

**THE ROLE OF THE NATIONAL SCIENCE
FOUNDATION IN K-12
SCIENCE AND MATH EDUCATION**

HEARING

BEFORE THE

**COMMITTEE ON SCIENCE
HOUSE OF REPRESENTATIVES**

ONE HUNDRED NINTH CONGRESS

SECOND SESSION

MAY 3, 2006

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THE ROLE OF THE NATIONAL SCIENCE FOUNDATION IN K-12 SCIENCE AND MATH EDUCATION

WEDNESDAY, MAY 3, 2006

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE,
Washington, DC.

The Committee met, pursuant to call, at 10:05 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Bob Inglis [Acting Chairman of the Committee] presiding.

**COMMITTEE ON SCIENCE
U.S. HOUSE OF REPRESENTATIVES**

***The Role of the National Science Foundation in K-12 Science
and Math Education***

Wednesday, May 3, 2006
10:00 a.m. – 12:00 p.m.
2318 Rayburn House Office Building (WEBCAST)

Witness List

Dr. Dennis Bartels
Executive Director
The Exploratorium

Dr. Joseph Heppert
Chair, Department of Chemistry
University of Kansas
Chair, Committee on Education
American Chemical Society

Ms. Rebecca Pringle
Physical Science Teacher
Susquehanna Township Middle School
Member, Executive Board
National Education Association

Ms. Judy Snyder
Mathematics Teacher
Eastside High School

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HEARING CHARTER

**COMMITTEE ON SCIENCE
U.S. HOUSE OF REPRESENTATIVES**

**The Role of the National Science
Foundation in K-12
Science and Math Education**

WEDNESDAY, MAY 3, 2006
10:00 A.M.—12:00 P.M.
2318 RAYBURN HOUSE OFFICE BUILDING

1. Purpose

On Wednesday, May 3, 2006, the Committee on Science of the U.S. House of Representatives will hold a hearing to review the effectiveness and value of the National Science Foundation's (NSF's) past and present programs in support of improvement of K-12 science and math education and to examine what role the Foundation should play in future federal initiatives for strengthening K-12 science and math education.

This hearing follows up on the March 30 Science Committee hearing entitled, "K-12 Science and Math Education Across the Federal Agencies," which featured Secretary of Education Margaret Spellings, NSF Director Arden Bement, and representatives from the National Aeronautics and Space Administration, the National Oceanographic and Atmospheric Administration, and the Department of Energy. The officials outlined their individual agencies' activities to improve K-12 science and math education and described interagency coordination efforts. The charter for that hearing is attached (Appendix I).

The 2005 Presidential Awards for Excellence in Mathematics and Science Teaching will be announced the week of May 1, and a number of the awardees will be present at the Science Committee hearing. Immediately following the hearing, the Chairman will invite the awardees to participate in a question-and-answer session with Science Committee Members to discuss the teachers' experience with K-12 science and math education and NSF.

2. Witnesses

Dr. Dennis Bartels is the Executive Director of The Exploratorium science museum in San Francisco. Before joining the Exploratorium in May 2006, he was the President of TERC, a Massachusetts-based not-for-profit education research and development organization dedicated to improving science, math, and technology teaching and learning.

Dr. Joseph Heppert is a Professor and Chair of Chemistry and Director of the Center for Science Education at the University of Kansas. He also chairs the American Chemical Society Committee on Education.

Ms. Rebecca Pringle is a physical science teacher at Susquehanna Township Middle School in Harrisburg, Pennsylvania. She serves on the Executive Board of the National Education Association.

Ms. Judy Snyder is a math teacher at Eastside High School in Taylors, South Carolina. She is a winner of a 2005 Presidential Award for Excellence in Mathematics and Science Teaching.

3. Overarching Questions

- What unique contributions does NSF make to K-12 science and math education programs? What types of programs should NSF sponsor to have the greatest impact on improving the capabilities of science and math teachers? To what extent are these types of programs currently being supported by NSF, and where is there room for improvement?
- Among existing mechanisms for improving K-12 science and math education, what is the correct level of priority to give to providing increased professional development opportunities to improve the subject matter knowledge of science

and math teachers? What is the correct level of priority to give to improving pedagogical skills?

- What types of education programs is NSF best suited to sponsor? What are the relative roles of NSF and the Department of Education in improving K–12 science and math education, and what opportunities exist for collaboration between the two agencies?

4. Brief Overview

- The National Academy of Sciences' report *Rising Above the Gathering Storm*¹ pointed to the relatively poor performance of U.S. students in science and math as a threat to the Nation's long-term economic health. The report's recommendations included attracting new science and math teachers through the use of scholarships and bolstering the skills of the existing science and math teaching corps through extensive professional development opportunities.
- Historically, NSF's mission has included supporting and strengthening science and math education programs at all levels. In the area of K–12, NSF carries out its mission by funding a variety of science and math education activities, including teacher training (both in-service and pre-service), curriculum development, education research, and informal education at museums and science centers.
- NSF also is the primary federal agency with programs focused on improving science and math education at the undergraduate level. At a Science Committee hearing earlier this year, Nobel Prize-winning physicist Carl Wieman emphasized that improving instruction in K–12 science and math education depends on improving the science and math training of the undergraduates who become K–12 teachers. NSF sponsors a number of programs to bolster the science and math skills of the Nation's future teaching corps, including the Robert Noyce Scholarship Program, which provides scholarships to students majoring in science and math fields in exchange for them serving as teachers after graduation.
- In the past few years, funding for NSF education programs, including K–12 and undergraduate programs, has declined. Most NSF education programs are housed in the Education and Human Resources (EHR) Directorate, and the President's budget proposes \$816 million for EHR in fiscal year 2007 (FY07), a level that only begins to restore cuts EHR experienced in previous years (dropping from \$944 million in FY04 to \$797 million in FY06).
- In his State of the Union Address in 2006, President Bush announced an American Competitiveness Initiative, which includes the creation and expansion of a number of programs specifically targeted at improving K–12 science and math education. The President's FY07 budget proposes \$380 million in new funding for these programs, all based at the Department of Education.
- In February 2006, Congress created the Academic Competitiveness Council (ACC), a cabinet-level group tasked with coordinating and evaluating federal activities in science and math education. On March 30, 2006, the Science Committee held a hearing in which the Secretary of Education, the Director of the National Science Foundation, and representatives from the National Aeronautics and Space Administration, the National Oceanic and Atmospheric Administration, and the Department of Energy discussed their efforts to strengthen K–12 science and math education.

5. Background

K–12 Science and Math Education at the National Science Foundation

Science and math education is a cornerstone of the historic mission of the National Science Foundation. The *National Science Foundation Act of 1950*, which established NSF, directed NSF to support and strengthen science and math education programs at all levels. NSF carries out its K–12 mission by supporting a variety of science and math education activities, including teacher training (both in-service and pre-service), curriculum development, education research, and informal education at museums and science centers.

Examples of NSF programs designed to improve teacher performance, enhance understanding of student retention of scientific content, and develop and assess cur-

¹*Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, National Academies Press, Washington, D.C. (2006).

ricula include the Centers for Learning and Teaching, which provide professional development opportunities for K–12 teachers; the Advanced Learning Technologies program, which supports cognitive science research on the use of technology to enhance learning and teaching; and the Instructional Materials Development program, which supports the development of curriculum as well as research into the most effective means of teaching math and science material.

In addition to these programs, other NSF education programs focused on improving K–12 education include the Math and Science Partnership Program and the Robert Noyce Scholarship Program, both authorized as part of the *NSF Authorization Act of 2002* (Public Law 107–368). The Math and Science Partnership Program funds partnerships between universities and local school districts to strengthen the science and math content knowledge of K–12 schoolteachers. The grants are awarded to support the creation of innovative reform programs that could be expanded to the state level if successful. The Robert Noyce Scholarship Program is designed to help recruit highly-qualified science and math teachers through grants to college and universities to give scholarships to science and math majors in return for their commitment to teach at the elementary or secondary school level.

Additionally, a number of programs exist at NSF to improve the content knowledge of undergraduate science and math majors, including those who may go on to become K–12 teachers. Examples include the Science, Technology, Engineering, and Mathematics Talent Expansion Program, which provides funding to colleges and universities to develop recruitment and retention strategies to increase the number of students majoring in science, mathematics, and engineering, and the Course, Curriculum and Laboratory Improvement Program, which supports efforts to create new learning materials and teaching strategies for science, mathematics, and engineering courses and conduct research on teaching and learning in those fields.

Most NSF education programs are housed in the Education and Human Resources (EHR) Directorate. The President’s budget proposes \$816 million for EHR in FY07, a level that only begins to restore cuts EHR experienced in previous years (dropping from \$944 million in FY04 to \$797 million in FY06). Funding for the K–12 programs within EHR experienced similar declines in that period, with “formal” K–12 programs² going from \$118 million in FY04 to \$93 million in FY06 and the NSF’s Math and Science Partnership Program (NSF MSP) dropping from \$139 million in FY04 to \$63 million in FY06.

Presidential Awards for Excellence in Mathematics and Science Teaching

As part of its mission to support outstanding classroom science and math instruction, NSF administers the Presidential Awards for Excellence in Mathematics and Science Teaching (PAEMST). Up to two K–12 science or math teachers from each of the U.S. states and territories are recognized each year for their contributions in the classroom and to the teaching profession. The Foundation provides each PAEMST recipient with a \$10,000 award and professional development opportunities while recognizing them as leaders in education and inspiration to their colleagues. The award was established by Congress in 1983.

The 2005 awardees, all 7th through 12th grade science or math teachers,³ have been invited to attend this hearing and to speak at a post-hearing open session about their experiences in science and math education and with NSF in particular. Ms. Judy Snyder, who is testifying at the hearing, is the 2005 awardee in math teaching from South Carolina. The full list of PAEMST awardees will be available at <http://www.paemst.org>.

6. Questions for Witnesses

The witnesses were each asked to address the following questions in their testimony before the Committee:

- To what extent could your programs have been created or operated without NSF? In what ways did NSF programs contribute to the way you decided to shape your programs? To what extent has NSF affected the way you are evaluating your programs? To what extent did NSF’s competitive, peer reviewed proposal process affect the way you designed and executed your programs?
- Among existing mechanisms for improving K–12 science and math education, what level of priority would you give to providing increased professional de-

²The “formal K–12 programs” are the Instructional Materials Development Program, the Teacher Professional Continuum Program, and the Centers for Learning and Teaching Program, which were combined to form the Discovery Research K–12 program in the recent reorganization of NSF EHR.

³In even-numbered years, the award is given to elementary teachers (grades K–6); in odd-numbered years, secondary teachers (grades 7–12) are recognized.

velopment opportunities to improve the subject matter knowledge of science and math teachers? What level of priority would you give to improving pedagogical skills? What types of programs should NSF sponsor to have the greatest impact on improving the capabilities of science and math teachers? To what extent are these types of programs currently being supported by NSF? What suggestions do you have for improving NSF education programs?

- What types of education programs is NSF best suited to sponsor? What do you see as the relative roles of NSF and the Department of Education in improving K-12 science and math education, and what opportunities exist for collaboration between the two agencies?

APPENDIX I

HEARING CHARTER

COMMITTEE ON SCIENCE
U.S. HOUSE OF REPRESENTATIVES
K-12 Science and Math Education
Across the Federal Agencies

THURSDAY, MARCH 30, 2006
 10:00 A.M.—12:00 P.M.
 2318 RAYBURN HOUSE OFFICE BUILDING

1. Purpose

On Thursday, March 30, 2006, the Committee on Science of the U.S. House of Representatives will hold a hearing to examine how federal agencies can improve their individual and collective efforts to strengthen K–12 science and math education.

2. Witnesses

Ms. Margaret Spellings is the Secretary of the U.S. Department of Education (ED).

Dr. Arden L. Bement is the Director of the National Science Foundation (NSF).

Ms. Shana Dale is the Deputy Administrator of the National Aeronautics and Space Administration (NASA).

Brigadier General John J. Kelly (ret.) is the Deputy Undersecretary of Commerce for Oceans and Atmosphere of the National Oceanic and Atmospheric Administration (NOAA).

Dr. James Decker is the Principal Deputy Director of the Office of Science at the U.S. Department of Energy (DOE).

3. Overarching Questions

- To what extent and how are the federal agencies involved in K–12 math and science education coordinating their efforts? What are their individual roles? To what extent and how do they ensure that their individual programs are complementary?
- Are there uniform evaluation tools that agencies do or could use to determine the effectiveness of their programs?
- How do individual federal agencies strike a balance in their portfolios among K–12 math and science programs that are designed to encourage students who show great promise and interest, programs that are designed to help students who are struggling academically, and programs that are designed to attract girls, under-represented minorities or students from low-income families? Should every federal agency administer programs for each subgroup of students or are some agencies better served by targeting specific populations, such as those who are academically promising and/or under-represented?

4. Background*Brief Overview*

The quality of K–12 math and science education has been a growing national concern. Most recently, the National Academy of Sciences' report *Rising Above the Gathering Storm* pointed to the relatively poor performance of U.S. students in math and science as a threat to the Nation's long-term economic health. Numerous reports in recent years, including the Academy report, have called for renewed efforts to improve K–12 education, particularly by attracting top students into teaching and improving the training of both current and future teachers to deepen their understanding of, and comfort with, math and science content. Prompted by such recommendations, the Science Committee has pushed for years to enhance federal K–12 math and science education efforts, particularly at NSF.

NSF and ED are the two primary federal agencies with responsibility to improve K–12 math and science education. Other federal agencies have also run a variety of programs to improve and promote math and science education, often because they have scientists and research facilities that can be tapped for such activities. Those agencies, including DOE and the NOAA, also feel a commitment to keeping science strong in the U.S. since performing research is part of their missions. In addition, Congress has earmarked funds for education programs and grants in some of the agencies, particularly NOAA and NASA.

The range of education programs across the agencies can be seen as a strength—allowing program diversity and ensuring that all available federal science resources are contributing to K–12 education. But that diversity has also provoked concerns periodically that the federal efforts are uncoordinated and include many programs that are too small to make a difference or are otherwise ineffective and that the education programs are a distraction from agencies’ primary missions. A report released by the Government Accountability Office (GAO) in October 2005 found that at least 13 agencies conduct programs designed to strengthen math and science education and raised questions about the lack of evaluation of a number of the programs. In February 2006, Congress created the Academic Competitiveness Council (ACC), a cabinet-level group tasked with coordinating and evaluating the federal role in math and science education.

Coordination could provoke a different set of concerns if it leads to all federal programs fitting a single mold, dominated by *No Child Left Behind*, which some critics charge has led to a reduced focus on science education in the schools. For example, a survey released this week by the Center on Education Policy found that most schools are increasing their focus on reading and math by reducing instruction in other areas, including science. However, others point out that proficiency in math is needed to progress in science so that the emphasis on math skills hardly detracts from the effort to improve science achievement. Moreover, testing in science under the *No Child Left Behind Act* will begin in 2007, and the preparation for these assessments should place a renewed emphasis on science, as seen in the design of new science tests and the reform of science courses to align them to state standards.

GAO Report

In October 2005, the Government Accountability Office (GAO), at the request of Rules Committee Chairman David Dreier, attempted to inventory the federal programs that were designed to increase the number of students or graduates in science, technology, engineering and mathematics (STEM) fields or to improve the quality of education in those areas. The GAO report examined education programs at all levels, from kindergarten to graduate school, not just the K–12 fields that are the focus of this hearing. Among other things, GAO found the following:

- In fiscal year 2004 (FY04), 13 agencies⁴ spent a total of \$2.8 billion for 207 programs that were designed to increase the number of students and graduates or to improve educational programs in STEM fields.
- Of the 207 programs, 103 had not been evaluated, including 17 programs that had been operating for more than 15 years.
- 94 of the programs identified were funded at less than \$1 million and 51 were funded between \$1 and \$5 million.
- Six federal agencies spent the bulk (about \$2.6 billion) of the reported funding for STEM education. The largest amount of funding was at the National Institutes of Health, followed by NSF, NASA, ED, the Environmental Protection Agency, and the Health Resources and Services Administration (within the Department of Health and Human Services). The remaining agencies spent a combined total of \$154 million.

According to GAO, the report took one year to complete due, in large part, to the amount of time agencies took to provide GAO with comprehensive information on their education programs. Also, since GAO relied primarily on self-reporting by agencies, the inventory is not a definitive list of STEM education programs or activities. (For example, the Science Committee is aware of programs that were not included in the survey, including several programs at NASA and the Department of Defense.)

⁴The 13 federal agencies are as follows—National Science Foundation, Department of Energy, National Aeronautics and Space Administration, Department of Commerce, Department of Education, Environmental Protection Agency, National Institutes of Health, Department of Agriculture, Department of the Interior, Department of Homeland Security, Department of Transportation, Indian Health Service, and Health Resources and Services Administration. The Department of Defense, while identified by GAO as having STEM programs, did not participate.

Academic Competitiveness Council

Partly in response to the GAO report, Congress established the Academic Competitiveness Council (ACC), a cabinet-level group tasked with coordinating and evaluating the federal role in math and science education. Established in the *Budget Deficit Reduction Act* (Public Law 109–171), the ACC is chaired by the Secretary of Education and includes “officials from federal agencies with responsibilities for managing existing federal programs that promote mathematics and science.” ACC is responsible, within a year, for (1) identifying all federal programs with a mathematics or science focus; (2) identifying the target populations being served by such programs; (3) determining the effectiveness of such programs; (4) identifying areas of overlap or duplication in such programs; and (5) recommending ways to efficiently integrate and coordinate such programs.

The ACC met for the first time on March 6, 2006, about a month after the Act creating it was signed into law. The ACC, in conjunction with the Office of Management and Budget, will inventory existing federal math and science education programs, sort these programs by program focus or goals, and then evaluate the effectiveness of the programs. Within one year, the ACC is required to submit to each Congressional committee with jurisdiction over a federal program identified as promoting math and science education a report detailing the ACC findings and recommendations, including recommendations for legislative or administrative action. The *Budget Deficit Reduction Act* provided ED with \$50,000 to support the ACC’s activities.

Prior to the creation of the ACC, there was already an existing mechanism for coordinating math and science education, established by Executive Order. The National Science and Technology Council (NSTC) is a cabinet-level council, overseen by the White House Office of Science and Technology Policy (OSTP), which serves as the principal means to coordinate the federal research and development enterprise. NSTC established a subcommittee on education in 2003, but it has been relatively dormant.

