U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE AND TECHNOLOGY
SUBCOMMITTEE ON RESEARCH AND SCIENCE EDUCATION

HEARING CHARTER

Engineering in K-12 Education

Thursday, October 22, 2009
10:00 p.m. – 12:00 p.m.
2325 Rayburn House Office Building

1. Purpose

The purpose of this hearing is to examine the potential benefits of, challenges to, and current models for incorporating engineering education at the K-12 level.

2. Witnesses

- **Dr. Linda Katehi,** Chair, National Academy of Engineering Committee on K-12 Engineering Education, and Chancellor, University of California, Davis
- **Dr. Thomas Peterson,** Assistant Director for Engineering, National Science Foundation (NSF)
- **Dr. Ioannis Miaoulis**, President and Director, Museum of Science, Boston and Founder, National Center for Technological Literacy
- **Dr. Darryll Pines,** Dean and Nariman Farvardin Professor of Engineering, A. James Clark School of Engineering, University of Maryland, College Park
- **Mr. Rick Sandlin,** Principal, Martha and Josh Morriss Mathematics and Engineering Elementary School, Texarkana, Texas

3. Overarching Questions

- How can engineering concepts be incorporated at the K-12 level? What are the potential benefits of pre-college engineering education? Can engineering be added to the classroom without sacrificing core competencies in math and science? What are reasonable learning outcomes for engineering education at the elementary school level? What about middle and high school?
- What are the current models and initiatives for teaching engineering at the K-12 level? What kind of curricula have been used and how were such curricula developed? What has been done in terms of curricula that combine K-12 engineering with science and math in an integrated approach? To what extent have these efforts

increased student learning and/or interest in STEM, and what metrics were used to carry out those assessments of learning and interest? What are the biggest challenges and barriers to incorporating engineering education in the elementary or secondary school classroom?

- What is the current state of research on engineering education at K-12? What are the biggest unanswered research questions? What assessment tools exist for evaluating the effectiveness of engineering education in primary and secondary school, and what are the barriers to improving assessment?

4. **Background**

Over the past decade, a variety of studies have documented the decline of American students' interest and achievement in science, technology, engineering, and math (STEM) fields, as well as the growing gap between American students' achievement compared to their international counterparts in these fields. A consensus now exists that improving STEM education throughout the nation is a necessary condition for preserving the United States' capacity for innovation and for ensuring the nation's economic strength and competitiveness. The 2005 National Academies report, "Rising Above the Gathering Storm," cited a vast improvement of science and math education as the highest priority policy recommendation for our nation to maintain its competitiveness in the 21st century global economy.

In recent years, a variety of educators and other STEM education stakeholders have advocated for pre-college engineering education, arguing that our current STEM education system is out-dated given the skills needed by today's workforce.

Engineering education has been introduced to a small but growing number of K-12 classrooms in the United States. The National Academy of Engineering study committee on K-12 engineering education estimates that six million elementary and secondary students have been exposed to engineering-related coursework. However, the implementation of such engineering education varies greatly in classrooms across the country, ranging from ad hoc infusion of engineering activities and ideas into existing science or math classes to stand-alone courses on engineering.

While K-12 engineering education is a relatively new phenomenon, there is much to suggest it has the potential to have profound implications for engineering fields as well as STEM education as a whole. While there is a critical need for more research and data on the impacts of K-12 engineering education efforts, preliminary research findings suggest that K-12 engineering education has the potential to not only increase the awareness of the work of engineers, boost youth interest in pursuing careers in engineering, and increase the technological literacy of students, but may also improve student learning and achievement in science and math.

Since it is such a new field for pre-college students, unlike science, math, and to a certain extent, technology education, many questions remain unanswered regarding how engineering education at the K-12 level is defined, designed, and implemented. At present, there are no established learning standards for K-12 engineering education, nor is there much in the way of professional development for teachers. Furthermore, most K-12 engineering education has been implemented in an ad hoc fashion and there is very little coordination between the various programs and curriculum developers, making it more difficult to compare programs and evaluate impacts.

National Academies Report on Engineering in K-12 Education

In order to begin to address some of these unanswered questions, in 2006, the National Academy of Engineering (NAE) and the National Academies' Center for Education established the Committee on K-12 Engineering Education to undertake a study regarding the creation and implementation of K-12 engineering curricula and instructional practices, focusing on the connections among science, technology, and mathematics education. In September 2009, the study committee released a report entitled, "Engineering in K-12 Education: Understanding the Status and Improving the Prospects," summarizing the key findings of the study and providing guidance to key stakeholders regarding future research and practice. The committee looked at the current scope and nature of K-12 engineering education and examined available curricula as well as professional development programs for teachers. Many of the recommendations stressed the need for continued investment in research in this area. Another key conclusion of the report was that engineering education could potentially serve as the catalyst for a less "siloed" approach to STEM education. Many have argued that our current STEM education system does not leverage the natural connections between STEM subjects. The NAE Committee suggests that engineering could be used as a tool to develop a more interconnected STEM education system in our Nation's K-12 schools.

Diversity

The lack of diversity in engineering fields is a well documented problem in the United States. In July of this year, the Subcommittee held a hearing to examine the status of participation and achievement of female students in STEM fields. Witnesses testified on the continued lack of participation of girls and young women in certain STEM fields, most notably in the engineering fields. The Subcommittee also plans to hold a series of hearings on the participation of historically under-represented minorities in STEM. Research findings suggest that women and other under-represented groups face unique challenges at multiple stages of the STEM pipeline, beginning at an early age. By helping to make STEM learning more tangible and relevant to students, pre-college engineering education has the potential to attract a more diverse group of students to STEM fields.

