Statement by

Dr. Ioannis Miaoulis, President and Director of the Museum of Science, Boston and Founding Director of the National Center for Technological Literacy on STEM Education and America COMPETES Reauthorization before the Senate Commerce, Science, and Transportation Committee

May 6, 2010

Good morning and thank you Mr. Chairman, Ranking Member, and members of the committee. It is an honor to be invited back to discuss our nation's ability to create a first class, competitive, and innovative workforce. My focus, and the work of the Museum of Science, Boston and the National Center for Technological Literacy ® (NCTL®), is at the very beginning of that process, working with young students in elementary and secondary school.

One of the Museum's primary missions is to promote and be a resource for the advancement of science, technology and engineering education. As New England's premiere source of public learning experiences, the Museum of Science serves as the go-to place for educators, students, and the public wishing to explore the relationship between science and technology through exhibits, planetarium shows, the Lyman Library, courses, and programs for all ages and abilities. The Museum also collaborates with partners throughout the nation to develop instructional materials and professional development programs for teachers and school administrators about how new technologies are created using the engineering design process.

The NCTL seeks to integrate engineering as a new discipline in schools nationwide and to inspire the next generation of engineers and innovators. The NCTL partners with educators, administrators, organizations, and industry representatives across the United States to introduce or modify standards related to technology and engineering and to provide cutting-edge curricular resources. Working together, we can engineer a better world for generations to come through our K-12 curricular and professional development programs, advocacy efforts, and museum programs.

Four years ago, I was invited to testify before the Science, Technology and Innovation Subcommittee to discuss K-12 engineering education, *Rising Above the Gathering Storm*, and what culminated in the America COMPETES Act (ACA). This ambitious, bi-partisan effort helped rejuvenate our STEM educational and R&D obligations and placed a new focus on STEM as a national priority. Unfortunately, we have not been able to live up to many of the goals set forth under the law – particularly in providing resources for STEM education programs, including many programs at the Departments of Energy and Education. The requisite funding did not materialize to make all these valiant programs and promises come true. Although some programs were funded either through appropriations or the Recovery Act, my concern is that very little was done in the K-12 STEM education space and even less was done for informal science education.

ENGINEERING EDUCATION PROGRESS SINCE ENACTMENT OF ACA

Despite the shortage of federal funding, there have been a number of significant developments since the enactment of ACA that have helped advance K-12 STEM education, particularly technology and engineering education. (Why K-12 Engineering? See Appendix A.)

The National Governors Association's report, "Building a STEM Agenda,"[i] recommended that states should develop standards and assessments in technology and engineering as well as math and science. The NGA was able to provide grants to six states to build their STEM education infrastructure and the NCTL has served as a resource to the NGA Center for Best Practices in this regard working most recently with Ohio and Minnesota in revising their state standards to include engineering. The NGA is also working with the National Academies Board on Science Education on developing common core science standards that will most likely include the engineering design process.

The new National Assessment of Educational Progress (NAEP aka the Nation's Report Card) for Science administered in 2009[ii] measured student technological design skills for the first time in history. The results will be available this summer. The NCTL worked to insure that this assessment include technological design because it resides in both the National Science Education Standards[iii] and Benchmarks for Scientific Literacy.[iv] The term "technological design" refers to the process that underlies the development of all technologies, from paper clips to space stations. The National Science Education Standards explain that this meaning "is not to be confused with 'instructional technology,' which provides students and teachers with exciting tools—such as computers—to conduct inquiry and to understand science."

In 2014, NAEP will administer the first-ever, computer-based assessment of Technology & Engineering Literacy.[v] Again, the NCTL worked to insure that engineering design be a component of this assessment, which was originally entitled NAEP Technological Literacy. This assessment will have three topical areas – use of information and communication technology, engineering design and systems thinking, and technology and its impacts on society.