American Competitiveness Initiative

In addition to proposing the doubling of the combined budgets of the NSF, the National Institute of Standards and Technology, and DOE’s Office of Science over the next 10 years, President Bush’s *American Competitiveness Initiative* (ACI), proposes the creation and expansion of a number of programs specifically targeted at improving K–12 math and science education. To implement ACI, the President’s budget request proposes \$380 million for programs at ED, including:

- expansion of the Advanced Placement/International Baccalaureate (AP/IB) program to support an additional 70,000 AP/IB math and science teachers;
- creation of an Adjunct Teachers Corps to encourage up to 30,000 math and science professionals to become adjunct high school teachers;
- creation of “Math Now for Elementary Students” to help elementary school teachers learn proven methods and practices of math instruction; and,
- creation of “Math Now for Secondary Students” to promote research-based instruction to improve upper level math proficiency.

ACI also provides for the evaluation of federal science, technology, engineering and math programs, and proposes an additional \$5 million to support the ACC’s evaluation efforts.

Key Federal Agencies

NSF and ED are the two agencies of the Federal Government that share primary responsibility for programs in K–12 education. While ED is responsible for K–12 education across all disciplines and is experienced in addressing the systemic problems of education, including such varied challenges as student diversity (i.e., English language learners, students from low socioeconomic backgrounds and students with special needs) and school financing, NSF is specifically concerned with improving math and science education. Another key difference between the two agencies is that ED funding is generally distributed by statutory formulas (usually based on student population and income), while NSF funding is competed for nationally and projects are chosen by peer review.

U.S. Department of Education

ED currently administers a budget of about \$88.9 billion per year (that covers more than K–12 programs)—\$57.6 billion in discretionary appropriations and \$31.3 billion in mandatory spending—and operates programs that touch on every area and level of education. ED’s current programs strongly emphasize equitable educational opportunity for all, and most major K–12 spending programs are designed either to

equalize available funding among schools or school districts or to help specific groups of students, such as English language learners or those with special needs. In addition, while some ED programs, such as Reading First, are subject-specific, the vast majority of ED's programs allow states and school districts flexibility in choosing what sorts of programs or disciplines federal funding will be used to support.

The Math and Science Partnership at ED (ED MSP) is the one program that specifically seeks to increase the academic achievement of students in mathematics and science by enhancing the content knowledge and teaching skills of classroom teachers. Allowable uses of funding include professional development opportunities, recruitment bonuses and performance incentives for qualified math and science teachers, and scholarships for advanced course work in math and science. Funding for ED MSP (\$182 million in FY06), is, like most ED programs, distributed from the Federal Government to all 50 states by a statutory formula, based on state factors such as population and poverty. The amount of funds awarded to the states in FY05 ranged from approximately \$888,000 for small states like Delaware to \$24 million for large states like California. Each state then distributes the funding, on a competitive basis, to partnerships of school districts, schools, and an institution of higher education. According to Congressional Research Service analysis of ED awards, funding at the local level can range from \$20,000 to \$3.3 million, but it is not clear if this amount is for a single year or for a multi-year award.

National Science Foundation

The *National Science Foundation Act of 1950*, which established NSF, directs NSF to support and strengthen math and science education programs at all levels. Other statutes, notably the *Education for Economic Security Act* (Public Law 98-377, signed in 1984), have expanded this authority. Most recently, the Science Committee created additional education programs at NSF in the *National Science Foundation Authorization Act of 2002* (Public Law 107-368).

NSF carries out its K-12 mission by supporting a variety of math and science education activities, including teacher training (both in-service and pre-service), curriculum development, education research, and informal education at museums and science centers. A recent reorganization of K-12 education has divided NSF's activities into three categories: the development of more effective tests in math and science, improving science teaching and learning, and translating the results of education and cognitive research into classroom practice.

Like all NSF programs, funds for education projects are awarded through a national, competitive process that draws on a wide variety of experts from outside government for peer review of proposed activities. While most federal agencies make little effort to evaluate the effectiveness of their math and science education programs, NSF requires an evaluation component to be included in individual education projects, and also has commissioned evaluations of NSF's overall NSF education programs. NSF has sought outside advice on how to perform the evaluations. For example, a National Academy of Sciences committee in 2004 provided recommendations to further improve program and project evaluations at NSF.

Most NSF education programs are housed in the Education and Human Resources (EHR) Directorate. The President's budget proposes \$816 million for EHR in FY07, a level that only begins to restore cuts EHR experienced in previous years (dropping from \$944 million in FY04 to \$797 million in FY06). Funding for the K-12 programs within EHR experienced similar declines in that period, with "formal" K-12 programs⁵ going from \$118 million in FY04 to \$93 million in FY06 and the NSF's Math and Science Partnership Program (NSF MSP) dropping from \$139 million in FY04 to \$63 million in FY06.

President Bush proposed the creation of the NSF MSP as part of his original *No Child Left Behind* initiative, and NSF MSP was authorized as part of the *NSF Authorization Act of 2002*. Congress then created a complementary (and similarly titled) program at ED as part of the *No Child Left Behind Act*. The NSF MSP program funds partnerships between universities and local school districts to strengthen the content knowledge of elementary and secondary schoolteachers. The grantees are expected to run innovative reform programs that, if successful, would be the key to large-scale reform at the State level. Unlike ED MSP, NSF MSP funds are competitively awarded at the national level, and the grants range from \$2.5 million per year for up to five years for targeted programs to \$7 million per year for comprehen-

⁵The "formal K-12 programs" are the Instructional Materials Development Program, the Teacher Professional Continuum Program, and the Centers for Learning and Teaching Program, which were combined to form the Discovery Research K-12 program in the recent reorganization of NSF EHR.

sive efforts to improve math and science teaching and learning across the K–12 continuum.

In addition to NSF MSP and the “formal” K–12 programs, NSF also runs the Robert Noyce Scholarship Program, created by the *NSF Authorization Act of 2002*. The Noyce program awards grants to colleges and universities to award scholarships to top math and science majors or minors in return for a commitment to teach at the elementary or secondary school level two years for each year of support received. Universities may also use the grant funds to support programs to help these prospective teachers obtain their certification and prosper in their new profession. In FY06, the program was funded at \$9 million, and \$10 million is requested for FY07.

Outside of EHR, NSF supports education through its “broader impacts” criteria for all research grants awarded through its Research and Related Activities account. Applications for NSF research awards are reviewed not only to determine the merit of the proposed research activity, but also to determine how the activity will promote teaching, training and learning, broaden the participation of under-represented groups, and provide larger benefits to society.

Other Federal Agencies

U.S. Department of Energy

DOE runs its K–12 programs out of both headquarters and its National Laboratories, focusing primarily on supporting of mathematics, science and engineering education programs by using the personnel, facilities, equipment and resources of its laboratories to assist local schools, teachers and students. DOE’s activities include providing research experiences for students intending to become math or science teachers, providing training for teachers who agree to become “teacher leaders” in math and science, and supporting academic competitions in science and math for high school students. The impetus for these programs often comes from individual National Labs, whose commitment to education often depends on the leadership at the lab. According to DOE, \$86 million was spent on education activities at all levels in FY05, with \$8 million specifically allocated for K–12 education.⁶

DOE’s involvement in education, particularly at the graduate level, go back to its predecessor agency, the Atomic Energy Commission. Congressional support for DOE’s educational programs has varied over time, with Congress sometimes encouraging these programs and sometimes discouraging them. In FY95, Congress appropriated \$70 million to the DOE Office of Science Education and Technical Information for science education activities, including undergraduate research activities at DOE laboratories, graduate and faculty fellowships, teacher development programs and K–12 outreach. In FY96, Congress abolished the Office of Science Education and Technical Information, reduced funding for science education, and centralized the remaining education programs within the Office of Energy Research (now the Office of Science). In FY97, Congress eliminated all funding for university and science education programs at DOE but, in FY97 and FY98, required that line programs should sponsor the education programs. Most recently, the *Energy Policy Act of 2005* included a set-aside of 0.3 percent of the applied energy program research and development funding to support DOE Office of Science education programs, and several new programs were created at the undergraduate and graduate levels, again affirming the role of the agency in education.

National Aeronautics and Space Administration

NASA’s organic act, the *National Aeronautics and Space Act of 1958*, directs the agency to expand human knowledge about space. As part of this effort, NASA’s K–12 education activities include workshops and internships for teachers and students offered by NASA’s centers, professional development for science and math teachers, and providing materials and visiting astronauts to schools, museums and science centers. Specifically, NASA K–12 education programs include the Educator Astronaut Program, which selects three teachers to become members of the Astronaut Corps, and the NASA Explorer Schools program, which brings together teachers and administrators to improve STEM teaching and learning in low-income schools.

In recent years, NASA education has been organized in a number of different ways, from being consolidated into an “Enterprise” on par with other NASA activities, such as space flight, to being spread out throughout the agency. Today, NASA education is centralized in the Office of Education, which contains five program

⁶Additional funding from DOE’s undergraduate activities, funded at \$40 million in FY05, may have supported teacher training in math and science but a breakdown of this funding was not available at the time of the charter.

areas,⁷ including one for Elementary and Secondary Education. Funding for Elementary and Secondary Education at NASA totaled \$29 million in FY06. (Many NASA earmarks are focused on education activities; according to NASA, in FY06, 72 earmarks, totaling \$82 million, were located within the \$162 million budget of the Office of Education.) The *National Aeronautics and Space Administration Authorization Act of 2005* (Public Law 109–155) requires NASA to have the National Academy of Sciences conduct a review and evaluation of NASA’s precollege science, technology, and mathematics education programs.

In addition to the activities funded through the Office of Education, NASA promotes education and outreach as an integral component of every major research and development mission, spending an additional \$150 million on activities at all educational levels through its Mission Directorates. For instance, as part of the Materials International Space Station Experiment, NASA researchers worked with high school students to analyze the effects of low orbit on a variety of materials.

National Oceanic and Atmospheric Administration

NOAA’s K–12 activities focus on improving understanding of Earth and ocean sciences through such activities as teacher training and the development of educational materials.

NOAA’s Office of Education serves as the primary point of contact for NOAA on education activities and coordinates the programs within the agency whose primary purpose is education. The FY06 budget for the Office was about \$38 million, but there is no breakdown available for K–12 education. Historically, many of NOAA’s education programs at the K–12 level have been funded through Congressional earmarks. The Administration believes that earmarks accounted for about half of the FY06 budget for the Office.

Earmarked programs include the creation of a high school Earth system science laboratory course (\$4 million in FY06), and several regional education and training programs to support hands-on environmental experiences (\$7 million in FY06). Congress has also added funding to programs that promote the sciences through scientific expeditions, like JASON, which uses live broadcasts to share the discoveries of research at sea with students and teachers. Past JASON expeditions have “taken” students on such missions as an exploration of the Titanic and the discovery of zooplankton in Monterey Bay.

In addition to formal K–12 education activities, NOAA conducts informal education through its support of marine sanctuaries and reserves, funds lesson plans and teacher professional development in ocean sciences, and supports a “Teacher at Sea” program, which allows elementary teachers to go aboard NOAA research and survey ships to deepen their understanding of the ocean.

Legislation

While this hearing is not designed to focus on any specific legislation, several bills have been introduced to strengthen STEM education in response to the various reports and commissions on U.S. competitiveness. Most of these bills seek to improve K–12 math and science education through teacher recruitment or training programs. For instance, S. 2198, *Protecting America’s Competitive Edge (PACE) Act*, and H.R. 4434, introduced by Congressman Bart Gordon, authorize NSF to award scholarships to students majoring in STEM education who concurrently pursue their teacher certification, per the recommendations of the National Academy of Sciences’ *Rising Above the Gathering Storm* report. S. 2197, PACE-Energy, also establishes a scholarship program for students in STEM fields and supports the creation of a part-time, three-year Master’s degree in math and science for teachers at DOE, not NSF. In addition, S. 2197 creates other new K–12 programs at DOE, including incentives to help states create math and science “specialty schools” and new training and research opportunities for K–12 teachers and students at the National Laboratories.

In addition to the competitiveness bills, other relevant introduced legislation includes H.R. 50, the *NOAA Organic Act*, which establishes as a NOAA mission educating the public about the Earth’s oceans and atmosphere and fostering the public’s ability to understand and integrate scientific information into considerations of national environmental issues. The Science Committee passed H.R. 50 last session.

5. Questions for Witnesses

The panelists were each asked to address the following questions in their testimony before the Committee:

⁷The other program areas include Higher Education, e-Education, Informal Education and Minority University Research and Education.

- What are the one or two most important steps the Federal Government should be taking to improve K–12 science and math education and what is the role of your agency in taking those steps? What is the single most effective program your agency runs to help take those steps? How do you know that that program has been effective?
- In general, how does your agency evaluate its programs? Have you examined the evaluation techniques of other federal agencies and departments and, if so, do they have techniques that you have made use of or plan to make use of?
- How have you ensured that your agency’s activities in K–12 math and science complement those of other federal agencies and departments in the following areas:
 - 1) attracting students to the teaching profession;
 - 2) providing pre- and in-service teacher training;
 - 3) developing curricula; and
 - 4) supporting informal learning.
- How do you decide how to strike a balance in your portfolio among K–12 math and science programs that are designed to encourage students who show great promise and interest, programs that are designed to help students who are struggling academically, and programs that are designed to attract girls, under-represented minorities or students from low-income families (whatever their level of proficiency)? Should every federal agency administer programs for each subgroup of students or are some agencies better served by targeting specific populations, such as those who are academically promising and/or under-represented?

Mr. INGLIS. [Presiding] Good morning.

The Chair has a motion, before we get to the hearing. By direction of the Republican Caucus of the Science Committee, I ask unanimous consent to ratify the election of Representative Randy Neugebauer of Texas to the Subcommittee on Energy, thereby filling an existing Republican vacancy, and Representative Mario Diaz-Balart to the Subcommittee on Space and the Subcommittee on Environment, Technology, and Standards, thereby filling existing Republican vacancies.

Without objection, so ordered.

It is my pleasure now to convene the hearing on the role of the National Science Foundation in K–12 science and math education. I want to welcome everyone here, and thank you for coming to participate.

As you know, this hearing is a followup to the K–12 science and math education across the federal agencies hearing that we held at the end of March. While it is always good to hear from agency witnesses on their work with respective agencies, I look forward to hearing today's testimony from our witnesses who are professionals in the field, those who are essential to preparing our students for potential careers in math and science. This hearing focuses specifically on NSF's role in K–12 education, and I look forward to hearing from those who share my belief that the NSF plays a unique and critical role in K–12 math and science education.

NSF is the only federal agency with a proven track record of selecting education projects through a rigorous, careful, and competitive process that draws on a wide variety of experts from outside government. They have a strong track record of bringing in outsiders to evaluate the success of their programs after they are launched. In addition, they have the experience and expertise in math and science education to fully appraise proposals, to link education practice with the latest research findings in the cognitive sciences on how children learn, and to review proposals in the context of decades of experience in both education research and practice. In fact, NSF was leading the successful effort to improve U.S. math and science education long before the Department of Education was ever created.

As I recently told my Science Appropriations colleagues, while I applaud the President's desire to improve math and science education in the American Competitiveness Initiative, I am somewhat perplexed that the majority of the newly proposed programs fall within the jurisdiction of the Department of Education, when the NSF has such a vital role to play. I also remain concerned that the fiscal year 2007 budget request for NSF, the Math and Science Partnership Program, continues to dwindle, while more responsibility for this program is shifted to the Department of Education. The NSF is better equipped to provide a solid foundation for this program.

I am hopeful that the testimony we receive today will reflect that the NSF is best equipped to provide a solid foundation, not only for programs like the Math and Science Partnership Program, but also for K–12 math and science education in general.

Before introducing our panel of witnesses, however, I want to take a moment to recognize a special group in our audience today.

Several of the participants of the 2005 Presidential Award for Excellence in Mathematics and Science Teaching. They are in Washington this week to receive their awards, and we are honored to have them with us today.

Maybe they could stand, those that are involved in the 2005 Presidential Awards for Excellence in Math and Science Teaching. So congratulations.

These teachers set a high standard of dedication to their profession, and are exemplary of the kind of math and science teachers our nation needs to keep us, to help keep us ahead of the curve on innovation and competitiveness. We owe them a great debt of gratitude for their commitment, and ask that they continue on in their good works.

And now, I would like to welcome our witnesses.

Dr. Dennis Bartels is the Executive Director of the—hold on. I am not going to introduce you. I am going to call on Mr. Gordon for an opening statement, if that—let us do that.

[The prepared statement of Mr. Inglis follows:]

PREPARED STATEMENT OF REPRESENTATIVE BOB INGLIS

Good morning. I want to welcome everyone, and thank you for coming to this morning's hearing on *The Role of the National Science Foundation in K-12 Science and Math Education*.

As you know, this hearing is a follow-up to the "K-12 Science and Math Education Across the Federal Agencies" hearing we held at the end of March. While it is always good to hear from agency witnesses on the work their respective agencies are doing, I look forward to today's testimony from our witnesses who are professionals in the field, those who are essential to preparing our students for potential careers in math and science fields. This hearing focuses specifically on NSF's role in K-12 education, and I look forward to hearing from those who share my belief that the NSF plays a unique and critical role in K-12 math and science education.

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As I recently told my Science Appropriations colleagues, while I applaud the President's desire to improve math and science education in the American Competitiveness Initiative, I am somewhat perplexed that the majority of the newly proposed programs fall within the jurisdiction of the Department of Education, when the NSF has such a vital role to play. I also remain concerned that in the FY07 budget request for NSF, the Math and Science Partnership Program continues to dwindle while more responsibility for this program is shifted to the Department of Education. The NSF is better equipped to provide a solid foundation for this program.

I am hopeful that the testimony we receive today will reflect that the NSF is best equipped to provide a solid foundation not only for programs like the Math and Science Partnership Program but also for K-12 math and science education in general.

Before introducing our esteemed panel of witnesses, however, I want to take a moment to recognize a special group in our audience today—several of the recipients of the 2005 Presidential Awards for Excellence in Mathematics and Science Teaching. They are in Washington this week to receive their awards, and we are honored to have them with us today. They set a high standard of dedication to their profession and are exemplary of the kind of math and science teachers our nation needs to help keep us ahead of the curve on innovation and competitiveness. We owe them a debt of gratitude for their commitment, and ask that they stand so that we may know who they are.

And now, I'd like to welcome our witnesses.

Dr. Dennis Bartels is the Executive Director of The Exploratorium science museum in San Francisco. Before joining the Exploratorium in May 2006, he was the president of TERC, a Massachusetts-based not-for-profit education research and development organization dedicated to improving science, math, and technology teaching and learning.

Dr. Joseph Heppert is a Professor and Chair of Chemistry and Director of the Center for Science Education at the University of Kansas. He also chairs the American Chemical Society Committee on Education.

Ms. Rebecca Pringle is a physical science teacher at Susquehanna Township Middle School in Harrisburg, Pennsylvania. She serves on the Executive Board of the National Education Association.

Ms. Judy Snyder is a math teacher at Eastside High School in Taylors, South Carolina. She is a winner of a 2005 Presidential Award for Excellence in Mathematics and Science Teaching.

