States. Thus, we can say little about the characteristics of aspiring teachers, the programs and pathways they follow, or the outcomes of their preparation. (p. 174)

This is equally true of professional development programs. The federal government could play a major role in the development of such a data system.

The authors of *Preparing Teachers* argued forcefully that we need research that studies core features of teacher preparation, not research that contrasts "traditional" and "alternative." Given the recent diversification of teacher preparation, the three areas they nominated were:

1. comparisons of programs and pathways in terms of their *selectivity*; their *timing* (whether teachers complete most of their training before or after becoming a classroom teacher); and their specific *components and characteristics* (i.e., instruction in subject matter, field experiences);

2. the effectiveness of various approaches to preparing teachers in classroom management and teaching diverse learners; and
3. the influence of aspects of program structure, such as the design and timing of field experiences and the integration of teacher preparation coursework with coursework in other university departments. (p. 174)

The National Academy of Education/NRC Ed in '08 committee on teacher quality made recommendations that resonate with this, noting that

> States, school districts, and the federal government should support research on a variety of approaches to teacher preparation. Investments should be made in research and development on the core practices and skills that early career teachers require; preparation programs should then focus on these skills. (p. 2)

In the area of professional development, the characteristics of high quality professional development nominated by researchers are not linked to measures of impact in terms of student engagement, motivation, continued interest in pursuing STEM disciplines, or student achievement. And because research has demonstrated that school culture and resources play an important role in developing effective teaching,we also need research that links student outcomes to teacher outcomes to school culture, in particular for schools that serve children who do not typically pursue STEM fields.

Finally, there is extraordinary need for research and development in tools and metrics to assess the effects of teacher support programs. These would range from measures of student learning/engagement, of teacher content and professional knowledge, and of classroom practices and school quality.

References

American Educational Research Association and National Academy of Education. (2011). *Getting teacher evaluation right: A brief for policymakers*. Washington, DC: Authors.

National Academy of Education. (2009). *Teacher quality: A white paper report*. (S. M. Wilson, Ed.). Washington, D.C.: Author.

National Research Council. (1996). *National science standards*. Center for Science, Mathematics, and Engineering Education (CSMEE). Washington, D.C.: The National Academies Press.

National Research Council and National Academy of Education. (2010). *Getting value out of value-added: Report of a workshop.* Committee on Value-Added Methodology for Instructional Improvement, Program Evaluation, and Educational Accountability (H. Braun, N. Chudowsky, & J. Koenig, Eds.). Center for Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

National Research Council. (2010). *Preparing teachers: Building evidence for sound policy*. Committee on the Study of Teacher Preparation Programs in the United States. Washington, D.C.: The National Academies Press.

National Research Council. (2011). *Successful K-12 STEM education: Identifying effective approaches in science, technology, engineering, and mathematics.* Committee on Highly Successful Science Programs for K-12 Science Education. Board on Science Education and Board on Testing and Assessment, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.