Engineering is also a key component of the Museum's informal educational programs and exhibits. The National Research Council report, "Learning Science in Informal Environments: Places, People, and Pursuits,"[vi] found that, "tens of millions of Americans, young and old, choose to learn about science in informal ways - by visiting museums and aquariums, attending after-school programs, pursuing personal hobbies, and watching TV documentaries, for example." The report also notes that informal learning experiences can significantly improve outcomes for individuals from groups historically underrepresented in science.

In 2009, the National Academy of Engineering and the National Research Council released, “Engineering in K-12 Education: Understanding the Status and Improving Prospects,” [vii] which found several potential benefits of K-12 engineering education, including improved learning and achievement in science and mathematics; increased awareness of engineering and the work of engineers; understanding of and the ability to engage in engineering design; and interest in pursuing engineering as a career; and, increased technological literacy. The report notes that several million K-12 students have experienced some formal engineering education. As of March 2010, one of our NCTL curricular projects, Engineering is Elementary,® has reached 18,200 teachers and over 1.1 million students in all 50 states and the District of Columbia and is highlighted throughout the report.

Since the enactment of ACA, numerous universities, community colleges, consortia and science museums have established or expanded engineering education programs for pre-service and in-service K-12 teachers.[viii] We have partnerships in 20 states including ME, NH, TX, OH, ND, NC, MN, NJ, PA, etc. (Appendix B)

States are also increasingly incorporating engineering into their science standards and assessments, like Massachusetts, including Ohio, Minnesota, Oregon, Washington, and Tennessee (Appendix C).

The professional association for technology teachers recently changed their organizational name to the International Technology *and Engineering* Education Association to better reflect the content of their instruction. This organization is also responsible for the development of the “Standards for Technological Literacy,”[ix] which most states have adopted, that includes the designed world and the engineering design process.

By far, the most exciting recent development in K-12 engineering education is the introduction of S.3043 on February 25, by Senators Gillibrand, Kaufman, Snowe, Cantwell, Klobuchar, and Murray. A companion bill, H.R.4709, was introduced by Representative Paul Tonko on the same day. More than 100 organizations are supporting this bill, including Intel, IBM, and Lockheed Martin. (Appendix D)

The Engineering Education for Innovation Act (E^2 for Innovation Act), based on the findings of the NAE K-12 Engineering report, will support K-12 engineering education and related evaluation research. In general, this legislation authorizes the Secretary of Education to competitively award planning and implementation grants for state educational agencies to integrate engineering education into K-12 curriculum and instruction. It also funds the research and evaluation of such efforts. Specifically, the E^2 for Innovation Act will enable states to:

- integrate engineering education into K-12 instruction by designing challenging content and curricula frameworks and assessments that include engineering;
- increase engineering and technology teacher preparation programs and recruit qualified teachers to provide engineering education in high-need schools;
- increase student achievement in STEM subjects and knowledge and competency in engineering design skills;
- promote aspirations for a career in engineering among diverse student populations, especially among girls and underrepresented minorities;
- invest in afterschool engineering education programs; and
- promote partnerships among K-12 school administrators and teachers and engineering professionals.

RECOMMENDATIONS

Given these positive developments in K-12 engineering education and informal science learning, and on behalf of the Museum of Science, our National Center for Technological Literacy, and hundreds of like-minded organizations, I offer the following policy recommendations as you consider reauthorization of the America COMPETES Act:

First and foremost, Congress should enact S.3043 as part of America COMPETES or included as part of the STEM initiative under the Elementary and Secondary Education Act (ESEA). K-12 engineering education will catalyze the development of a highly skilled STEM workforce necessary to insure our global competitiveness and national security.

Congress should highlight and support NASA's ability to be a leader among federal agencies in K-12 and informal engineering education. As a member of the NASA Education and Public Outreach Committee, I am alarmed by all the reports that NASA will face a shortage of engineers in the near future due to retirements. NASA is unique in its ability to inspire students to pursue high-tech careers in engineering and the Congress should continue to make this issue a priority for the agency and direct programmatic support and funding accordingly.