We look forward to hearing from you, and I recognize the Ranking Democratic Member, Mr. Gordon, for any opening statement he may have.

Mr. GORDON. Thank you very much.

I know there is little difference between Chairman Boehlert and myself on the high value we place on the National Science Foundation as an engine to bring constructive change to the science and math education in our nation's schools. Science education has been a major component of the NSF's activities since the agency's creation over 50 years ago, and the Foundation has a widely acknowledged record of accomplishments in K-12 STEM education improvement.

I was frankly disappointed that the STEM education component of the President's American Competitiveness Initiatives totally ignored the National Science Foundation's potential contribution to STEM education reform. Instead, this initiative places all of the proposed activities at the Department of Education. Not only does the President's Competitiveness Initiative ignore NSF, the Administration's overall FY 2007 budget request actually proposes cutting NSF's existing K-12 STEM education program by seven percent. Moreover, the fiscal year 2007 cut is on top of prior reductions that would lower funding for NSF's principal K-12 STEM education programs by 47 percent over the last three years.

The witnesses before the Committee this morning, all have experience with the NSF's education activities, and could speak to their value with firsthand knowledge. I look forward to their observations and insights on the kinds of education programs NSF does well, and on the factors that lead to successful outcomes.

There is a convergence of views by Congress and the Administration that STEM education improvement is one of the key factors in ensuring our nation's future wellbeing and economic competitiveness. The American Competitiveness Initiative was proposed in the President's fiscal year 2007 budget request, and several bills have been introduced in the Senate, and I have introduced bills in the House, which are generally based on the recommendations of the recent report from the National Academies, *"Rising Above the Gathering Storm."*

There is a disagreement regarding priorities between the President's K-12 STEM education provisions and the Gathering Storm report's recommendations. While both recommend about the same level of funding increases for fiscal year 2007, the Gathering Storm report directs approximately 70 percent of the new funding for programs to improve the undergraduate education of new teachers,

and to increase substantially the professional development opportunities for current teachers, in order to raise their subject knowledge and teaching skills. On the other hand, the President's initiative places approximately 70 percent of the new funding on development of math curriculum for education in middle school students.

I look forward this morning to hearing the views of our panelists on what ought to be the priorities for any new federal initiative to improve K-12 STEM education, and on the specific kinds of programs that would best implement those top priorities.

I cannot predict, or rather, I cannot pretend that I do not have a preference in this choice of—the Gathering Storm report states that laying the foundation for a scientifically literate workforce begins with developing outstanding K-12 teachers in science and mathematics. I believe the report got it exactly right, and has identified teachers as the first priority, a goal that can and must be achieved.

As the son of two teachers, I admire the skill and dedication of these outstanding teachers, and extend my warmest congratulations to all those teachers that are here with us from the Presidential Award for Excellence in Mathematics and Science Teaching. And Mr. Chairman, I also would like to ask unanimous consent to insert a statement for the hearing record from the Project Lead the Way. This nonprofit organization designated and has disseminated a pre-engineering program that is now being used by over 1,300 schools in 45 states. This program was cited in the National Academies' Gathering Storm report as a model worthy of widespread replication.

So, once again, Mr. Chairman, thank you for allowing us to be here today, and for bringing this good panel of witnesses before us.

[The prepared statement of Mr. Gordon follows:]

PREPARED STATEMENT OF REPRESENTATIVE BART GORDON

Mr. Chairman, I am pleased we have been able to reach agreement, as we generally do, and are jointly convening this hearing to review NSF's role in federal efforts to improve K-12 science, technology, engineering and mathematics education.

I know there is little difference between us on the high value we place on NSF as an engine to bring constructive change to science and math education in the Nation's schools.

Science education has been a major component of NSF's activities since the agency's creation over 50 years ago, and the Foundation has a widely acknowledged record of accomplishment in K-12 STEM education improvement.

I was frankly disappointed that the STEM education component of the President's American Competitiveness Initiative totally ignored NSF's potential contributions to STEM education reform. Instead, this initiative places all of the proposed activities at the Department of Education.

Not only does the President's competitiveness initiative ignore NSF, the Administration's overall FY 2007 budget request actually proposes cutting NSF's existing K-12 STEM education programs by seven percent.

This is a proposed cut that is part of a request that otherwise seeks to double the overall NSF budget over 10 years. Moreover, the FY 2007 cut is on top of prior reductions that would lower funding for NSF's principal K-12 STEM education programs by 47 percent over three years.

The witnesses before the Committee this morning all have experience with NSF's education activities and can speak to their value with first hand knowledge. I look forward to their observations and insights on the kinds of education programs NSF does well and on the factors that lead to successful outcomes.

There is a convergence of views by Congress and the Administration that STEM education improvement is one of the key factors in ensuring the Nation's future well being and economic competitiveness.

The American Competitiveness Initiative was proposed in the President's FY 2007 budget request, and several bills have been introduced in the Senate and I have introduced bills in the House, which are generally based on the recommendations of the recent report from the National Academies, *Rising Above the Gathering Storm*.

There is a disagreement regarding priorities between the President's K-12 STEM education provisions and the *Gathering Storm* report's recommendations.

While both recommend about the same level of funding increases for FY 2007, the *Gathering Storm* report directs approximately 70 percent of the new funding for programs to improve the undergraduate education of new teachers and to increase substantially the professional development opportunities for current teachers, in order to raise their subject knowledge and teaching skills.

On the other hand, the President's initiative places approximately 70 percent of the new funding on development of math curriculum for elementary and middle school students.

I look forward this morning to hearing the views of our panelists on what ought to be the priorities for any new federal initiative to improve K-12 STEM education and on the specific kinds of programs that would best implement those top priorities.

I cannot pretend that I do not have a preference in this set of choices. The *Gathering Storm* report states that "laying the foundation for a scientifically literate workforce begins with developing outstanding K-12 teachers in science and mathematics." I believe the report got it exactly right and has identified teachers as the first priority, a goal that can and must be achieved.

Finally, Mr. Chairman I want to acknowledge our witness, Judy Snyder, and her fellow teachers in the audience, who have come to Washington to receive the Presidential Award for Excellence in Mathematics and Science Teaching. These are the men and women who serve with distinction on the front lines of K-12 science and math education.

As the son of two teachers, I admire the skill and dedication of these outstanding teachers and extend my warmest congratulations to each of them.

Mr. Chairman, I want to join you in welcoming all our witnesses this morning, and I yield back my time.

Mr. INGLIS. Excuse me. Without objection, that will be accepted in the record.

[The information follows:]

RECIPIENTS OF THE 2005 PRESIDENTIAL AWARDS FOR EXCELLENCE IN MATHEMATICS AND SCIENCE TEACHING SCHEDULED TO ATTEND SCIENCE COMMITTEE HEARING ON MAY 3, 2006

Maryland: Susan Brown, Central Middle School in Edgewater, MD

Maryland: Edward Nolan, Albert Einstein High School in Kensington, MD

Minnesota: Steven Benson, Owatonna High School, MN

Minnesota: Debra Las, John Adams Middle School in Rochester, MN

Missouri: Paula Young, Francis Howell North High School in Saint Charles, MO

New Jersey: Bonnie Scott Gendaszek, John Witherspoon Middle School, Princeton, NJ

New Jersey: Lois Elizabeth Lyons, High Technology High School, Lincroft, NJ

North Carolina: Samuel Wheeler, Southeast Raleigh Magnet High School, NC

Oklahoma: Julie Owens, El Reno High School, OK

South Carolina: Judy Snyder, Eastside High School in Taylors, SC

Texas: Nancy Schunke, Dunbar Middle School in Lubbock, TX

[The prepared statement of Mr. Costello follows:]

PREPARED STATEMENT OF REPRESENTATIVE JERRY F. COSTELLO

Good morning. I want to thank the witnesses for appearing before our committee to review the effectiveness of the National Science Foundation's (NSF's) past and present K-12 science and math education programs and discuss the role the Foundation should play in future federal initiatives.

Today's hearing follows up on the March 30, 2006 Science Committee hearing entitled, "*K-12 Science and Math Education Across the Federal Agencies*," in which federal agency representatives came to testify. I am pleased Chairman Boehlert and Ranking Member Gordon are holding a second hearing on this topic because the presence of outside witnesses to carefully examine the Administration's Science Technology Education and Mathematics (STEM) education programs at NSF is needed to openly discuss the President's failed priorities in these federal programs.

Science and math education is a cornerstone of the mission of the National Science Foundation. Examples of NSF programs are designed to improve teacher performance, enhance understanding of student retention of scientific content, and develop and assess curricula. Over the past few years, the Administration has been eroding NSF funding for K-12 and, to a lesser extent, undergraduate STEM education programs. Most of the decline for K-12 STEM education funding has resulted from the Administration's persistence, beginning with the FY 2005 budget request, to close out the Math & Science Partnerships (MSP) program, even though results coming from MSP awards are promising. Further, it is no secret that the President's American Competitiveness Initiative sharply contrasts with the National Academy of Sciences report, "*Rising Above the Gathering Storm*," which made several recommendations to improve K-12 STEM education. The report is the basis for H.R. 4434, *10,000 Teachers, 10 Million Minds Science and Math Scholarship Act*, introduced by Ranking Member Gordon, and of which I am an original co-sponsor.

I am interested in hearing whether, and to what degree, NSF should be involved in any new federal K-12 STEM education initiative. The President's American Competitive Initiative funds education programs only through the Department of Education and does not propose increases for NSF's existing K-12 STEM education programs. In addition, the President places the bulk of the funding on narrow curriculum development activities. Conversely, H.R. 4434 places all the K-12 education programs at NSF and focuses on teacher quality improvement.

As an oversight committee, it is important we carefully review the effectiveness of the NSF because our future federal initiatives for K-12 science and math education must be strengthened. Our children's education is not only the key to their personal success, but also to the success of our country's economic growth.

I look forward to hearing the testimony from the witnesses.

[The prepared statement of Ms. Johnson follows:]

PREPARED STATEMENT OF REPRESENTATIVE EDDIE BERNICE JOHNSON

Thank you, Mr. Chairman and Ranking Member.

The National Science Foundation is a great contributor to our nation's science and technology workforce.

When it comes to the physical sciences, NSF supports research, science education at all grade levels, and encourages diversity.

The Science and Engineering Magnet at Townview High School in my home District of Dallas consistently ranks among top schools by *U.S. News & World Report*. The school stands out as a shining example of excellence against the odds.

I am glad that the Committee has invited these outside witnesses to give us an unbiased view of NSF's programs. It is important for the Committee to know what programs have been successful so we can continue to build on that model.

Also, I welcome all of the exceptional educators who are recipients of the 2005 Presidential Awards for Excellence in Mathematics and Science Teaching. I commend you for your hard work and dedication to this most noble profession.

Thank you, Mr. Chairman. I yield back.

[The prepared statement of Mr. Honda follows:]

PREPARED STATEMENT OF REPRESENTATIVE MICHAEL M. HONDA

Chairman Boehlert and Ranking Member Gordon, thank you for holding this important hearing today. I also thank the witnesses for making the time to be with us today. I am glad that we are having these outside witnesses to balance what our prior Administration-only panel told us. The witnesses here today can give us an independent assessment of the current STEM education programs that we have in place and the proposals that the President has put forth in his budget and State of the Union address.

There are a number of major questions that need to be addressed, such as the difference in focus between the President's American Competitiveness Initiative proposal and the recommendations of the Augustine Report of the National Academies. The ACI focuses almost exclusively on the development of curriculum for math,

while the Augustine Report suggests that focusing on teacher education and professional development are the greatest areas of need.

I hope the witnesses can shed some light on whether it makes sense, as the President's budget request proposes, to de-emphasize the role of the National Science Foundation in K-12 STEM education, especially since evaluations have shown that the Math and Science Partnerships program has produced substantial improvements in student performance and all NSF programs score highly in assessments.

I also look forward to hearing the witnesses thoughts on an idea I have for the need to change our K-12 curriculum to include more of what I call "teaching innovation," which would teach students the habits of mind to think outside the box and to channel their creativity, along with their knowledge of science and math, to become more inventive and innovative. High-tech executives have told me that they think this is an important element missing from our educational system, that we are often reliant on people who are inherently good at doing this to be leaders but that we don't try to teach it.

Studies of patents awarded to companies such as AT&T and Xerox during their innovative heyday and the Naval Research Lab show that in highly innovative companies, a few of the people are responsible for a large proportion of the patents awarded, and that those patents are the most significant ones. If we can figure out what makes those special people tick and teach that to the rest of our students, America will be able to remain ahead of the rest of the world no matter how many "regular" scientists and engineers they can educate.

I think that it is important to do this, and I have developed legislation that I plan to introduce soon that will put us on the track to "teaching innovation" in our classrooms.

[The prepared statement of Ms. Jackson Lee follows:]

PREPARED STATEMENT OF REPRESENTATIVE SHEILA JACKSON LEE

Thank you, Mr. Chairman and members of the Committee. We are here today to review the effectiveness and value of National Science Foundation (NSF)'s past and present programs in support of improvement of K-12 science, technology, engineering, and mathematics (STEM) education and to examine what role the NSF should play in future federal initiatives for strengthening K-12 STEM. At a time when, American students are lagging behind the world in these areas, there is a need to examine how to improve the education of American students.

Companies located in the U.S.A. are currently hiring foreign educated individuals to fill jobs in the areas of science, technology, engineering and mathematics because of a lack of American educated candidates. A serious evaluation of our education in these areas is needed to ensure the American education system produces an abundance of students who excel in these areas.

Representatives from the oil and natural gas industries have indicated that they will need to replace over 50 percent of their technical workforce within the next ten years, a level that represents close to 40,000 jobs. These high paying, high skill jobs include: physicists, geologists, and engineers. The current production of Earth scientists from American colleges and universities that are considered part of the potential employment pool, namely those who graduated with a Master's degree or a doctorate, is about 1,200 per year. Having a skilled workforce with a technological background will be key for these industries to maintain jobs in the United States.

I am here today to hear the assessments of the Administration's priorities in the education component of the President's American Competitiveness Initiative. Also, I want to hear how the NSF has contributed to improving K-12 STEM education and whether it has been effective.

The President's American Competitive Initiative funds education only through the Department of Education and does not even propose increases for NSF's existing K-12 STEM education programs. The President's budget places the bulk of the funding on narrow curriculum development activities.

Since its inception, NSF has supported STEM education programs and is generally regarded as the premier federal agency with STEM education responsibility. It is unfortunate that over the past few years the Administration has been eroding NSF funding for K-12 for Math and Science Partnership (MSP) programs. MSP elementary school students showed significant improvements in science proficiency and high school math students also showed great improvements. Thus, the evidence would indicate that an inquiry of NSF programs and proposals is a must to determine how to improve the American educational system in science, technology, engineering and mathematics.

Thank you Chairman and Members of the Committee.

Mr. INGLIS. And I am not really the Chairman. I am just playing one on TV today. The real Chairman, Chairman Boehlert, will be here, we hope shortly. He is testifying at Energy and Commerce, and so, we will be happy to have him back when he is able to get here.

Now, if I may, I will introduce our panel.

Dr. Dennis Bartels is the Executive Director of the Exploratorium, a science museum in San Francisco. Before joining the Exploratorium in May of 2006, he was the President of TERC, a Massachusetts-based not-for-profit education research and development organization dedicated to improving science, math, and technology teaching and learning.

Dr. Joseph Heppert is a Professor and Chair of Chemistry and Director of the Center for Science Education at the University of Kansas. He also chairs the American Chemical Society Committee on Education.

Mrs. Rebecca Pringle is a physical science teacher at Susquehanna Township Middle School in Harrisburg, Pennsylvania. She serves on the Executive Board of the National Education Association.

And Ms. Judy Snyder is a math teacher at Eastside High School in Taylors, South Carolina. This is not in my script, but I will also add, before that, she was a teacher at Travelers Rest High School in Travelers Rest, South Carolina, and one of her adoring students was actually my son, who is now a junior in college, who communicated recently with her about how to choose rooms in a house that he and a bunch of folks are renting. So, you all have to tell us about the theory about how you choose rooms, based on an economic model. She is a winner of the 2005 Presidential Award for Excellence in Mathematics and Science Teaching, and we are very happy to have Ms. Snyder with us.

Dr. Bartels will—

Dr. BARTELS. Thank you, Mr. Chairman, for this—

Mr. INGLIS. One last logistical note I have got here in my script. The teachers who we just recognized and Ms. Snyder are recipients of a Presidential Award, and the good news of that is that they need to go see the President, but it is sort of close after our hearing today. So, to make sure we get a chance to hear from the teachers that are in the audience today, we are going to pause the hearing at 11:20, and go to an open mike session with the teachers, so that they can be dismissed in time, dismissed, teachers dismissed, usually, the teachers—anyway, they can be dismissed in time to go down to the White House.

And so now, Dr. Bartels.

Mr. SCHWARZ. Mr. Chairman, I wonder if I might have 15 seconds at this very propitious moment. Dr. Bartels is from Battle Creek, Michigan. His father, George, and his mother, Sherry, are great and dear friends of mine, and his father George, a physician, was a colleague of mine for many years, practicing in Battle Creek, Michigan, and I have known Dr. Bartels since he was little Dennis, but he has lived right around the corner from me, and graduated from Battle Creek Central High School. His testimony here today is serendipitous. I had nothing to do about that, but I wanted to

give you a little bit of his superb, outstanding background, from the Nation's Midwest.

Thank you, Mr. Chairman, and Dennis, welcome.

**STATEMENT OF DR. DENNIS M. BARTELS, EXECUTIVE
DIRECTOR, THE EXPLORATORIUM**

Dr. BARTELS. That is all right. Thank you, Mr. Schwarz. A wonderful product of that Battle Creek education system. It was a terrific experience. And thank you for this wonderful opportunity. It means so much to so many of us out here in the field. Rest assured, I am not going to read from my written testimony.

As you know, the staff kept encouraging me to add more and more and more as we went along, and so, the advice that I have gotten today is actually speak from the heart on just a couple of points, and speak very quickly, and I think I can do both of those things quite well. I should also note right from the beginning that although I have worked for many different institutions in the last 20 years, the one constant has been actually my work for the National Science Foundation since 1993, and in fact, they have been essentially my boss for now the last 17 years. Although I do think there is a Congressman present who has had even more personal experience with the National Science Foundation than I.

In any case, I want to limit it to three general points, and they are these. First, and I will describe it by sort of a personal frustration of my own. We always hear about this important connection between research, policy, and practice. That is what all of the educators love to talk about, and it is so frustrating, because they leave out this really important part that most of us, as policy people or as teachers, or anybody else, actually don't read the research. It doesn't come to us raw from the lab to our desks, and in fact, that is not the way it is supposed to happen. We keep forgetting, I think, the most critical step, which the engineers amongst us would rejoice, which is how do you take that basic research and turn it over to a development community that can turn it into useful things in classrooms like curricula, technology tools, new teaching programs, instructional interventions, and the like. And that, I think, has been the main legacy of our National Science Foundation for the last 50 years, taking the best of knowledge of how kids learn, but then turning it into useful things. And it is not true that teachers don't use research. It just comes to them in a very different form, and a critical form, that the National Science Foundation, should take a lot of credit, and a lot of pride in producing.