5. K-12 Engineering Education and Research at NSF

STEM education research and activities are funded by a number of federal agencies, with NSF being the primary source of support for STEM education research. Historically, NSF's mission has included supporting and strengthening the nation's STEM research and education activities at all levels. NSF funds research on K-12 engineering education as well as a variety of K-12 engineering education activities ranging from teacher training to curriculum development. Many of the Foundation's STEM education and research activities are housed in the Directorate for Education and Human Resources (EHR), but some K-12 engineering activities are funded out of NSF's Engineering Directorate through the Engineering Education and Centers (EEC) Division, which funds work that encourages the integration of engineering research and education with the goal of improving the quality and diversity of engineering graduates entering the workforce.

In his testimony, Dr. Peterson will provide more detailed information regarding the K-12 engineering research and activities funded by NSF. As an example, the GK-12 program, which provides funding for graduate students to bring their research practice and findings to K-12 classrooms, funds a variety of projects that place graduate engineering students into high schools in their communities to do hands-on engineering activities. In addition, the Research and Evaluation on Education in Science and Engineering (REESE) program has funded research on evaluation of pre-college engineering curricula. The Museum of Science, Boston, represented at the hearing by Dr. Miaoulis, also received support from NSF for the development of their "Engineering is Elementary" Curriculum.

6. Questions for Witnesses

Linda Katehi

1. Please summarize the findings and recommendations of the recent National Academy of Engineering report, "Engineering in K-12 Education: Understanding and Status and Improving the Prospects."

2. What is the current state of research on engineering education at the K-12 level? What do we know about the influence of early exposure to engineering concepts on student interest and achievement in STEM fields in the elementary, middle, and high school years? What are the most important unanswered research questions?

3. What metrics and methodologies exist for evaluation and assessment of K-12 engineering education? What are the barriers to developing better metrics? Is the current level of support for research in these areas adequate?

Michael Peterson

1. How is engineering education incorporated into NSF's K-12 STEM education programs, including the Math and Science Partnerships Program and K-12 education programs within the Engineering Directorate?

2. What is the current state of research on engineering education at the K-12 level? What do we know about the influence of early exposure to engineering concepts on student interest and achievement in STEM fields in the elementary, middle, and high school years? What are the most important unanswered research questions?

3. What is the current level of support and scope of NSF-funded research on K-12 engineering education? How much of NSF's research support in this area is funded out of the Engineering Directorate? How much research support is funded through Education and Human Resources Directorate programs? How do you communicate the findings supported by your division to your colleagues in the Education and Human Resources Directorate and vice versa?

4. What metrics and methodologies exist for evaluation and assessment of K-12 engineering education? What are the barriers to developing better metrics? What is or should be NSF's role in developing those metrics?

Ioannis Miaoulis

1. Please describe the mission and work of the Museum of Science, Boston's National Center for Technological Literacy (NCTL.) How did NCTL develop its K-12 engineering curricula? What have you learned about combining engineering concepts with science and math in an integrated approach to K-12 STEM education? To what extent have these efforts increased student learning and/or interest in STEM, and what metrics were used to carry out those assessments of learning and interest?

2. Where has NCTL received its financial support? What types of federal resources were most valuable in supporting the development of NCTL's engineering education programming? Has the NCTL partnered with stakeholders in the private sector and/or academia for intellectual and financial support? If so, what is the nature of such partnerships?

3. What do you see as the biggest challenges and barriers to incorporating engineering education in the elementary or secondary school classroom?

4. What is the appropriate role of informal learning environments, such as museums, in educating students and teachers about engineering design?

Darryll Pines

1. As a dean of an engineering school, what do you consider to be the necessary skills that make for a successful undergraduate engineering student? Which of those skills should students ideally possess upon enrolling in the university? Which of those skills are better taught and learned at the undergraduate level?

2. What do you consider to be the potential benefits of pre-college engineering education, and at what grade level would you suggest beginning to introduce engineering concepts? What do you see as potential challenges or disadvantages of pre-college engineering education?

3. Please describe the University of Maryland's (UMD) K-12 engineering programs and initiatives. Do these programs involve formal partnerships with local K-12

schools, and if so, what is the nature of such partnerships? How do you evaluate the effectiveness of these programs and partnerships? What kind of engineering related professional development programs does the University provide for K-12 teachers? Does UMD incorporate engineering into any of its degree or certification programs for pre-service STEM teachers?

Rick Sandlin

1. Please describe the establishment of the Martha and Josh Morriss Mathematics and Engineering Elementary School. What was the impetus for its development? What role did partnerships with local businesses and institutes of higher education play in the development of the school?

2. What do you consider to be the benefits of pre-college engineering education? Can engineering be added to the classroom without sacrificing core competencies in math and science? What are reasonable learning outcomes for engineering education at the elementary school level? What do you consider to be the biggest challenges and barriers to incorporating engineering education in the elementary school classroom?

3. What kind of curricula does the school use? What percentage of your teachers have engineering degrees? What kind of teacher training and professional development opportunities do you provide for your teachers?

4. Once a student has completed the elementary grades at your school, do they have the opportunity to go on to a STEM-focused middle school? Are there programs in place to ensure these students maintain an interest in STEM subjects as they transition to middle school and high school?