Congress should highlight and support NSF's commitment to Education and Human Resource development by providing for a balanced portfolio of research and development funds. The recent shift in focus to research has shortchanged the development of innovative interventions. The House COMPETES bill, H.R. 5116, includes many important provisions for informal science education and engineering education research. I also believe that broader impacts and greater public understanding can be achieved if grantees are directed to partner with outreach entities, such as informal STEM education institutions that have a proven record of success communicating STEM research to the general public.

We support efforts to improve coordination among the federal agencies on STEM education and the creation of a STEM advisory committee of relevant stakeholders including engineering education providers and informal STEM education institutions.

We urge Congress to support the President's proposed RE-ENERGYSE - Regaining our Energy Science and Engineering Edge - initiative at the Department of Energy that includes K-12 and informal educational components to promote and support innovative approaches to foster sustainability and energy literacy.

Finally, the Museum is also concerned with public education concerning new technologies and in public engagement with science and technology policy. The Museum has joined forces with the Science and Technology Innovation Program at the Wilson Center, the Consortium of Science, Policy, and Outcomes at Arizona State University, Science Cheerleader, and the Loka Institute to create a nationwide network to conduct Expert & Citizen Assessment of Science & Technology (ECAST). The ECAST network will combine the skills of nonpartisan policy research organizations with the research strengths of universities and the public outreach and education capabilities of science museums. By educating and engaging laypeople, participatory technology assessment enables decision-makers to learn of their constituents' informed views regarding emerging developments in science and technology. We urge Congress to support OSTP and GAO in efforts to support ECAST and engage the public in discourse about STEM-related policy issues.

Again, I thank the Chairman for the invitation to participate in this hearing and the Committee members for their attention to this issue of American competitiveness and K-12 engineering education. I look forward to working with this Committee, the Congress and this Administration in advancing an innovative U.S. workforce. Please let me know if you have questions or need additional information.

APPENDICES

A. Why K-12 Engineering?

1. Technological Literacy is Basic Literacy
How can one claim to be literate if she does not understand how 95% of her environment works, or how it was made? Understanding how an engineer designs is just as important as understanding how a scientist thinks.

2. Engineering Promotes Problem Solving and Project-Based Learning
The Engineering Design Process starts by identifying a need or a problem. It follows an organized path to arrive at one or more solutions that satisfy the need or solve the problem. Problem solving skills are far more valuable than many of the other skills that are the focus of our K-12 educational systems.

3. Engineering Makes Math and Science Relevant
Engineering makes math and science relevant which is critical in the middle school and high school years. Relevance is particularly important for retention of girls in science fields. Girls gravitate toward science disciplines that have an evident benefit to society. Half of the medical school students are women, and women comprise the majority of students in the life sciences. In some highly competitive veterinary schools, more than 80% of the students are female. Ability is clearly not the limiting factor. Engineering in K-12 can make science relevant and improve student interest, especially among girls.

4. Engineering as a Career
In order to preserve the innovation culture in the U.S., numerous committees have issued reports calling for an increase in support of K-12 mathematics and science education. What these reports have missed is that the connector between math, science, and innovation is engineering. We also know that a majority of existing engineers where inspired to pursue engineering by a family member. If we want to diversify this workforce of predominantly white men, we cannot rely on them alone to expose and inspire the next generation of engineers. We cannot expect more high school students to enroll of engineering if they have never heard of it before. To broaden and diversify this pipeline or pathway into engineering, we must expose all students to engineering, starting in the very early grades, before they are able to opt out of an engineering or STEM career pathway. Unless this connection is made in school, the number, gender, and race of future engineers will continue to fall short of current and future demands.

5. Navigating in a Three-Dimensional World
We live in a three dimensional world and we should be able to conceptualize it as such. At times we all have to imagine and sometimes sketch things in three dimensions for considering optimal designs, for example when we redesign a kitchen or set up a warehouse. Children now spend most of their discretionary time in front of 2-D screens, televisions, video games, laptops, MP3 players, and mobile phones.