So, what I would like to suggest is that the National Science Foundation in a lot of ways, in its relationship to the Department of Education, could be construed as the same relationship between the NIH and the FDA. The NIH is responsible for the basic R&D, applied research, and moving research through clinical trials, to make sure that, in fact, there is promise in these new innovations. But there should be someone else who is out there making sure on a large scale that these are effective for most people, most of the time, and that is what the FDA does. And I believe what NSF is to the Department of Education is what NIH has been to the FDA,

in terms of looking at sort of the different parts in the research pipeline that each agency should be most worried about.

I also like to think of NSF at its best as a venture capital firm. And what I mean by that is they ask the right questions, they ask for evidence, they find the best people to conduct this work, and they always look for high leverage. They will take chances on experiments. So, let me give you a couple of examples from my own experience.

The first one, beginning teacher induction for science and mathematics teachers. Ten years ago, beginning teachers came back up on the policy screen, and lots of states started pouring money into these beginning teacher programs, but if you look, not a single one was dedicated to a specific discipline. There wasn't a beginning teacher program for science teachers or math teachers or history teachers or art teachers. They were all generic. How do you get through your first year? How do you get through your first parent/teacher conference? What are the district policies? How do I sign up for my benefits program? And the like. NSF recognized this, and took a chance on the Exploratorium, to start the first science-specific teacher induction program for the first two years of practice. And the reason this is so significant is I have become convinced that dollar for dollar, the most cost-effective program for teachers, period, that we can be investing in is those first two years of practice. But in fact, we know that what kind of teacher you become has more to do with what you experience in that first two years, more than your college preparation program. Moreover, you are much more likely to stay in the field. In the Exploratorium, in fact, those science teachers who come through that program, 91 percent of them are still teaching science five years later, and on average, we know in the urban centers, that figure is closer to 50 percent. So, we keep them there longer, and they become more effective teachers more quickly. And now, of course, discipline-specific teacher induction programs in mathematics and science are all the rage, because of NSF's commitment.

The second one is a bit of a sadder story. Today, we are living off of the educational technology innovations, our digital tools in our classrooms, from work that was invested in the 1980s and '90s. Since 1996, there has not been one dedicated pool of money for developers, designers, and innovators in educational technology, since the NSF went out of business with the Test-Bed Technology projects in 1996, under Nora Sabelli's leadership. Since then, anybody who is working on designing great and effective things that use technology, these new digital technologies, and think how much they have changed in these last 10 years, in our classrooms, there has been no place to go. And this, I think, is where a lot of the hope for the future lies, in that there is no program for this dedicated program, I think, so a real mistake. So, NSF takes chances, which in the funding community, is increasingly harder to come by.

Second, NSF never overlooked the informal sector. Museums, aquaria, science centers, after school places, film makers, television. In fact, it is the only agency that sort of recognized that science education in this country is more than university and schools, it is all these other places where you learn about science. And in a lot of ways, this is a lot more real for individuals. Where

did we learn about the phenomenon of light? It would be hard for us to say exactly, but it is probably a culmination of lots of different experiences, both in school and out of school, and the NSF, for the last 40 years, has been investing in informal education, and really deserves most of the credit for the capacity that it has.

But more than that, and I will use the Exploratorium as an example, we think of these things as places that we go visit, but in fact, 75 percent of the work of the Exploratorium isn't even invested in the place. It is invested in teachers and kids outside, that—in some research that Mark St. John conducted about 10 years ago, we discovered that 40 percent of the staff development for elementary science teachers, of any intensity, was being conducted by informal science institutions.

More recently, we have learned that these 1,500 organizations around this country, 75 percent of them are providing teacher staff development and other resources beyond sort of the day trip. And then finally, the Exploratorium itself today produces 100,000 hours per year of teacher staff development, both locally and nationally.

Finally, I want to urge the Committee to be certain that the National Science Foundation stays in the teacher enhancement business. The only major large scale teacher enhancement program left at NSF, after 40 years of history in this work, is actually the MSP program. But in fact, where teachers and others gain most of their credibility in K–12 education is from their own experiences, and these staff development programs that the NSF has been sponsoring for more than forty years, and because of that, they have set the standard. We now know, for instance, through this work, that staff development that isn't tied to the specific curriculum that a teacher is asked to teach actually doesn't do much for student achievement. It has to be about what you are being asked to teach your children. We know that it takes sixty hours or more over a couple of years to produce the kinds of changes for teachers, to take advantage of new scientific knowledge in these programs, and finally, we know that others, such as the Department of Education, and locales, are getting away from the one day workshops and one hour sort of experiences and pushing towards the standard that the National Science Foundation has set.

So, to conclude, I think our agenda is still very much unfinished. We are about to enter a cognitive science revolution sponsored by the NSF and the Centers for Learning, but I think we will have as big impact on education as biochemistry had on medicine. In the next 20, 30 years, we will discover so much about how people learn, and there needs to be a place that sort of takes these basic understandings of learning, and turns them into useful things for our teachers and kids.

Two, 21st Century skills, through moving and changing quickly, and three, we still haven't included everybody. I think our secret weapon, if we want to remain a competitive country, of the 70 percent of women and ethnic minorities who compose our workforce, who really need to fully participate, not just as scientists and engineers, but as the technical workforce and the entrepreneurs, and yes, even the Congressmen and Senators of the future.

And so, I think there are big problems still, and there are big opportunities, and the NSF has never been needed more than now.

Thank you.
 [The prepared statement of Dr. Bartels follows:]

PREPARED STATEMENT OF DENNIS M. BARTELS

Chairman Boehlert and Members of the Committee, thank you for this opportunity to testify on the *Role of the National Science Foundation in K-12 Science and Mathematics Education*. Specifically I have been asked to discuss my views on the effects and value of NSF's past and present K-12 math and science programs and the future role NSF should play with respect to these initiatives.

These are vital questions for literally tens of thousands of us in the field who are dedicated to the improvement of science and mathematics education outcomes for not only the best and brightest, but for every student who finds a need for science and mathematics in their future—which is just about all of them.

I should disclose that the NSF is largely responsible for my own career path and growth. The NSF has been an instrumental partner in my own work, starting with the Statewide Systemic Initiative, when I served as the Principal Investigator for the award to South Carolina. You asked to what extent could your programs have been created or operated without NSF? NSF program officers used to ask us the same question in South Carolina. What the NSF SSI grant really did for us is to get us to do what we knew we needed to do, but couldn't seem to do for ourselves. South Carolina would never have allocated an additional \$10 million of its own resources and built a new comprehensive professional development system for science and mathematics teachers that continues to thrive today. NSF insists on the highest level of quality. That's why the State continues to support it on its own today.

For almost 20 years, I have dedicated myself to the challenges of universal technical literacy from about every institutional angle: at a University, from a State Department of Education, from a two-year college system, as a PI of several NSF grants, from an informal science institution, and most recently a non-profit learning R&D organization.

In this last instance, at TERC, the organization represents a unique class of organizations in this country, numbering less than a dozen, which grew up with the NSF as non-profit centers dedicated to STEM education research and development of curricula, technology tools, teacher education programs and instructional experiences for students, adults and the public. The advantage of such places, in comparison with other countries that tend to do this work either inside of government ministries or as individual faculty efforts at universities, is found both in their independence and ability to pull diverse and talented teams of scientists, teachers, cognitive psychologists, designers and developers together around large-scale problems and projects in STEM education.

Without NSF's support, these places would have never existed (if we contrast ourselves with the lack of examples from these other countries). What is the consequence? People like Jerrold Zacharias, the Radiation Lab Director at MIT, started places like EDC in the 1960s because he thought the projects too big for one faculty or university. He envisioned an effort in science education equal to the Manhattan Project that required independent education labs like EDC, TERC and the Exploratorium. In the last 40 years, some of our best curricula, research on learning, teacher education ideas, and innovations in staff development have come from these organizations.

Interestingly, my new home, the Exploratorium is another one of those dozen organizations. Started by the physicist Frank Oppenheimer in 1969 and based partially on his work on the development of NSF supported elementary school science curriculum, the Exploratorium is often best known for its hands-on exhibits and as a public place. It is less well known that the Exploratorium is a premier national teacher education center and research laboratory for science education where dozens of NSF K-12 and Informal Science Education (ISE) funded projects have resulted in exhibits, digital tools, school curricula, media projects and after-school programming that reaches millions of children and adults across this country. The Exploratorium produces some 100,000 contact hours of teacher professional development a year.

Collectively, these experiences have led me to the realization that the total STEM education system is much larger than university and school, and I firmly believe we must expand our set of solutions beyond them as well. NSF intuitively sensed this from the beginning and through its unique peer review funding system distributed its investments for innovative models and ideas across many kinds of institutions, centers and networks that continue to contribute to and support science and mathematics education improvement locally and nationally.

In my written testimony, I will make the claim that NSF covers a unique and essential gap in our STEM education system and that without it, much of what we have accomplished over the last 20 years simply would not have happened. I will outline some of the unique qualities and accomplishments of the NSF from my own experience and offer some suggestions for future directions.

The missing link among research, policy and practice

Education reformers love to talk about the connections among research, policy and practice, as if all teachers, administrators and policy-makers needed to do is read the latest research reports! Unfortunately, this is a very poor model of how it actually works. Most basic research on learning and education never makes it beyond scholarly circles. However, new and promising ideas from research do make it to our classrooms—all the time. They most often show-up as a new curriculum, technology tool, teaching program or instructional intervention. The part everyone leaves out when they talk about education reform and improvement is the development and design steps (won't the engineers among us be happy!).

Basic research in the learning sciences is developing quickly, but never translated into classrooms raw. The process depends on a robust development community that creates useful and valuable things that take the latest in research and translate it into something that works for regular teachers and classrooms.

Whereas schools provide direct educational experiences for students, and districts and states implement policies and programs for instruction, improvement requires students have greater access to and engagement with good teaching, better designed materials and tests, more opportunities with high quality out-of-school learning experiences, etc. The improvement of classrooms, and strengthening the systems that support them, requires a capacity for improvement—a capacity that might be called the Nation's educational improvement infrastructure.¹ NSF invests in the people, ideas and tools that comprise this infrastructure and that support the capacity for ongoing improvement in STEM education.

NSF has a 50 plus year history, still running, which has resulted in accumulated knowledge and generations of people that enable better and better improvement efforts, stronger management of systems, breakthrough ideas and valuable tools. It is not reasonable to expect thousands of school districts, colleges and universities and informal learning institutions to take on this special R&D role for themselves. To wit, the programs at NSF in STEM education remain the envy of the world. There are lots of reasons cited by our counterparts in other countries for this perception, but it is more than just the monetary support and investments provided by the NSF. It is the accumulated wisdom, knowledge and experience contained within an independent scientific agency.

For example, too often reformers attempt to do something on the cheap, and it's not done in a scientifically rigorous way. A free and voluntarily produced curriculum, such as some web sites attempt to do, almost always lacks any of the instructional design, cognitive and learning research, and scaffolding components necessary for a superior curriculum, let alone the prototype testing, iterative testing and all the rest that goes into a carefully produced, classroom-ready instructional program. Quality curriculum development is far more complicated than the typical person appreciates, is expensive and takes several years to complete. NSF has earned this wisdom through large-scale curriculum projects such as Physical Sciences Study Curriculum (PSSC) and Elementary Science Study (ESS). Almost everyone in STEM education still knows these curricula. Many versions of them are still in existence today. A few historians even credit these initial curricula efforts from the 1960s as the genesis of the science center movement, a claim with some merit when you notice that several of the most popular exhibits in science centers started out as simple experiments in those texts. However, it never came cheap. Noted education historian George Hein estimates in today's dollars that CHEM Study cost \$11.9 to develop and (ESS) an incredible \$41.7 million.²

Therein lies another very nice quality of the NSF. It is in the habit of treating grant awards like experiments, in the best scientific sense. That means learning as much from our failures and mistakes as from our clear successes, and revising hypotheses as the data come in. So for instance we now understand that staff development that is not connected with a specific student curriculum that teachers are

¹ Mark St. John, President of Inverness Research and independent evaluator of scores of NSF projects deserves much of the credit for these ideas about an STEM education improvement infrastructure.

² From a talk given by George Hein at the Science Education for a Thriving Democracy conference in Cambridge, Massachusetts on November 18, 2005 entitled *Science Education 1965 and 2005: Myths and Differences*.

asked to teach is not as effective for student learning gains as professional development programs that are explicitly tied to that curriculum—both its content and expectations about ways of teaching it. This is a major finding from years of NSF funded work. Without it, the standard of extensive workshops (totaling 60 hours or more) focused on particular content and concepts from the student-taught curriculum, extended over one or more years time would not exist in contrast to the one-hour or one-day workshops that so dominated what constituted staff development experiences in school systems 20 years ago.

NSF's other unique qualities

First and obviously, NSF holds all of its grant recipients to exceptionally high thresholds of quality and performance. I like to think of the NSF as a public venture capital firm. It is smart, strategic and sophisticated. It asks the right questions, asks for evidence, and looks for high leverage ideas. For example, it recognized that a new kind of position was appearing in many school districts and schools across the country: that of a “data facilitator.” As more and more districts embraced the use of data for making instructional decisions, the NSF realized both the complexity of using data in scientifically appropriate and valid ways and the problem that most “facilitators” inherited the role, along with their other school or district duties, and were never provided any formal training for it. Seizing the opportunity, NSF provided TERC with a grant to begin national training institutes for data facilitators that have led to substantial gains in mathematics and science test scores in several districts, including Canton City, Ohio; Johnson County, Tennessee; Salt River reservation in Arizona; and Colorado Springs, Colorado. Again, this is in contrast to the more common practice of CTOs sending raw test data to classroom teachers or department heads and asking them to “do something” without a formal process for verifying causes, formulating hypotheses and rigorously testing out different possible interventions.

Likewise, there are more than two million teachers of mathematics and science in this country, if you count elementary level teachers. The numbers appear overwhelming. However, the number of persons responsible for staff development of mathematics and science teachers is much smaller, perhaps in the thousands. It begs the question, who is responsible for the professional development of the professional developers? Seeing a chance to leverage its other investments, the NSF awarded a grant to the Exploratorium to create a national center—in essence a professional development school for staff developers and project leaders to experience and study professional development designs in science, and then to take back to their own teacher workshops. Part of the center's legacy is a new generation of more than 1000 professional developers who are able to multiply and expand on what they learned at the Exploratorium.

In another example from the Exploratorium, eight years ago the value of beginning teacher induction programs began to catch the attention of state educators and policy-makers. Recent research suggests that what kind of teacher you become has more to do with what you learn in the first or second year of practice than even what you learned in your college program. Teachers are on the steepest part of their learning careers in these first few years and essentially there exists no organized system of support. And even where beginning teacher programs exist—and the states are starting to pay attention and pour some money in—when the Exploratorium got started, it could find no other example of a discipline-based teacher induction program. That is, no beginning teacher program just for history teachers, language arts teachers, or science and mathematics teachers.

The NSF started the Exploratorium with a “proof of concept” grant—which to our great fortune allowed us to make some substantial modifications from the first to second year of the program. We thought our initial model was about two-thirds designed, when in reality it was a totally different kind of program than what you do in normal inservice program and it required a major overhaul after one year of hard-earned experience. NSF support—not just financial but programmatic expertise—made a critical difference. They insisted that the new program be thoroughly studied by Suzanne Wilson and her colleagues out of Michigan State University. Now discipline-specific teacher induction programs are the rage and many policy groups point to the Exploratorium as the model for middle and high school science teacher induction, of which the NSF is justifiably proud for recognizing and starting first there.

There is also the value of the NSF brand. Its support has been key for many to experiment and innovate, and to start new trends for entire fields such as it has over and again for the 600 science centers found worldwide. For many teachers and school district administrators, an NSF-funded project carries a strong signal of its likely quality and positive impact. Without NSF, I dare to say that the science cen-

ter field ten years ago almost tipped in favor of experiences with a greater entertainment value because of market pressures. However, NSF's investments in informal education demanded bona fide educational experiences based on real science and reversed this unsettling trend. NSF's influence on the field remains pivotal.

The NSF is still unique in its ability to pull together the traditions of science and the Nation's scientific and educational expertise as the premier general science and engineering research funding agency in the United States with the major responsibility for both the strength of America's research portfolio and the development of the science and engineering workforce. As my colleague Rob Semper said recently,

Science education improvement is too unique to be left to the work of general education by itself. Not only is the world of science and therefore the requirements of good science education changing at a rapid pace, the very nature of science as a discipline requires involvement of the science community in its educational development. This is because as physicist John Layman says "the special character of science—that it is at once a body of knowledge and a dynamic questing activity."³

The NSF takes chances on experimental ideas, an attribute that is increasingly more difficult to find in the funding community.

Nonetheless, our STEM education agenda is unfinished. New understandings and important knowledge are being generated by the learning sciences. Some believe we are on the edge of a cognitive science revolution that can mean as much for the practice of education as the modern advances in our understanding of biochemistry had on medicine. For instance, we now understand that a six-year-old's understanding of "which is more" in comparing two numbers has high predictive power in how well they will be doing in third grade mathematics, regardless of their backgrounds. For students who don't come with this understanding into kindergarten, as long as they still leave kindergarten with it, they will do as well as their peers who understood it before, and much better than others who still don't understand it by the end of kindergarten. With known interventions, it is possible that nearly every child can leave kindergarten with it.

At the same time, we are redefining the essential skills and thinking abilities required for a 21st century economy and democratic society which challenge our traditional practices in STEM education. And we have yet to reach all entrants, ethnic groups, and a majority of women fully capable of participating in STEM-related careers, let alone universal scientific literacy. We continue to need an R&D infrastructure that turns advances in our knowledge into useful and effective things for teachers and learners that address these grand challenges.

In the pursuit of these significant goals, we have accumulated our share of well-intentioned missteps and mistaken hypotheses, but we've had some astounding successes to point-out as well.

For instance, in a recent analysis conducted by Uri Triesman from University of Texas in Austin, he examined NAEP data from 1990 to 2005 from several major urban areas. What he found surprised him. If you look at the mathematics performance of students by race, compared with national NAEP averages by race, some cities like Austin, Charlotte and Boston consistently out-perform the national averages for black and Hispanic students by large margins. Moreover, black and Hispanic students in some cities were matching performances of white students elsewhere. And Hispanic students in Texas today are out-scoring white students from Texas on the same test in 1990. His main point: demography is not destiny.

So what gives in Charlotte, Austin and Boston? He points to several possibilities. Each committed to higher-level mathematics programs—many funded in development by NSF—and stayed with the new program for more than five years. Sustained and significant professional development for teachers followed the curriculum in each grade. Interestingly, not all of these cities received direct support from the NSF. However, my hypothesis is if you did a survey of each of these cities, you would find any number of artifacts and tools—curricula, teaching programs, staff development tools—developed elsewhere with NSF support. I would venture to say that the mathematics gains from the last 15 years, especially in many of the country's urban areas, are very much a credit to NSF's long line of work in this area, starting with a number of NSF sponsored research studies conducted in the 1970s.

Likewise, informal education institutions are easy to overlook. But the NSF never did overlook this unique resource, not just as an out-of-school resource but also as major teacher development and curriculum development institutions in their own right. The informal science infrastructure is really very strong. NSF deserves most

³ Rob Semper, Associate Executive Director of the Exploratorium, to the National Science Board in testimony delivered on March 9, 2006 in Los Angeles, CA.

of the credit for building the capacity of the informal science learning community. It may come as a surprise that in a survey conducted by Inverness Research and Associates in 1996 that 40 percent of all professional development provided for elementary teachers in science of any intensity (defined as more than a week) was provided by informal institutions. More recent research conducted last year by the Center for Informal Learning and Schools (CILS) found almost 75 percent of the informal science institutions, including zoos, aquaria, and museums provide programs, workshops, materials or curriculum support for K–12 science education beyond the one-day field-trip. Nationally these institutions serve approximately 62 percent of the total number of schools. Even today the NSF is making aggressive funding investments in the Nation’s after-school provider networks and infrastructure, the most rapidly growing sector of informal education.

We are coming around to the notion that learners learn science all the time every where, and we cannot separate school from the rest of the settings and avenue where students are turned on to learn science. With significant support and help from NSF, we are beginning to appreciate the importance of the total science-learning environment. And NSF, for its part, is perhaps the only federal agency with its hand in every part of the total system from university science labs to Sesame Street.

Recommendations

I am very supportive of the comments made by NSF Director Arden Bement in his testimony before this committee on March 30. Our views about NSF’s role in K–12 education are very consistent and I believe the proposed program changes and reorganization with the Education and Human Resource Directorate open up more opportunities for the field to innovate, experiment and test new ideas.

In terms of specific guidance on prioritizing certain activities related to professional development and teacher quality, I will note these three:

1. Professional development that is specifically tied to the instructional program or student curriculum in use at the school;
2. Comprehensive and systemic beginning teacher programs that are discipline-specific, focused on common instructional issues, and leaves little up to chance for a new teacher’s education; and
3. A special focus in the near-term on middle school teachers where students are moving from informal notions to more formalized understandings about science and where the greatest number of out-of-field mathematics and science teachers are found.

More broadly, if you accept my claim that the agenda is unfinished, that the R&D step between research and practice is imperative, and NSF is uniquely suited to that role, then where might we make the most strategic investments with potential for the highest leverage and biggest payoffs?

Among my top recommendations:

1. Seriously invest in R&D for the next generation of STEM curricula, assessments, instructional approaches, preservice and inservice professional development programs, exhibits, media, texts, digital technologies, novel teaching programs, etc., based on the emerging cognitive revolution in the Learning Sciences, so new innovations are constantly tested, improved, abandoned or moved into commercial or public markets. This is especially true for stimulating development and experiments with the new digital learning technologies as the last active federal program dedicated to them went out of business in 1996 (i.e., the Technology Test-bed Program at NSF).
2. Tie these activities to a roadmap for the improvement of infrastructure development, that NSF could develop and manage, that includes support for national centers of excellence focused on key problems or grand challenges to facilitate rapid consolidation and dissemination of progress and knowledge. An essential part of this roadmap is the clear articulation of NSF’s role vis à vis the other federal science agencies and the large-scale state and district implementation efforts supported by the U.S. Department of Education. For instance, one might imagine a relationship between the NSF and Dept. of Education similar to that of the NIH to the FDA. The NSF provides most of the applied research and clinical trials from basic research while the Department of Education is responsible for large-scale effectiveness studies to determine the ultimate benefits of new approaches on learners compared with existing approaches. In this way, everyone avoids the appearance of conflicts of interest and confusion about roles.
3. Stimulate rapid adoption of two-year intensive teacher induction programs that compares favorably with our best medical residency programs for every

teacher of mathematics and science so that they not only stay in the profession but also learn how to become a competent, confident and successful teacher as quickly as possible. I believe this is the most cost-effective way to address our concerns about teacher quality.

4. Expand the investment, experimentation and resources for community and technical college education, especially as many teachers and most teachers of color start their collegiate education in two-year institutions and because developmental math courses prove to be the second greatest gatekeeper to technical careers (high school algebra being the first). In addition, provide extensive staff development for two-year college teachers, whose participation in NSF programs to date is much lower than for K–12 teachers.
5. Accelerate growth and capacity of the informal and out-of-school education sectors as vital participants and providers in the total K–12 science education system, including comprehensive teacher development programming, while continuing to innovate ever more creative ways to motivate children and adults of all ages to engage in everyday questions of science, mathematics, engineering and technology.
6. Keep at least some fraction of the NSF EHR portfolio dedicated to teacher institutes and large scale teacher enhancement efforts. NSF has a unique role in supporting the development of a leadership cadre of highly developed science and mathematics teachers through fostering critical collaborations with science rich institutions such as university science and mathematics departments, informal science education institutions such as museums and science and education research laboratories. The quality and reputation of these experiences for thousands of teachers over the last several decades creates in large part its credibility and reputation for teachers and in the eyes of Congress. This should not diminish the need for other federal agencies, states, or local districts to provide similar support for teacher enhancement, given the overwhelming numbers.
7. Leave some fraction of the investment portfolio aside for field-initiated proposals. True to the nature of doing science, there should be room for innovation and transformative ideas from the field that are not anticipated by the Foundation, which may be high risk but lead to significant breakthroughs.

Because of its natural connection to the science and mathematics academic community, its focus on field driven research and innovation, and its long standing relationship with all of the necessary players of this improvement in infrastructure, NSF has a unique role to play in fostering each and every one of the above recommendations.

Thank you, Mr. Chairman and Members of the Committee, for your attention. I would be happy to respond to any of your questions.

BIOGRAPHY FOR DENNIS M. BARTELS

Dennis Bartels is the Executive Director of the Exploratorium—San Francisco's acclaimed museum of science, art and human perception. Founded by physicist and educator Frank Oppenheimer in 1969, the Exploratorium has achieved worldwide recognition as the prototype for hands-on science museums around the world.

Until May, 2006, Dr. Bartels served as President of TERC, a nationally known education research and development center known for its innovative curricula, products and tools for teachers and students in K–12 classrooms. While at TERC, he led the Cambridge, Massachusetts-based organization's efforts to expand its endeavors in online learning, informal science education, and after-school programming. Prior to 2001, Dr. Bartels directed the Center for Teaching and Learning at the Exploratorium, where he was responsible for the establishment of the Exhibit-Based Teaching Partnerships program in several centers around the world, including Beijing, China.

He also was Principal Investigator and Project Director of the National Science Foundation sponsored South Carolina Statewide Systemic Initiative and directed the development of the state curriculum frameworks there. He received his Ph.D. in Education Administration and Policy Analysis from Stanford University and completed his undergraduate degree at the University of North Carolina at Chapel Hill.

He has served on several committees, advisory boards and review panels for the National Science Foundation and other education organizations, including the Merck Institute for Science Education and the International Organization of Economic Cooperation and Development (OECD). Dr. Bartels has testified before committees of both the United States Senate and House of Representatives. He has

been an invited guest and speaker on science and mathematics education in England, France, Brazil, the Netherlands, Malaysia, Japan and China. He recently was appointed to the NSF Advisory Committee for the Directorate of Education and Human Resources.

Dr. Bartels has been awarded the distinction of American Association for the Advancement of Science (AAAS) Fellow. He was elected AAAS Fellow from the Section on Education for his energetic leadership in systemic science education reform, informal science education, and research and development of innovative mathematics, science, and technology curricula.

Dr. Bartels has enjoyed over \$28 million in grant funding for his work. He remains a student of curriculum reform, teacher professional development, technology in education, learning theory, and organizational change.

LLMAS—education and science leadership



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April 27, 2006

The Honorable Sherwood Boehlert
Chairman, Science Committee
2320 Rayburn Office Building
Washington, DC 20515

Dear Congressman Boehlert:

Thank you for the invitation to testify before the Committee on Science of the U.S. House of Representatives on May 12th at the hearing entitled “*The Future of Computer Science Research in the U.S.*” In accordance with the Rules Governing Testimony, this letter serves as formal notice of the federal funding TERC currently receives related to the hearing topic. I do not serve as a Principle Investigator nor am I a current participant in any active NSF or Department of Education grants. Rather, as President of TERC, I represent a number of awarded grants to the organization. Below is a complete accounting of them by major program area.

TERC – Awards received from NSF

<u>NSF Program</u>	<u>2003</u>	<u>2004</u>	<u>2005</u>	<u>Total</u>
CCP	\$68,370	\$45,000	\$62,059	\$175,429
DUE	\$256,020	\$277,227	\$875,020	\$1,408,267
ESIE	\$12,876,446	\$6,737,069	\$7,781,315	\$27,394,830
ESR	\$0	\$58,588	\$31,905	\$90,493
GEO	\$190,248	\$265,555	\$144,500	\$600,303
HRD	\$624,182	\$416,731	\$563,467	\$1,604,380
REC	\$1,461,288	\$0	\$1,563,647	\$3,024,935
Total	\$15,476,554	\$7,800,170	\$11,021,913	\$34,298,637

Sincerely,

Dennis Bartels, Ph.D.
President

Mr. INGLIS. Thank you, Dr. Bartels.

Dr. Heppert, I might point out, if you noticed that—

Mr. MOORE. Point of personal privilege here, Mr. Chairman. Mr. Chairman, down at this side.

Mr. INGLIS. Yes, sir.

Mr. MOORE. Could I have just 10 seconds? I am a proud alum of the University of Kansas, and I am proud to welcome here Dr. Joe Heppert today, as one of the panelists to testify, and I am interested in hearing your views on K–12 STEM education. I really appreciate your coming, Dr. Heppert, and all the other panelists.

Thank you, Mr. Chairman.

Mr. INGLIS. Great.

And I might point out that when the light is green, it means you have got five minutes there at the start. When it starts yellow, start summing up, and then, red means we are out of time.

STATEMENT OF DR. JOSEPH A. HEPPERT, CHAIR, DEPARTMENT OF CHEMISTRY, UNIVERSITY OF KANSAS; CHAIR, COMMITTEE ON EDUCATION, AMERICAN CHEMICAL SOCIETY

Dr. HEPPERT. I will do my best. I am going to try to stick to my script today.

Mr. Chairman and distinguished Members of the Committee, good morning. I am addressing you today as both the chair of the chemistry department at the University of Kansas, and as the chair of the American Chemical Society's Committee on Education.

It is a distinct pleasure to address the Committee on a subject of the utmost importance to the future of our country, how the Nation is going to tackle the challenges of preparing the next generation of scientists, technical workers, engineers, and mathematicians, the so-called STEM workforce, to compete in the global economy of the 21st Century.

As everyone in this room now recognizes, when it comes time to find a job in the life sciences, my daughter Jennifer, who is sitting right behind me, will no longer be competing with her fellow American students for an American job. She will be competing with all of the outstanding students in her field on the planet for the most rewarding high tech jobs, jobs that know no national or geographic boundaries.

In such environments, she and other students of her generation need to be well prepared. The subject of today's hearing, the role of the National Science Foundation in promoting effective pre-college STEM instruction and learning, is an absolutely critical element in our national response to this competitiveness challenge. There is no doubt that NSF is one of the premier agencies that supports STEM education research around the world, or that maintaining this title is the focus of pride for the Foundation. I believe that NSF should clearly hold the title of being the world's leader in education innovation, helping educators more effectively deliver a 21st Century STEM education to eager young minds.

For the record, I have submitted a copy of "Science Education Policies for Sustainable Reform," the American Chemical Society's comprehensive statement on priorities, practices, and policies related to science education at all levels (*see Appendix 2: Additional*

Material for the Record). I respectfully suggest that the Committee review the Society's recommendations on a wide range of education issues.

Today, I have five specific recommendations for the Committee that relate to NSF's role in improving K–12 education. First, I would encourage the Committee to continue efforts to develop comprehensive legislation that lays out a concerted national response to the innovation and competitiveness challenge. If we are to sustain a national focus on this issue, as we most certainly must do if we are to succeed, we need to forge a clearly articulated national strategy endorsed by a significant bipartisan mandate from Congress.

Second, such legislation must clearly acknowledge and recognize the key role of NSF in improving K–12 math and science education, and must also address in concrete terms how NSF's Education and Human Resources Directorate will work together with the Department of Education and other federal agencies on improving student achievement in K–12 science and mathematics.

NSF provides leadership in research on human learning, and is at the forefront of research on STEM education, pedagogy curricula, and assessment. The Department of Education has an extensive network of contacts with state and local education agencies that can scale up and fund the dissemination of innovative programs produced by NSF. It is essential that these two agencies form an effective partnership to deliver the best new educational strategies and materials to K–12 educators.

Third, I believe that NSF should maintain its strong educational research focus, playing a central role in improving student achievement in the STEM fields. As with every major challenge our country has faced over the course of our history, our ability to innovate, our vision to invest in fundamental research, will play a decisive role in improving student achievement in math and science.

NSF should be the lead agency in fostering the development of our STEM education pipeline, from evaluating the best textbooks, to pioneering new student learning methods and new curricula, to developing better ways to employ technology in the classroom. NSF has a unique role as the bridge between the science and education communities. It is the only federal agency that can attract all of the best minds in both communities to the table, with the common intention of solving some of the thorniest problems facing our system of science education.

Fourth, NSF should develop significant resources, or NSF should devote significant resources to programs that increase the number of careers K–12 STEM teachers, with detailed science knowledge and/or STEM degrees, emerging from the American universities. This issue cannot be solely addressed by providing more numerous scholarships and better salaries and resources for pre-service teachers. The resolution of this issue requires that we foster changes that have only begun to occur in the nature and culture of most of our universities. We must induce schools of education, science, and engineering to form more effective partnerships to address these issues. NSF already has substantial experience forging these relationships, and with the cooperation of the private sector, is

ideally suited to facilitate partnerships that can tackle this particular challenge.

I believe that there is evidence that teacher preparation programs that emphasize strong pre-service teacher engagement with scientific content, including undergraduate research experiences, are very effective at attracting and retaining new science teachers. My institution will be examining how we can adapt elements of the UTeach program, one such program developed at the University of Texas to enhance our teacher, science teacher preparation efforts.

Fifth, and finally, I think that NSF can contribute to the successes of No Child Left Behind program by providing scalable model programs that help achieve improvements in science, students' science and mathematics performance in specific areas of focus. As an example, a recently publicized release of data from NSF's Math and Science Partnership program has established that innovative, rigorously evaluated programs supported by NSF's Directorate can produce measurable, dramatic improvements in student achievement. In the instance that I cite, high school students showed a 14 percent improvement in math proficiency after one year under the MSP program.

In closing, I would like to thank the Committee for the opportunity to testify here today. In my research experiences, I have seen firsthand the success of NSF programs in improving K-12 science and math teaching and learning. I cannot emphasize strongly enough that NSF is uniquely situated as the agency that can best bridge the gulf between the scientific and education communities.

If, in responding to the math and science challenge our nation faces, we do not take full advantage of the unique strengths of NSF, we will be making a mistake. I am confident that the investments we are making in NSF today will result in a brighter future for our children.

[The prepared statement of Dr. Heppert follows:]

PREPARED STATEMENT OF JOSEPH A. HEPPERT

Introduction

Mr. Chairman and distinguished Members of the Committee:

Good Morning.

I am addressing you today as both the Chair of the Chemistry Department at the University of Kansas and as the Chair of the American Chemical Society's Committee on Education.

It is a distinct pleasure to address the Committee on a subject of the utmost importance to the future of our country—how our nation is going to tackle the challenge of preparing our next generation of scientists, technical workers, engineers, and mathematicians (the so-called "STEM workforce") to compete in the global economy of the 21st century.

As everyone in this room now recognizes, when it comes time to find a job in the life sciences, my daughter Jennifer, who is sitting right behind me, will no longer be competing with her fellow American students for an "American" job. She will be competing with all of the outstanding students in her field on the planet for the best, most rewarding high-tech jobs—jobs that know no national or geographic boundaries. In such an environment, she and other students of her generation need to be well prepared.

The subject of today's hearing—the role of the National Science Foundation in promoting effective pre-college STEM instruction and learning—is an absolutely critical element in our national response to this competitiveness challenge. If we engage in a comprehensive examination of the health of our pre-college STEM programs, we will find a muddled diagnosis. There is much to be proud of in our accom-

plishments in elementary and secondary math and science education; many exemplary programs to emulate, challenging curricula to adopt and adapt on a local level, and many outstanding teachers who can help to lead our educational system into the future. Yet, we also see components of our pre-college STEM programs that are desperately struggling; unsatisfactorily low student scores on international tests of science knowledge, declining student interest in science careers, and many high school graduates who do not have sufficient preparation to choose scientific and technical career pathways.

There is no doubt that NSF is one of the premier agencies that supports STEM research in the world, or that maintaining this title is a point of pride for the Foundation. I believe that NSF should also proudly hold the title of being the world's leader in educational innovation; helping educators to more effectively deliver a 21st century STEM education to eager young minds.

The Role of NSF in Education

For the record, I have submitted a copy of "Science Education Policies for Sustainable Reform," the American Chemical Society's comprehensive statement on priorities, practices, and policies related to science education at all levels. I respectfully suggest that the Committee review the Society's recommendations on a wide range of science education issues.

NSF's leadership in these arenas takes many forms. I would like to begin my testimony by describing some areas in which I have observed NSF programs provide focused, effective leadership in addressing the Nation's K-12 STEM challenges, and a few areas in which NSF needs additional support and direction in order to most effectively adopt its appropriate role. I intend to conclude my remarks with a discussion of recommendations relating to NSF's role in strengthening our STEM education programs.

It would be an epic understatement to characterize educational systems as 'complicated.' I believe that educational systems are among the most complicated systems that humans have constructed, and this complexity arises from many sources. Take, for example, students. Pre-college students progress through many stages of cognitive, physical, emotional, and social development during their years of preparation for adulthood. Creating an excellent educational environment requires understanding the developmental progress of students at a particular grade level, and then engineering sufficient flexibility into that learning environment to accommodate very real variations in developmental progress among individuals. We can also examine societal stakeholders as another source of complexity in educational systems. Stakeholders in K-12 educational systems include students, parents, teachers, educational administrators, higher education, private sector employers, community leaders and organizations, officials of state and federal governments, and American society as a whole. Though all of these stakeholders embrace the common goal of providing the best possible education for American children, their different expertise, experiences, and goals influences the priorities they set for fostering educational change and the strategies they propose for achieving that change. We already have an incredibly complicated description of educational systems, and we have only barely described two parameters in a system with many, many more variables.