Building, tinkering, and other 3-D activities that previously engaged mostly boys are no longer the preferred pastime. We have started creating generations of people that will not be able to visualize and design in three dimensions. This will not only affect the abilities of future engineers, designers, and architects, but also deprive people from a basic life skill. By introducing engineering in K-12 schools we will remediate this issue for both boys and girls.

B. NCTL Partnerships and Collaborations

Formal Educational Partnerships

BEST – Building Engineering and Scientific Talent
National Defense Education Program, US Department of Defense
Maine Mathematics and Science Alliance
Minnesota Department of Education
New Hampshire Department of Education
Stevens Institute of Technology, NJ
Transformation 2013, TX
Valley State City University, ND
Villanova University College of Engineering, PA

Educational Collaborations

Aldine Independent School District, TX
Bristol Community College, MA
Charles Dana Center, TX
Education Service Center (ESC) Region 1 – Edinburg, TX
ESC Region 3 – Victoria, TX
ESC Region 4 – Houston, TX
ESC Region 9 - Wichita Falls, TX
ESC Region 11 - Fort Worth, TX
ESC Region 12 – Waco, TX
ESC Region 16 – Amarillo, TX
ESC Region 18 – Midland, TX
Falcon School District #49, CO
Georgia Department of Education
Hofstra University, NY
Holyoke Community College, MA
Long Beach Unified School District, CA
Massachusetts Department of Elementary and Secondary Education, MA
Minorities in Mathematics, Science, and Engineering, OH
Mobile Area Education Foundation, AL
Montgomery County ESC – Dayton, OH
National Governors Association, Center for Best Practices
North Carolina State University, NC
Northern Essex Community College, MA
North Central Texas College, TX
Ohio Department of Education, OH
Oregon Museum of Science and Industry, OR
Oregon State University, OR
Pennsylvania Department of Education, PA
Purdue University, IN
Putnam County Education Service Center, OH
Sally Ride Academy, WI
Science and Math on the Move Center, OH
Science Museum of Minnesota, MN
Stark County Education Service Center, OH
Texarkana ISD, TX
Towson University, MD
Tufts University, MA
University of Louisville, KY
University of Maryland Baltimore County, MD
University of Alabama, Huntsville, AL
University of Cincinnati, OH
University of Texas - Austin
Vermont Department of Education, VT
Wichita Falls ISD, TX
Worcester Polytechnic Institute, MA

C. State Engineering Standards Snapshot

Massachusetts
In 2000, Massachusetts became the first state in the nation to develop and adopt Science and Technology/Engineering standards and subsequently implemented a statewide assessment which measures technology/engineering knowledge and skills. Technology/Engineering is considered a core science content area.

Vermont
In 2000, Vermont standards included a strand entitled Science, Mathematics, and Technology, which focuses on design and technology, an integral part of engineering.

New Jersey
In 2004, New Jersey adopted New Jersey Core Curriculum Content Standards for Technological Literacy. Standard 8.2 states that all students will develop an understanding of the nature and impact of technology, engineering, technological design, and the designed world as they relate to the individual, society, and the environment.

Maryland
In 2005, Maryland adopted the Voluntary State Curriculum (VSC) that identifies five overarching themes in Technology Education: the Nature of Technology; the Impacts of Technology; Engineering Design and Development; Core Technologies; and, the Designed World. Maryland differentiates Technology Education from Technology Literacy for Students (computer literacy skills).

New Hampshire
In 2006, the NH Department of Education recognized the importance of "enabling our children to understand how humans modify the natural world to solve problems and to meet human needs and desires is equally as important as teaching them how to inquire about the natural world," and modified their curriculum framework to include design technology.