We are asking NSF to step into the midst of the multidimensional problem and affect positive change. It is entirely reasonable to ask what unique qualifications and characteristics NSF brings to this task.

NSF is the federal agency with the broadest expertise with STEM content knowledge; consequently, it is the agency best able to oversee the development of quality STEM curricula for all educational levels, evaluate the quality of existing curricula and programs, and develop research and assessment methods that successfully evaluate student learning of science.

Through its reputation and resources, NSF has enormous power to convene. NSF education programs often mandate that scientists, mathematicians, educational professionals and educational policy specialists all collaborate on the development of solutions to problems in STEM education. These are exactly the type of multidisciplinary consortia that are required to formulate and implement solutions to complex educational issues.

Many NSF programs thrust STEM content professionals into leadership roles in educational research projects. NSF is one of the select Federal agencies funding educational research that guarantee STEM professionals a voice at the table in projects affecting the future of their own disciplines. This approach is crucial for building a sense of responsibility for educational progress in STEM fields among scientists, mathematicians and engineers. It also results in the development of enhanced educational research capacity among STEM professionals. Late last year, I participated

in a National Academies workshop funded by NSF that focused on assessing the status of STEM education research faculty in STEM discipline departments. NSF is clearly interested in fostering the careers of science, mathematics and engineering faculty engaged in STEM education research, and in supporting an appropriate increase in the numbers of such researchers. This is a praiseworthy objective.

NSF's strength lies in its emphases on innovation and on fostering broader societal impact through the programs it funds. Research and development are NSF's dual specialties; so it follows that its mission is admirably suited to provide oversight of STEM educational research.

There are areas in which NSF could improve its programs, and its advocacy and support for STEM education research. Scientists, mathematicians and engineers occasionally fall into the trap of behaving as if funding for our 'traditional' research programs is our sole priority and only use of resources that will benefit for our particular discipline. This is not true. Without sufficient funding for educational research that fosters improvement in STEM learning at all educational levels—the type of research that renews our disciplinary core content, enlivens our teaching, improves student comprehension, informs us about more effective uses of technology, and increases student wonder about the character of the natural systems in which we live—our disciplines will inevitably suffer. Our disciplines, and NSF as the proxy for research in those disciplines, must constantly balance the need for investment in research with the equally crucial need for fundamental research in STEM education. NSF's emphasis on using research as a driver of innovation and its strong focus on the content of STEM disciplines makes it the best agency to manage this educational research mission.

Paradoxically, the funding needs of No Child Left Behind programs, which are intended to foster near-term improvement in student achievement, have created a countervailing pressure on NSF resources that support the basic educational research that is foundational for longer-term improvements in STEM education. Substantial NSF funding has been re-tasked from programs that cultivated K–12 curriculum innovation and developed new models for enhancing the pedagogical content knowledge of inservice teachers. As a result, these programs are funding fewer initiatives that will provide new strategies to improve student achievement.

In order to drive change in K–12 education, it is necessary to create change in how colleges and universities teach STEM content to future teachers. Instructional strategies at universities are notoriously difficult to change. NSF resources have, in previous initiatives, provided an important impetus for innovation in college and university STEM instruction. Such programs are sorely under-funded in the current NSF educational research portfolio. Now, as we need to increase the number of students choosing to major in K–12 STEM teaching, is the time to enhance support for these programs.

Recommendations Regarding Future Action

The American Chemical Society supports the recent recommendations of (1) the National Academies, (2) the Council on Competitiveness, and (3) the Task Force on the Future of American Innovation. These organizations have established a powerful roadmap showing how the United States should respond to existing threats to our scientific and technological leadership. Furthermore, the American Chemical Society is prepared and committed to contribute to the development of a national innovation strategy for the 21st century and to support legislation that embodies key elements of these reports.

Today, I have five specific recommendations for the Committee that relate to NSF's role in improving K–12 education:

First, I would encourage the Committee to continue efforts to develop comprehensive legislation that lays out a concerted national response to the innovation and competitiveness challenge.

If we are to sustain a national focus on this issue—as we most certainly must do if we are to succeed—we need to forge a clearly articulated national strategy, endorsed by a significant, bi-partisan mandate from Congress.

Second, such legislation must clearly acknowledge and recognize the key role of NSF in improving K–12 math and science education, and must also address, in concrete terms, how NSF's Education and Human Resources (EHR) Directorate will work together with the Department of Education and other federal agencies on improving student achievement in K–12 science and mathematics. NSF provides leadership in research on human learning, and is at the forefront of research on STEM education pedagogy, curricula, and assessment. The Department of Education has an extensive network of contacts with State and local educational agencies that can scale up and fund the dissemination of the innovative programs produced by NSF.

It is essential that these two agencies form an effective partnership to deliver the best new educational strategies and materials to K–12 educators.

Third, I believe that NSF should maintain its strong educational research focus, playing a central role in improving student achievement in the STEM fields.

As with every major challenge that our country has faced over the course of our history, our ability to innovate—our vision to invest in fundamental research—will play a decisive role in improving student achievement in math and science.

NSF should be the lead agency in fostering the development our STEM education pipeline; from evaluating the best textbooks, to pioneering new student learning methods and new curricula, to developing better ways to employ technology in the classroom.

NSF has a unique role as the bridge between the science and education communities. It is the only federal agency that can attract all of the best minds in both communities to the table with the common intention of solving some of our thorniest problems facing our system of science education.

Fourth, NSF should devote significant resources to programs that increase the number of career K–12 STEM teachers with detailed science knowledge and/or STEM degrees emerging from American universities. This issue cannot be addressed solely by providing more numerous scholarships, and better salaries and resources for preservice teachers. The resolution of this issue requires that we foster changes that have only begun to occur in the culture of most universities. We must induce Schools of Education, Science and Engineering to form more effective partnerships to address these issues. NSF already has substantial experience in forging these relationships, and, with the cooperation of the private sector, is ideally suited to facilitate partnerships that can tackle this particular challenge.

I believe that there is evidence that teacher preparation programs that emphasize strong preservice teacher engagement with scientific content, including undergraduate research experiences, are very effective at attracting and retaining new science teachers. My institution will be examining how we can adapt elements of the UTeach program, one such program developed at the University of Texas, to enhance our science teacher preparation efforts.

Fifth, I think NSF can contribute to the successes of the No Child Left Behind program by providing scalable model programs that help achieve improvements in student science and mathematics performance in specific areas of focus.

As an example, a recently publicized release of data from NSF's Math and Science Partnership program has established that the innovative, rigorously evaluated programs supported by NSF's EHR Directorate can produce dramatic, measurable improvements in student performance. In the instance that I cite, high school students showed a 14 percent improvement in math proficiency after one year under the MSP program.

I hope we can effectively work together to continue this and other successful programs funded by NSF, and to fund new NSF education initiatives that hold the promise of improving the quality of STEM education for our children.

Conclusion

In closing, I would like to thank the Committee for the opportunity to testify here today. In my research experiences, I have seen first hand the success of NSF programs in improving K–12 science and math teaching and learning.

I cannot emphasize strongly enough that NSF is uniquely situated as the agency that can best bridge the gulf between the scientific and education communities. If, in responding to the math and science challenge our nation faces, we do not take full advantage of the unique strengths of NSF, we will be making a mistake.

I am confident that the investments we are making in NSF today will result in a brighter future for our children. Thank you.

BIOGRAPHY FOR JOSEPH A. HEPPERT

B.S., 1978, San Jose State University

Ph.D., 1982, University of Wisconsin-Madison

Postdoctoral Associate, 1983–85, Indiana University

Science Education

Joseph A. Heppert, Professor and Director of Center for Science Education

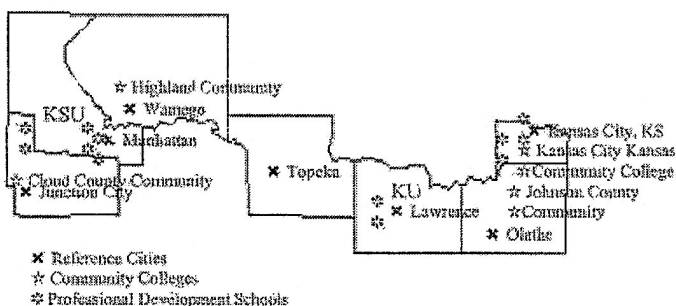
Research Interests: Science education, science teacher preparation, technology in science education, the role of scientific research in preparing K–12 science educators

and student perceptions of science during the transition between two-year and four-year colleges.

Professor Heppert's research group concentrates both on the implementation of reforms in science instruction at the university and K-12 levels, and on developing a fundamental understanding of how these reforms improve student retention of scientific principles and student attitudes toward science. The two projects outlined below are typical of research plans in Professor Heppert's group.

The Paradigm Laboratory Project. This project, funded by the William and Flora Hewlett Foundation, is undertaking a comprehensive redesign of laboratory experiments used in the introductory undergraduate chemistry courses. The purpose of the redesign is to present students with an opportunity to apply the scientific method from the earliest stages of their university careers. Laboratories are designed to avoid the skills-driven cookbook character of traditional introductory laboratories. Instead, students are required to work in groups and use their critical thinking skills to develop strategies for solving the problems posed in the laboratories. Teaching assistants act as mentors and coordinators for students as they develop problem-solving strategies. Curriculum design is based on constructivist, including a 5-e learning cycle instructional model. The flow diagram of the redesigned laboratories illustrates that 1) the new experiments include an active and engaging pre-laboratory component, 2) envision a modified role for teaching assistants, who introduce overarching concepts and terminology only after students begin to construct these concepts for themselves and 3) remove procedure and technique from their usual prominence in the flow of the laboratory in order to re-establish inquiry and critical thinking as principle objectives of the laboratory experience. A discussion of the principles of the laboratory reform program and working drafts of revised laboratories can be accessed through the *project web site*.

The Kansas Collaborative for Excellence in Teacher Preparation (KCETP). KCETP is an NSF-funded project to reform K-12 science and mathematics teacher preparation programs at KU, Kansas State University and associated two-year colleges and school districts. As a systemic reform program, KCETP takes the position that science and mathematics teacher preparation begins with K-12 students before they have made the decision to pursue careers in mathematics and science education, and continues through the college and university experiences of these students into the early years of their activity in K-12 classrooms. KCETP embraces the concept that scientists, engineers, mathematicians, and science and mathematics teachers are all committed to professions that require lifetime learning. This lifetime commitment requires that participants both maintain a current and active knowledge of mathematics and science content and have a continuing commitment to improve the skills needed to communicate the challenge and excitement of mathematics and science to future generations. The scope of KCETP requires a far-reaching collaboration between K-12 teachers, two-year and four-year college and university faculty, and representatives of the Department of Education.



The KCETP collaborative currently encompasses two Regents Universities, four-two-year colleges and ten school districts shown in this map of Northeastern Kansas. See the *project web site* for more information.

The KU Center for Science Education. The KU Center for Science Education is an interdisciplinary Center focusing on improving mathematics and science education throughout the university and on fostering scholarship in science and mathematics education in the University community. Participants in Center activities are drawn

from Chemistry, Physics, Biology, Mathematics, Environmental Engineering, and Teaching and Leadership.

The Center is working on projects in four general areas:

- 1) implementation of the recommendations of the Chancellor's *Science Education Task Force*;
- 2) funding of projects to improve science and mathematics curricula at KU;
- 3) partnering with the State and local school districts to improve science teacher preparation and serve existing science teachers;
- 4) enhancement of informal science education outreach to the Kansas City metropolitan area and the state.

Additional information about Center projects and programs is available at:
<http://www.kuscied.org>.

The University of Kansas

Chemistry Department

27 April 2006

The Honorable Sherwood Boehlert
Chairman, Science Committee
2320 Rayburn Office Building
Washington, D.C. 20515

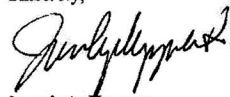
Dear Congressman Boehlert:

Thank you for the invitation to testify before the Committee on Science of the U.S. House of Representatives on May 12th for the hearing entitled "*The Future of Computer Science Research in the U.S.*" In accordance with the Rules governing Testimony, this letter serves as formal notice of the following federal funding I currently receive related to the hearing topic:

- \$199,941; SBE-0521860; NSF; "Learning from Dynamic Visual Displays"; 2005-2007
- \$1,060,747; ESI-0096679; NSF; "Extending Scientific Inquiry Through Geographic Information Systems"; 2001-2006
- \$2,900,000; HER-9876676; NSF; "CETP: The Kansas Collaborative for Excellence in Teacher Preparation, Noyce Scholarships"; 1999-2006
- \$64,800; EEC-0310689; NSF; "REU Supplement to the Center for Environmentally Beneficial Catalysis"; 1994-2007
- \$17,000,000; EEC-0310689; NSF; "Center for Environmentally Beneficial Catalysis"; 2003-2008

I hope that this satisfies the committee's disclosure requirement.

Sincerely,



Joseph A. Heppert
Professor and Chair

JAH/sm

Mr. INGLIS. Thank you, Dr. Heppert. Ms. Pringle.

**STATEMENT OF MS. REBECCA PRINGLE, PHYSICAL SCIENCE
TEACHER, SUSQUEHANNA TOWNSHIP MIDDLE SCHOOL;
MEMBER, EXECUTIVE BOARD, NATIONAL EDUCATION ASSO-
CIATION**

Ms. PRINGLE. Good morning Congressman Inglis, and the Members of the Committee. My name is Becky Pringle, and I am a member of the Executive Committee of the National Education Association. I thank you for this opportunity today to speak with you about the critical issues involved in improving math and science education in this country.

Before I begin my statement, though, I want to take this opportunity to thank the chairman for his long and distinguished career in Congress, and for the support, very, very strong support that he has given to public education, and we will miss his leadership. And we wish him well, as he embarks on many more exciting endeavors, so please extend our congratulations and best wishes to him.

I would also like to thank Ranking Member Bart Gordon and his staff for inviting me here today at this hearing, and also for his advocacy, specifically with math and science, but in general, with public education. I applaud the chair and Congressman Gordon and the Committee for recognizing the importance of the practitioner's voice.

I understand this is a second hearing. You invited not one, not two, but three teachers to share their thoughts with you today. I cannot tell you how much I appreciate that, and on behalf of the 2.8 million members of the National Education Association, thank you. And I would point to that as one of the most valuable components of the National Science Foundation, not only their programs, but the very premise from which they operate. They understand that they cannot put in place programs that are going to be effective at improving education if they do not involve teachers who are in classrooms with children every day. And so, I speak to you, not only as an NEA leader, but I also come to you as an eighth grade teacher of 30 years.

As a science teacher, I am passionate about ensuring the highest quality math and science education for our children, so they cannot only compete successfully, but so that they can help to position our nation at the forefront of an increasingly global society. We must equip them with the 21st Century math and science skills that they will need to help us lead the way tomorrow. And I am equally passionate in my belief that a highly skilled math and science teaching force, knowledgeable in both subject matter and pedagogy, is the most important factor in improving math and science education.

Because NEA believes that improving professional development is the most important factor in strengthening math and science education, the first priority must be to address the education of both new teachers and veteran teachers, providing them with professional development programs that improve continuously their capabilities for improving the instruction for their students.

Given the clear link between teacher quality and student learning, I too, Congressman Inglis, am a bit perplexed. We are very dis-

appointed that the Administration's proposal for improving math and science education focuses overwhelmingly on developing curriculum materials for elementary and middle schools. While ensuring rigorous curriculum is absolutely important, we believe this allocation of resources will not offer the most effective approach to reaching the intended goal. Rather, we would recommend redirecting resources to focus primarily on professional development for teachers.

I teach middle school. No one knows better than teachers of middle level learners that lessons must be developed and adjusted to address the different developmental needs of our students, as well as their different learning styles. With students who seemingly change from one minute to the next, who are constantly hormonally challenged, we must have the knowledge and the skills to adapt our teaching methods to convey difficult concepts, like Bernoulli's principle.

I can tell you that through the work, the research, and in addition to that, the partnerships that the National Science Foundation has established, they have become a major player in making sure that teachers receive the kind of professional development that they actually can put to use in their classroom.

So as I attempt to teach the difficult concept of Bernoulli's Principle, when I talk to my students about fast moving particles creating an area of low pressure, I can't just say that. They would look at me like some of the people behind me are looking at me, what is she talking about? Make her stop. So, I have to use the skills and the training that I learned from these kinds of programs, that the National Science Foundation afforded me. So, by using this simple technique of blowing over this paper, and demonstrating to the children that it rises, because that area of low pressure, where those fast moving particles are, also results in this higher pressure underneath the paper pushing it up. Can you imagine teaching that to middle school students, and making sure that they understand, as is stated in our science principles, and our science standards in Pennsylvania, that they have to not only be able to identify, but they have to be able to explain principles of forces and motion.

Those kinds of techniques and skills are the kinds of opportunities that the programs that have been funded by the National Science Foundation have given us. I want to emphasize the partnership piece. That is so important. There is absolutely no way we are going to improve science instruction in this country if we are not united in that cause. It takes all of us, it takes policymakers, it takes teachers, it takes principals, it takes school districts, it takes all of us to do that. It takes the research from the National Science Foundation. I had the honor and pleasure to participate in one of these partnerships with the Lebanon Valley College, where they brought in teachers from all over Central Pennsylvania, to participate in a weeklong program, where we not only worked very closely with the chemistry, physics, and biology professors there at the school, strengthening our content knowledge, but also working on, together, collaboratively, working on improving our skills at explaining those concepts to students. But you see, we didn't just come there for one week. We had tune-ups, so the funds allowed us to come back, and we didn't just have that. They provided much-

needed materials that many of our science classrooms do not have, to our teachers.

Not only did they do that, but they bring those experiences on-site, so that we have regional math science alliances that are very close. They give us an opportunity to have professional development right in our backyard, that also provide libraries and resources for us. It is the National Science Foundation's work over these many long years that has helped to not only promote, but provide funds for these many programs. So, I would encourage your continued support of the National Science Foundation, and I would like to say that not only are their efforts in professional development, but also, all of the work that they have also done in curricular design, so I would encourage you to continue to push for their increased funding.

Thank you for your kind attention.

[The prepared statement of Ms. Pringle follows:]

PREPARED STATEMENT OF REBECCA PRINGLE

Mr. Chairman and Members of the Committee:

My name is Becky Pringle and I am a member of the Executive Committee of the National Education Association. I thank you for the opportunity to speak with you today about the critical issues involved in improving math and science education in our nation's elementary and secondary schools.

This is a timely and important issue, not only because the 2007–08 school year marks the beginning of required science testing under No Child Left Behind, but, most especially, because we know that for our nation to position itself at the forefront of an increasingly global society, we must equip our students today with the 21st century math and science skills they will need to lead the way tomorrow.

I speak to you today as an NEA leader, representing NEA's 2.8 million members. But, I also come to you as an eighth grade science teacher with 30 years of classroom experience. As a science teacher, I am passionate about ensuring the highest quality math and science education so that all of our students can compete successfully in the global economy. And, I am equally passionate in my belief that a highly skilled math and science teaching force, knowledgeable in both subject matter and pedagogy, is the most important factor in improving math and science education.

My testimony today will highlight the importance of focusing resources on professional development to improve math and science education and the critical role the National Science Foundation (NSF) can play in these efforts.

A Focus on Professional Development

NEA believes that improving professional development is the single most critical factor in strengthening math and science education. No single change will make a bigger difference in helping students reach high academic standards than ensuring quality teachers. Therefore, the first priority for improving K–12 math and science education should be to address the education of new teachers and provide professional development programs to improve continuously the capabilities of current math and science teachers.

Given the clear link between teacher quality and student learning, we are disappointed that the Administration's proposal for improving math and science education focuses overwhelmingly on developing math curricular materials for elementary and middle schools. In fact, 70 percent of the proposed funding would go toward these efforts. While ensuring rigorous curricula is certainly an important part of strengthening math and science education, we believe this allocation of resources will not offer the most effective approach to reaching the intended goal. Rather, we would recommend redirecting resources to focus primarily on professional development and training for teachers.

Quality professional development programs focus both on content and pedagogy. Improving subject matter knowledge and pedagogical knowledge are equally important in preparing math and science teachers. Effective teachers have a deep knowledge of their subject matter and are equally skilled at using appropriate strategies to teach that knowledge to students.

Understanding content is essential. Educators with a breadth and depth of content knowledge are the foundation for excellent math and science teaching and

learning. However, it is also important to know how children learn, how different children learn differently, and how to tailor instruction accordingly. Our increasingly diverse classrooms demand that teachers understand a number of ways of providing instruction to students. For example, students with learning disabilities, or those for whom English is a second language, may require instruction delivered in a different way than their peers.

I teach middle school. No one knows better than teachers of middle level learners that lessons must be developed and adjusted to address the different stages of cognitive developmental levels as well as learning styles. With students who seemingly change from moment to moment, we must have the knowledge and skills to adapt our teaching methods to convey difficult concepts like Bernoulli's Principle. We must have strategies and tools that allow us to help students make science connections with their world by relating, for example, Newton's 2nd Law of Motion ($F=ma$) to their batting practice. It was through professional development opportunities that I learned and developed techniques to bring science alive for my students, so they could understand both the content and its relevance.

Attached to this testimony are some general guidelines that NEA believes exemplify quality professional development for teachers. These guidelines—including language from the current Elementary and Secondary Education Act and standards developed by the National Staff Development Council—are applicable to the sort of training we believe is essential to ensure excellent K–12 math and science education. For example, quality professional development:

- Focuses on both content and pedagogy;
- Is sustained, intensive, and classroom-focused;
- Aligns with State and local goals and standards;
- Prepares educators to understand and appreciate all students, create safe, orderly, and supportive learning environments, and hold high expectations for their academic achievement;
- Provides educators with knowledge and skills to involve families and other stakeholders appropriately; and
- Addresses different levels of professional development, including individual, school, district, and state. NSF has historically funded a variety of program aimed at each of these levels.

The Role of the National Science Foundation

NEA believes that NSF should be a major player in any federal initiative to improve K–12 math and science education, and we are concerned that the Administration's competitiveness initiative does not include NSF as a significant partner. The Administration's budget request would actually cut NSF's K–12 programs by about seven percent. In fact, between FY 2004 and the FY 2007 request, funding for the main NSF K–12 programs (Math and Science Partnerships, Instructional & Assessment Materials Development, and Teacher Development) has declined by nearly half, from \$283 million to \$150 million.

NSF is an ideal partner in improving math and science education. The Foundation has a long history of providing effective professional development for teachers; they understand the importance of developing and providing experiences that focus on both content and pedagogy. Nearly 50 years ago, NSF ran a Summer Institute Program that has been widely acknowledged as one of the most important steps in improving K–12 mathematics and science education. NSF has the infrastructure not only to seed, drive, and facilitate the use of developed mathematics and science curricula, but also the development and assessment of new curricula for the 21st century.

As an independent federal agency, NSF has the experience in leading research that can promote K–12 mathematics and science education. NSF's long history of funding and supporting research in a variety of disciplines is one to be proud of. For example, it is quite common to hear people say "just Google it," meaning to use a search engine to find out something of interest. What most people don't know, however, is that both founders of Google studied under an NSF funded faculty member. Clearly, NSF has played a leading role in advancing effective research.

NSF can use its experience of funding large-scale research studies at universities, foundations, school districts, and other institutions to improve K–12 science and math education. Currently, NSF promotes partnerships between and among Schools and Colleges of Education, Engineering, Mathematics, and Science, as well as local school districts.

The NSF Math and Science Partnership (MSP) awards competitive, merit-based grants to teams composed of institutions of higher education, local K–12 school sys-

tems, and their supporting partners. These partnerships develop and implement pioneering ways of advancing math and science education. The program is based on five pillars: Partnership-Driven, Teacher Quality, Quantity and Diversity, Challenging Courses and Curricula, Evidence-Based Design, and Institutional Change and Sustainability. It involves four components:

- Comprehensive partnerships, which implement change across the K–12 continuum in math and science;
- Targeted partnerships, focusing on improved student achievement in a narrower grade range or disciplinary focus in math and science;
- Institute partnerships, helping to develop math and science teachers as school- and district-based intellectual leaders and master teachers; and
- Research, Evaluation, and Technical Assistance activities assisting partnership awardees in the implementation and evaluation of their work.

The collaboration at universities between education, mathematics, science, and engineering faculty required by the MSP program takes advantage of the best universities and colleges have to offer. Partnerships such as the one I participated in focus on strengthening both the knowledge base of science teachers, as well as enhancing their pedagogical skills. I attended one such program at Lebanon Valley College that brought teachers from all over the Central Pennsylvania area together to review, update, and enhance our knowledge of the physics and chemistry principles contained in our state's science standards. We spent the week learning together, developing activity-based, hands-on lessons and labs for our students. The college was also able to provide teachers who did not have the resources in their school districts with materials and kits for use with their students.

NSF funding has also advanced the efforts of the National Science Teachers Association (NSTA) to provide professional development to science teachers nationwide. For example, as a participant in NSTA's national conferences, I was able to attend workshops that improved my practice, as well as learn about the ongoing research projects NSF was conducting to advance science education.

Additionally, members of NSTA, benefit from the research and information available to us because of NSF-funded activities. For example, NSTA's Science Program Improvement Review (SPIR) program, which was designed to assess a school's complete science instructional program across all grade levels, helped schools and districts align science instruction more closely with State and national science standards for teaching, professional development, assessment, content, and program.

A five-year, \$12.5 million NSF initiative in Arizona, which began in 2004, offers a tuition-free program at Arizona State University providing teacher training to more than 100 educators. Teachers participating in the program take graduate-level integrated math and science classes. The program was designed not only to benefit those teachers taking part, but in its ongoing research efforts, NSF hopes to learn and share how professional development of teachers affects student achievement in math and science.

NSF supports programs that promote the kind of individual professional development plans NSTA recommends, ones that include a variety of opportunities to learn, practice, and enforce new behaviors through workshops and seminars that focus on immersion into inquiry science, and provide training in mentoring and coaching.

NSF and the Department of Education: A Partnership for Quality Math and Science Education

We believe that the National Science Foundation should focus on supporting professional development programs that take advantage of the research on adult learning. Teachers need sustained, long-term professional development. Today, unfortunately, some teachers receive what they call "drive-in" professional development—quick and fulfilling only for a short time. These programs leave little time for teachers to reflect on their own learning, internalize and incorporate their new skills and knowledge into their teaching, and collaborate with and learn from their colleagues. Given their experience with programs such as the Math and Science Partnerships, NSF is uniquely qualified to promote and finance quality programs that will ensure effective professional development with long-term application.

NSF can also assist in the curriculum development aspect of math and science education. The foundation has had success with the development of mathematics curricula, but has lacked the funds to implement the curricula on a large scale. Therefore, we recommend that any initiatives to develop new curricula include resources both for development and implementation.

The Department of Education has a critical role to play in these efforts. We welcomed Secretary Spellings' recent announcement of Teacher to Teacher regional

workshops as an important addition to teacher professional development. We continue to believe, however, that professional development that is likely to promote long-term change and instructional improvement is more appropriately addressed by local universities, foundations, and school districts that can support year-long professional development experiences.

The Department of Education should focus on gathering information about programs that work and disseminating this information to state and local agencies. On a larger scale, the Department should work both to ensure equitable access to education for all of our nation's students and to promote support for education to the general public. Both of these factors are essential to ensuring that improvements in math and science education reach all students, regardless of income level, geographic location, or ethnic or minority status.

Recruitment of Math and Science Teachers

Although today's hearing focuses primarily on professional development and curriculum to strengthen math and science education, I would like to offer one additional thought regarding recruiting quality math and science teachers, particularly from the private sector. Two current provisions of Social Security law—the Government Pension Offset (GPO) and Windfall Elimination Provision (WEP)—are undermining efforts to attract quality teachers. The WEP in particular is a disincentive for individuals to move from the private sector into teaching, as it cuts significantly the Social Security benefits they can receive from their private sector job. The GPO and WEP have the most impact in 15 states where teachers do not pay into Social Security, including large states such as California, Texas, and Illinois. Repeal of these offsets is a top priority for NEA and should be part of any initiative to attract quality math and science teachers.

Conclusion

Improving math and science education is vital to the future strength of our nation and to the ability of our future workforce to compete in the global economy. Ensuring quality teachers is the single most important element to address if we are to reach this goal.

Therefore, NEA recommends:

- Focusing efforts to improve math and science education on professional development for new and veteran teachers.
- Continuing and expanding funding for NSF's Mathematics Science Partnership Programs to allow new partnerships.
- Allowing NSF to take the lead and partner with the Department of Education in professional development and curriculum design.

I thank you for the opportunity to provide this testimony to you today and look forward to working with the committee on these important issues.

APPENDIX:**Guidelines for Quality Professional Development****From Current Elementary and Secondary Education Act:**

Sec. 9101(34) PROFESSIONAL DEVELOPMENT—The term ‘professional development’—

(A) includes activities that—

- (i) improve and increase teachers’ knowledge of the academic subjects the teachers teach, and enable teachers to become highly qualified;
- (ii) are an integral part of broad schoolwide and districtwide educational improvement plans;
- (iii) give teachers, principals, and administrators the knowledge and skills to provide students with the opportunity to meet challenging State academic content standards and student academic achievement standards;
- (iv) improve classroom management skills;
- (v) (I) are high quality, sustained, intensive, and classroom-focused in order to have a positive and lasting impact on classroom instruction and the teacher’s performance in the classroom; and
(II) are not one-day or short-term workshops or conferences;
- (vi) support the recruiting, hiring, and training of highly qualified teachers, including teachers who became highly qualified through State and local alternative routes to certification;
- (vii) advance teacher understanding of effective instructional strategies that are—

(I) based on scientifically based research (except that this subclause shall not apply to activities carried out under part D of title II); and

(II) strategies for improving student academic achievement or substantially increasing the knowledge and teaching skills of teachers; and

(viii) are aligned with and directly related to—

(I) State academic content standards, student academic achievement standards, and assessments; and

(II) the curricula and programs tied to the standards described in subclause (I) except that this subclause shall not apply to activities described in clauses (ii) and (iii) of section 2123(3)(B);

(ix) are developed with extensive participation of teachers, principals, parents, and administrators of schools to be served under this Act;

(x) are designed to give teachers of limited English proficient children, and other teachers and instructional staff, the knowledge and skills to provide instruction and appropriate language and academic support services to those children, including the appropriate use of curricula and assessments;

(xi) to the extent appropriate, provide training for teachers and principals in the use of technology so that technology and technology applications are effectively used in the classroom to improve teaching and learning in the curricula and core academic subjects in which the teachers teach;

(xii) as a whole, are regularly evaluated for their impact on increased teacher effectiveness and improved student academic achievement, with the findings of the evaluations used to improve the quality of professional development;

(xiii) provide instruction in methods of teaching children with special needs;

(xiv) include instruction in the use of data and assessments to inform and instruct classroom practice; and

(xv) include instruction in ways that teachers, principals, pupil services personnel, and school administrators may work more effectively with parents; and

(B) may include activities that—

(i) involve the forming of partnerships with institutions of higher education to establish school-based teacher training programs that provide prospective teachers and beginning teachers with an opportunity to work under the guidance of experienced teachers and college faculty;

(ii) create programs to enable paraprofessionals (assisting teachers employed by a local educational agency receiving assistance under part A of title I) to obtain

the education necessary for those paraprofessionals to become certified and licensed teachers; and
 (iii) provide follow-up training to teachers who have participated in activities described in subparagraph (A) or another clause of this subparagraph that are designed to ensure that the knowledge and skills learned by the teachers are implemented in the classroom.

National Staff Development Council Standards for Staff Development

(Revised, 2001)

Context Standards

Staff development that improves the learning of all students:

- Organizes adults into learning communities whose goals are aligned with those of the school and district. (Learning Communities)
- Requires skillful school and district leaders who guide continuous instructional improvement. (Leadership)
- Requires resources to support adult learning and collaboration. (Resources)

Process Standards

Staff development that improves the learning of all students:

- Uses disaggregated student data to determine adult learning priorities, monitor progress, and help sustain continuous improvement. (Data-Driven)
- Uses multiple sources of information to guide improvement and demonstrate its impact. (Evaluation)
- Prepares educators to apply research to decision making. (Research-Based)
- Uses learning strategies appropriate to the intended goal. (Design)
- Applies knowledge about human learning and change. (Learning)
- Provides educators with the knowledge and skills to collaborate. (Collaboration)

Content Standards

Staff development that improves the learning of all students:

- Prepares educators to understand and appreciate all students, create safe, orderly, and supportive learning environments, and hold high expectations for their academic achievement. (Equity)
- Deepens educators' content knowledge, provides them with research-based instructional strategies to assist students in meeting rigorous academic standards, and prepares them to use various types of classroom assessments appropriately. (Quality Teaching)
- Provides educators with knowledge and skills to involve families and other stakeholders appropriately. (Family Involvement)

BIOGRAPHY FOR REBECCA PRINGLE

Rebecca “Becky” Pringle, an eighth grade physical science teacher from Harrisburg, Pennsylvania, was re-elected for a second three-year term to the National Education Association’s (NEA) nine-member Executive Committee in July 2004.

A middle school teacher with 29 years’ classroom experience, Pringle has held Association positions at the national, State and local levels. For the past five years, she has served on the Board of Directors of the NEA. She has also served on the Pennsylvania State Education Association’s Board.

Pringle’s long history of leadership has included attention to diversity issues, student achievement, and developing leaders within the Association. She chaired the PSEA Human and Civil Rights Award Committee, the PSEA Task Force on Minority Representation, and the Strategic Planning Committee on Diversity for her local Susquehanna Township School District. In addition, she served as regional chair of the PSEA Leadership Development Committee and on the Institute for Educational Leadership Task Force.

Since being elected to her post on the Executive Committee for NEA, Pringle has served on the NEA’s Women’s Issues Committee, Distance Learning Task Force and both the National and State Media Advisory Groups. With the passage of the latest reauthorization of the Elementary and Secondary Education Act, Pringle has become a leader in the organization as chair of NEA’s ESEA Advisory Committee. She also serves on the National Board for Professional Teaching Standards.

Pringle has been active in the area of literacy and served as the Chair of NEA’s Reading Task Force. As a member of NEA’s Professional Standards and Practices Committee, she provided leadership in the development of the Committee’s report on “Excellence and Equity: Closing the Student Achievement Gaps.” She has been honored with the Pennsylvania Academy for the Profession of Teaching Award, and AAUW’s Harrisburg Community Woman of the Year Award. Pringle currently teaches at Susquehanna Township Middle School.

A Philadelphia native, Pringle received her Bachelor of Science degree in elementary education from the University of Pittsburgh in 1976. She earned a Master’s of Education from Pennsylvania State University in 1989. She and her husband, Nathan, live in Harrisburg. Their son, Nathan III, is a recent graduate from Drexel University, and their daughter, Lauren, is a senior at New York University.

The NEA Executive Committee comprises the three NEA executive officers plus six members elected at large.



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Executive Director

May 3, 2006

The Honorable Sherwood Boehlert
Chairman, Science Committee
2320 Rayburn Office Building
Washington, DC 20515

Dear Congressman Boehlert:

Thank you for the invitation to testify before the Committee on Science of the U.S. House of Representatives on May 3rd for the hearing entitled "*The Role of the National Science Foundation in K-12 Science and Math Education.*" In accordance with the Rules Governing Testimony, this letter serves as formal notice of the federal funding I currently receive related to the hearing topic.

I received no federal funding directly supporting the subject matter on which I testified, in the current fiscal year or either of the two preceding fiscal years.

Sincerely,

Rebecca S. Pringle
NEA Executive Committee

Mr. INGLIS. Thank you, Ms. Pringle. Mrs. Snyder.

STATEMENT OF MS. JUDY D. SNYDER, MATHEMATICS TEACHER, EASTSIDE HIGH SCHOOL, TAYLORS, SOUTH CAROLINA

Ms. SNYDER. Congressman Inglis and Members of the Committee, I appreciate the opportunity to share with you the impact of NSF programs from my viewpoint as a high school teacher of mathematics.

I believe the strength of the Foundation lies in its unique ability to tap the creativity of university scientists, mathematicians, and educators, to direct their vision towards helping teachers in the classroom. The NSF programs I have been fortunate enough to participate in have been grounded in content and research, but have been equally balanced with pedagogy. The opportunity they have provided for collaboration between K-12 teachers and higher education has enabled me to build relationships that have molded my teaching career.

An NSF-sponsored program at Furman University provided me with increased knowledge of science and research that led me to pursue classroom collaboration with a biology teacher. This "Young Scholars" summer program provided immersion in science classes and research opportunities for gifted high school students, and a few lucky high school teachers. This program made me realize that high school students are capable of doing research at a level beyond what I considered possible, and allowed me to experience firsthand how exciting hands-on research can be. I took away from this program the desire to involve my students in hands-on learning connecting math and science. Relationships built with Furman science faculty as a result of this NSF program proved immediately beneficial. A Furman plant physiologist, Dr. Laura Thompson, aided in the writing and implementation of a GTE Growth Initiatives for Teachers grant that funded technology and professional development opportunities to connect math and science. That grant allowed a biology teacher and I to develop activities connecting geometry and biology.