Texas
In 2007, the Texas legislature enacted a requirement for four years of high school science; engineering is a considered an eligible science course. Since Spring 2008, writing teams have been working to review the current Texas Essential Knowledge & Skills (TEKS) and make recommendations for revisions. One of the clusters is Science, Technology, Engineering and Mathematics

Tennessee
In 2007, Tennessee revised their state K-8 science standards by embedding both inquiry and technology and engineering design. For example, in grade four, students should be able to: describe how tools, technology, and inventions help to answer questions and solve problems; recognize that new tools, technology, and inventions are always being developed; identify appropriate materials, tools, and machines that can

extend or enhance the ability to solve a specified problem; and, recognize the connection between scientific advances, new knowledge, and the availability of new tools and technologies.

Oregon
In 2009, the Oregon Department of Education that revised their state science standard into four core strands: Standard I, *Structure and Function*, and II, *Interaction and Change*, describe the big ideas in the three science disciplines of physical, life, and Earth and space. Standard III, *Scientific Inquiry*, and IV, *Engineering Design*, describe the science process skills and understandings that characterize the nature and practice of science and engineering design. These process standards are intended to be interwoven with content in the three science disciplines.

National Governors Association STEM Grant States
In 2007, NGA awarded six states**:** Colorado, Hawaii, Minnesota, Ohio, Pennsylvania and Virginia $500,000 matching grants to establish science, technology, engineering and mathematics (STEM) education centers in their states. The grants are helping states create new or repurpose existing STEM centers. The centers will serve as the foundation for an improved workforce by:

- Aligning K-12 STEM education requirements with postsecondary and workplace expectations;
- Improving the quantity and quality of STEM teachers;
- Benchmarking state K-12 STEM standards, assessments and curricula to top performing nations in STEM education achievement and attainment;
- Garnering public will for change to implement a better aligned system; and
- Identifying best practices in STEM education and bringing them to scale.

D. Organizations that Support S.3043/H.R.4709, the Engineering Education for Innovation Act (E^2) (as of 5/5/2010)

Quote from Norm Augustine, former CEO, Lockheed Martin Corporation, and Gathering Storm report committee member.

"One of the many reasons our nation does not seem to attract young people into engineering is that many seem to have no idea what an engineer does. Although we attempt to teach math and science in K-12, seldom do we expose students to engineering. Congratulations on this fine effort (to introduce K-12 engineering legislation)...I believe it is well aimed."

1. Alabama Mathematics, Science, and Technology Education Coalition (AMSTEC)
2. American Chemical Society
3. American Society for Engineering Education
4. American Society of Civil Engineers
5. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
6. Arc Capital Development

7. ASME Center for Public Awareness
8. Association of Science and Technology Centers
9. Bechtel Power Corporation
10. BEST Robotics, Auburn University
11. Center for Innovation in Engineering and Science Education, Stevens Institute of Technology
12. Center for Mathematics and Science Education, Teaching and Technology at John Carroll University
13. Center for Mathematics, Science, and Technology
14. Center for Minority Achievement in Science and Technology
15. Center for the Advancement of STEM Education
16. Chicago Educational Publishing Company
17. Colorado Technology Education Association
18. Consortium for School Networking
19. Cuyahoga Falls High School Technology Education Department
20. Delaware Foundation for Science and Mathematics Education
21. Depco, LLC, Pittsburg, KS
22. East Central Ohio Technology Education Association
23. Eastwood Middle School Career Cluster Technologies, AL
24. Engineering & Technology Educators of Indiana
25. Hockaday School
26. Hofstra University Center for Technological Literacy
27. IBM Corporation
28. IEEE-USA
29. Illinois Mathematics and Science Academy
30. Illinois State University, Center for Mathematics, Science, & Technology
31. INSPIRE, Institute for P-12 Engineering Research and Learning, Purdue University
32. Intel Corporation
33. International Technology and Engineering Education Association
34. International Technology and Engineering Education Association/Council for Supervision and Leadership
35. JETS
36. Kentucky Engineering & Technology Education Association
37. Learning Institute for Technology Education, MI
38. LearnOnLine, Inc.
39. Lockheed Martin Corporation
40. Massachusetts Technology/Engineering Education Collaborative
41. MassTEC
42. Museum of Science, Boston
43. National Alliance for Partnerships in Equity
44. National Association of State Directors of Career Technical Education Consortium
45. National Center for Technological Literacy
46. National Council of Teachers of Mathematics
47. National Girls Collaborative Project
48. National Institute of Building Sciences

49. National Middle Level Science Teachers Association
50. National Science Education Leadership Association
51. National Science Teachers Association
52. National Society of Black Engineers
53. National Society of Professional Engineers
54. New Jersey Technology Education Association
55. New York Hall of Science
56. New York State STEM Education Collaborative
57. New York State Technology Education Association
58. North Carolina Technology Education Association
59. North Dakota State University's College of Engineering and Architecture
60. North East Ohio Technology & Engineering Educators Association
61. Ohio Engineering Deans' Council
62. Ohio Northern University
63. Ohio Technology and Engineering Educators Association
64. Ohio Technology Education Advisory Council
65. Ohio Technology Education Association
66. Pathways into Science
67. Pennsylvania Technology Student Association
68. Project Lead the Way
69. PTC
70. PTC-MIT Consortium
71. Real World Design Challenge
72. Rensselaer Polytechnic Institute, School of Engineering
73. Science Museum of Minnesota
74. Skillpoint Alliance
75. Sloan Career Cornerstone Center
76. Society of Women Engineers
77. South Carolina's Coalition for Mathematics & Science
78. Stevens Institute of Technology, Center for Innovation in Engineering and Science Education, NJ
79. Teachers Clearinghouse for Science and Society Education
80. Technology Education Association of Maryland
81. Technology Education Association of Pennsylvania
82. Technology Education Department at Cuyahoga Falls High School, OH
83. Technology Is Elementary
84. The CAD Academy
85. The Engineering Place at North Carolina State University
86. The Learning Institute for Technology Education
87. The Ohio Academy of Science
88. The Pittsburgh Regional Center for Science Teachers
89. The STEM Academy
90. The Teachers Clearinghouse for Science and Society Education
91. Triangle Coalition
92. Tuscaloosa City Schools, Career Cluster
93. Tuscaloosa Magnet Middle School

94. University of California
95. University of Pittsburgh at Johnstown
96. Urban STEM Strategy Group, Philadelphia
97. Valley City State University, ND
98. Vernier Software & Technology
99. Western Illinois University College of Business and Technology
100. Western Illinois University School of Engineering
101. Wisconsin Science Network
102. Wisconsin Technology & Engineering Education Association
103. Worcester Polytechnic Institute, K-12 Outreach Office

---

[i] National Governors Association, Building a Science, Technology, Engineering and Math Agenda, February 2007, page 2.

[ii] National Assessment Governing Board, "Science Framework for the 2009 NAEP," September 2008, pages 76-80.

[iii] National Science Education Standards, National Research Council, 1996.

[iv] Benchmarks for Scientific Literacy, American Association for the Advancement of Science, 1993

[v] National Assessment Governing Board, "National Assessment of Educational Progress (NAEP) Technology and Engineering Literacy Framework and Test Item Specifications," www.edgateway.net/cs/naepsci/print/docs/470.

[vi] National Research Council, "Learning Science in Informal Environments: Places, People, and Pursuits," January 2009,

[vii] National Academy of Engineering and National Research Council, "Engineering in K-12 Education," September 2009, pages 49-62.

[viii] A sampling of Institutions with of pre-service and in-service K-12 engineering education programs: Stevens Institute of Technology, Virginia Tech, Purdue University, North Carolina State University, Valley City State University, Holyoke Community College, Fitchburg State College, National Center for Engineering & Technology Education, Museum of Science, Boston, Science Museum of Minnesota, Oregon Museum of Science & Industry

[ix] International Technology and Engineering Education Association, Standards for Technological Literacy, 2000, Standard 9, page 99-105.