NSF also funded a teacher enhancement program at the University of South Carolina at Spartanburg entitled "Partnership for Excellence: A Model Program for Professional Development of Middle and Secondary School Mathematics Teachers." These courses changed my approach to teaching, by not only deepening my content knowledge, but modeling a hands-on, inquiry-based, technology-rich approach to teaching. Dr. Celia Adair, the principal investigator of this program, modeled in her teaching the pedagogical approach encouraged by the national standards. She has become a mentor, not only for me, but for teachers all over the state. And I have worked to infuse the discovery approach to teaching in my classroom, with the help of several grants funding materials and technology.

One of the strong points of NSF programs is the balance between content, research, and pedagogy. Content and pedagogy should not be considered separate entities, as the USCS program demonstrates. If teachers are exposed to content without pedagogy, like the students they lecture to, they can be heard to grumble, when am I ever going to need to know this? When teachers get pedagogy

without content, they can be heard to grumble, if I have to sit through one more session on learning styles, I am going to scream. When content and pedagogy are taught in concert, both become meaningful. Content makes sense when teachers and students are discovering it and doing it. Therefore, NSF programs that combine content and pedagogy will have the most impact, by improving the capabilities of science and math teachers.

I believe collaboration between NSF, the Department of Education, and other agencies is important. NSF is best suited to the development of new programs that take advantage of the creativity of the scientific community. The Department of Education should take those programs that have proved successful, and provide funding for their continuation, and for the publication of resulting materials.

In conclusion, I believe that NSF must continue to have a strong role in K–12 education. It is possibly the only agency that can make the long, sustained effort necessary to improve math and science education, because it is less subject to the shifting winds of political opinion. Additionally, its funding is direct, and funding from agencies such as the Department of Education often comes through the states, down to the district level. School districts are subject to constant change, meaning that programs showing promise may not last long enough to show results, if a new superintendent with a new agenda is hired. NSF programs are not affected by that kind of instability, and are thus the best hope for K–12 educators.

Thank you for the opportunity to speak on behalf of the many teachers and students who have benefited from the strong commitment of NSF to the improvement of math and science teaching. It is my hope that K–12 teachers will continue to be the beneficiaries of this commitment.

Thank you, Mr. Inglis.

[The prepared statement of Ms. Snyder follows:]

PREPARED STATEMENT OF JUDY D. SNYDER

Chairman Boehlert and Members of the Committee:

I appreciate the opportunity to share with you the impact of NSF programs from my viewpoint as a teacher of high school mathematics. From my position at the receiving end of NSF's educational programs I believe the strength of the Foundation lies in its unique ability to tap the creativity of university scientists, mathematicians, and educators to direct their visions toward helping teachers in the classroom. The NSF programs I have been fortunate enough to participate in have been grounded in content and research but have been equally balanced with pedagogy. The opportunity they have provided for collaboration between K–12 teachers and higher education has enabled me to build relationships that have molded and shaped my teaching career.

My participation in an NSF sponsored program at Furman University provided me with an increased knowledge of science and research that led me to pursue classroom collaboration with a biology teacher. The "Young Scholars" summer program provided immersion in science classes and research opportunities for gifted high school students and a few lucky high school teachers. This program made me realize that high school students are capable of doing research at a level beyond what I considered possible and allowed me to experience first hand how exciting hands-on research can be. I took away from this program the desire to involve my students in hands-on learning connecting math and science. Relationships built with Furman science faculty as a result of this NSF program proved immediately beneficial. A Furman plant physiologist, Dr. Laura Thompson, aided in the writing and implementation of a GTE Growth Initiatives for Teachers grant that funded tech-

nology and professional development opportunities to connect math and science. That grant allowed a biology teacher and me to develop activities connecting geometry and biology. One of the activities involved comparing the shapes of “sun” and “shade” tree leaves in geometry class and examining the differences in chlorophyll content in the same leaves in the biology lab. A second activity involved using surface area-to-volume-ratios studied in geometry to make the connection to cell-size and cell-diffusion in the biology lab.

NSF also funded a teacher enhancement program at the University of South Carolina at Spartanburg, entitled “Partnership for Excellence: A Model Program for Professional Development of Middle and Secondary School Mathematics Teachers.” This program offered workshops, academic year courses, and summer institutes designed to increase teachers’ effectiveness in implementing national curriculum and evaluation standards. I took several of the courses offered through this program and they changed my approach to teaching. These courses not only deepened my content knowledge, but modeled a hands-on, inquiry-based, technology rich approach to teaching. Dr. Celia Adair, the principal investigator of this program, taught several of the courses, modeling in her teaching the pedagogical approach encouraged by the national standards. She has become a mentor, not only for me, but for teachers all over the state. I learned from her and from this program a new approach to teaching. This has resulted in several successful grant applications providing materials and technology necessary for the discovery approach to teaching I have tried to infuse into my classroom. One of the activities I developed as a result makes the connection between music and mathematics, and another asks students to answer the question, “Why are there only five regular polyhedra?” It was this second activity that I used in my Presidential award application.

I believe one of the strong points of NSF programs is the balance between content, research, and pedagogy. Dr. Adair’s program at USCS best answers the question about prioritizing content vs. pedagogy by demonstrating that they should not be separate entities. If teachers are exposed to content without pedagogy, they are just like the students they lecture to. They can be heard to grumble “When am I ever going to need to know this?” When teachers get pedagogy without content, they can be heard to grumble, “If I have to sit through one more session on learning styles, I’m going to scream!” When content and pedagogy are taught in concert both become meaningful. Content makes sense to students and teachers alike when they are “discovering” it and “doing” it. Many teachers still teach the way they were taught—by lecturing. Changing how teachers are taught can and does result in a change in the way they teach. Therefore, NSF programs that combine content and pedagogy will have the most impact on improving the capabilities of science and math teachers. I also believe that NSF could improve education programs by taking advantage of talented high school teachers such as the Presidential Awardees in town this week to offer professional development programs for other teachers.

I believe collaboration between NSF, the Department of Education, and other agencies, is important. NSF is best suited to the development of new programs that take advantage of the creativity of the scientific community. The Department of Education should take those programs that have proven successful and provide funding for their continuation and for the publication of resulting materials. Dr. Adair’s program at USCS was funded for an additional two years with Eisenhower funds, much to the benefit of teachers in South Carolina. One of the teachers benefiting from the continuation of this program was Joyce Dodd, last year’s Presidential Awardee from South Carolina.

In conclusion, I believe that NSF must continue to have a strong role in K–12 education. It is possibly the only agency that can make the long, sustained effort necessary to improve math and science education because it is less subject to the shifting winds of political opinion. Additionally, its funding is direct, and funding from agencies such as the Department of Education often comes through the states down to the district level. School districts are subject to constant change meaning that programs showing promise may not last long enough to show results if a new superintendent with a new agenda is hired. NSF programs are not affected by that kind of instability and are thus the best hope for K–12 educators.

Thank you for the opportunity to speak on behalf of the many teachers and students who have benefited from the commitment of NSF to the improvement of math and science teaching. It is my hope that K–12 teachers will continue to be the beneficiaries of this commitment.

This concludes my statement, Mr. Chairman. I will be glad to respond to any questions the Committee may have.

BIOGRAPHY FOR JUDY D. SNYDER

Mrs. Snyder has served as a mathematics educator in the Greenville County School District for the past 27 years. She has taught at Tanglewood Middle School, Travelers Rest High School, and currently teaches at Eastside High School. During that time Mrs. Snyder has been an active member of the National Council of Teachers of Mathematics, serving on the local board as Newsletter Editor, and on the state board as Vice President for High Schools. She has been a presenter at numerous local, State, and regional conferences. She holds South Carolina teaching certification in Secondary Mathematics, Middle School Mathematics, Elementary, and Gifted and Talented. She achieved National Board Certification in Early Adolescence/Mathematics in 2002.

During her career Mrs. Snyder has received several awards including:

GTE GIFT (Growth Initiatives for Teachers) Fellow 1996–1997

Greenville County Teacher of the Year 1999–2000

ING Education's Unsung Heroes Award 2003–2004

Presidential Award for Excellence in Mathematics and Science Teaching 2005

Mrs. Snyder received a B.M. and B.A from the University of Akron in 1966 where she graduated summa cum laude and was class valedictorian. She studied in Paris, France, as a Fulbright Scholar in 1966–1967. She received a M.A. from Furman University in 1978, and did further studies in mathematics to achieve Master's plus 30 certification.

She has two publications:

Snyder, J.D. "The Oak Leaf, Connecting Biology and Geometry," *Mathematics Teacher*, National Council of Teachers of Mathematics, April, 1999, vol. 92(4):294–298.

Snyder, J.D. "A Pythagorean View of the Basics," *Mathematics Education Dialogues*, National Council of Teachers of Mathematics, October, 1999, vol. 3(1):10.

Mrs. Snyder was born in Akron, Ohio. She is married to Dr. John Snyder, Professor at Furman University and has three children, Dr. Erin Shelor, Dr. Benjamin Snyder, and Dr. Philip Snyder.

May 3, 2006

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Chairman, Science Committee
2320 Rayburn Office Building
Washington, DC 20515

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I received no federal funding directly supporting the subject matter on which I testified, in the current fiscal year or either of the two preceding fiscal years.

Sincerely,



Judy Snyder

DISCUSSION

Mr. INGLIS. Thank you, Ms. Snyder. Thank you all for your testimony. I recognize myself for a round of questions.

Ms. Snyder, Ms. Pringle, you mentioned in your written testimony the role of mentors in improving education, improving opportunities for teachers. Maybe you would like to comment on that, further about the role of mentors in assisting teachers, especially is it useful just for brand new teachers, or is it also useful for more experienced teachers, to have a mentoring opportunity?

Ms. SNYDER. Obviously, I think it is important for both, and I think what I mentioned was the importance of having mentors that are in higher education, as well as mentors who are on the job with you. New teachers need mentors that are in the building, that they can go to. Older teachers need mentors from people who are in the profession, maybe in the same district, or across the state, and that is why it is important that teachers not be isolated from each other, not feel isolated, be able to attend professional development, where they can network with other teachers, and learn from each other. You don't teach in a vacuum. You learn from each other, and a single teacher cannot do this kind of job alone. They need other people to help them.

Mr. INGLIS. Ms. Pringle.

Ms. PRINGLE. And I am so glad you added the veteran teachers as well, because we often times just think about mentoring for that first two years or so. So, we don't often call it mentoring, but it is important, especially, I would say, in science and in math, that teachers have the opportunity, the time, to have that collegial sharing of ideas, exchanging their practices, observing each other, and critiquing their teaching. So, those are kinds of mentorship opportunities that we often don't give our veteran teachers, that we need to have the funding and the time structured into the school day to provide for.

Mr. INGLIS. I was once talking with someone in an industry, a fairly high tech industry, and he said that he wished that there were opportunities for his company to interact with teachers, so the teachers in our high schools would know what it is that they were looking for in industry.

Any of these mentoring opportunities you have seen work with actually industry as well as, say, somebody at a college or a university? Ms. Snyder.

Ms. SNYDER. I can speak to that. We had an excellent program in Greeneville County, where we connected with industries. Those industries provided us with mathematical questions that—part of what their workers did. The students studied those mathematical questions, and studied about the particular industry. The industry gave the information about what the workers did, and then, the students were invited to the industry on a field trip, to see first-hand what went on in that industry, and then, another interesting thing is that they gave them a test that they would give future employees, that was a math test, and so, the students were able to see could I actually get hired at that place? I thought that was an excellent program.

Ms. PRINGLE. I would add to that, that it not only provides that mentoring opportunity for the teacher, but it provides real life experiences for students, that we are continuously encouraging to pursue math and science as a career.

We had an opportunity to work in a partnership with Penn State University, who was in partnership with industry, that was producing hybrid cars. And not only did they help us, the teachers that were a part of that partnership, to focus the skills that we were teaching, the concepts, especially the concepts around force and motion, as it related to the hybrid car, and chemistry, too, but we also—they also provided us with equipment for our classroom, where we had an eye on our computer, and the students were able to talk directly with the men and women that were working in industry as they came up with a question, and it went on, the partnership went on throughout the entire year. This is our eighth year, I believe, that we have been engaged in that, and they were able, they gave up their own time, and helped our students with their science fair projects, et cetera. So, it provided a mentoring opportunity for the teachers, but it also provided real life experiences for the students.

Mr. INGLIS. Thank you. It goes a long way to answering that question that you described earlier, about what practical impact will this have on my life, learning this principle, doesn't it, when you see it in operation?

Ms. PRINGLE. Yes.

Mr. INGLIS. Thank you. Mr. Gordon.

Mr. GORDON. Thank you, Mr. Chairman.

Chairman Boehlert and I, a couple of years ago, joined with some Senators, and requested that the National Academy do a report on the competitiveness of the United States in the 21st Century, and make any kind of recommendations. The unanimous conclusion was that we are in an international race, and that we are losing it, and Dr. Heppert, your daughter and my five-year-old daughter could very well be a part of the first generation of Americans that inherit a national standard of living that is lower than their parents, a complete reverse of the American dream. It is somewhat camouflaged now, because we are eating our seed corn, but you know, it will catch up with us. And so, I am very concerned.

The report went on to make recommendations. They discussed the role of math, science, and STEM education in our country, and how we are losing that edge, and trying to say why, they pointed out that over half of our math and science teachers in this country have neither a major or a certificate in that subject. Both my parents were teachers. My father, as I mentioned earlier, was an agriculture major, and when he got out of school, to help make a living, he taught as well as be a farmer. And he was asked to teach high school science, and to coach the girls' basketball team. Now, I am not sure which he knew least about, coaching girls' basketball, or high school science. He was put in a very difficult situation, just like many of our teachers today, and they went on to say that the best way to try to correct that was to both bring existing teachers, and raise a new level of teachers, their skill level, in the areas of math and science.

I think this is very important. The National Science Foundation has been doing this for 50 years, has a proven record, and that is why it is really disappointing that at this point in time, when there is a lack of resources, that we have come together knowing that we need to increase these skills, but we seem to be doing it the wrong way, with a 47 percent cut in the National Science Foundation, with 70 percent of our new dollars going into curriculum. There seems to be some misguided priorities. I hope that today can be the start of an education program, so that we can get this right. We may not have a second chance.

So, let me just ask cumulatively if this panel agrees that the National Science Foundation should be the leading player in the federal initiative to improve the K-12 STEM education. Just raise your hand if that is the case. So, we will—for the record, we will show that we are unanimous.

Dr. Heppert and Ms. Snyder made their views, I think, pretty clear, in terms of the important relationship between the National Science Foundation and our Department of Education. I think there can be a partnership, but we have got to get it right.

So, let me ask Dr. Bartels and Ms. Pringle if you would like to add any thoughts as to the appropriate partnership between the Department of Education and the National Science Foundation, and how this should go forward. So, Dr. Bartels?

Dr. BARTELS. I was just at an OECD conference not long ago, talking about the declining enrollments in science and technology

in most of the Western developed countries, and the interesting thing is, when they sort of talked about solutions to those particular problems, how much farther behind, interestingly, they seem to be, than the United States, and we sat back and paused about that, and realized that one of the difficulties at this point was made, I believe, by Ms. Pringle, is that in most other countries, a lot of this research work and development in education is part of the government ministries, or is sort of isolated efforts at universities. And what was sort of missing was sort of this independent scientific agency that used scientific rigor at its very basis to accumulate wisdom over time, and to continue to apply that wisdom to new ideas, new products, new tools, and that was sort of independent from any particular administration sort of going through.

I think the Department of Education has every right to support states and school districts in implementing programs, and implementing policies, and giving guidance, and in lots of ways, reinforcing what has been the tradition of our country, local control and effort, whereas the NSF, I do not believe, is responsible for implementation, and I don't think should be held accountable for that. I think they should be held accountable for the success of a lot of their ideas and innovations, and how many of them make it successfully into the marketplace, into our classrooms, into commercial markets, and are used well and to great effect by our students. And so, I would separate implementation and direct service, as that belongs to the Department of Education, from applied research and R&D, again, the same way that the NIH does this for medicine.

Mr. GORDON. Ms. Pringle.

Ms. PRINGLE. Additionally, I do think that the Department has a critical role to play. It certainly should and could act as a clearinghouse, gathering information on best practices and programs that work, and disseminating this information, so that it can be used at the state and local level.

On a larger scale, I think the Department should work to ensure equitable access to education, which is a critical issue, as you very well know, to make sure that all of our nation's students, all of them, have access to a quality science education.

Both of these factors are essential in ensuring that the improvements in math and science, and this, I can't emphasize this enough, that the improvements in math and science reach all students, regardless of their economic background, or the geographic location, or their ethnic or minority status, and I think that the Department has a large role to play in that.

However, I think that because of the National Science Foundation's long history of providing effective—providing and promoting and funding-effective professional development programs for teachers, because they understand the importance of developing and providing experiences that focus on both the content and the pedagogy, and that they understand that professional development has to be approached at different levels. You have to talk about what the needs of the teachers are. You have to talk about what the needs of the school district are. You have to talk about what the needs of the state, and quite honestly, as you talked about, the country are, and the National Science Foundation has done that throughout its long history.

Mr. INGLIS. Thank you. Mr. Gutknecht.

Mr. GUTKNECHT. Thank you, Mr. Chairman.

Let me first of all welcome two special guests from my district, Mr. Steven Benson, who teaches math in Owatonna, Minnesota, and we are delighted to have him with us, and also, Ms. Debra Las, who teaches at John Adams Middle School. She teaches science there to eighth graders, and let me just say several things about that I want to mention.

First of all, it doesn't really surprise me that two of the most outstanding teachers come from my Congressional district, and more importantly, from those particular school districts, and I take no credit, although politicians should be able to take credit for things which they don't deserve, and avoid blame for things that they do. But let me just say that first of all, those two school districts, I think, Minnesota in general, and those two school districts in particular, I think set very high expectations, and as a result, we do expect that kids are learning math and science, and particularly in Rochester, where we have both IBM and the Mayo Clinic, we have an awful lot of people who live in that town who take math and science very seriously, and so, I know a lot about John Adams Junior High School. Two of my kids went there, and it really is an outstanding school, and we are delighted to have you with us.

One of the things, though, that has concerned me about math and science in general is talking about expectations, in part, and basically, the United States culture, if you will, we are big on sports. And in fact, in Minnesota, we have baseball camps, we have football camps, we have basketball camps, and in fact, in Minnesota, we have hockey camps, too. And any Saturday, you see how seriously we take soccer. Unfortunately, and I have been trying to promote this idea for a very long time, and I have only had a couple of takers, and that is that we need more science and math camps. And I think we need those for a variety of reasons. Number one, you have all talked a little bit about the importance of teachers being able to get together, and work with outside experts. Now, IBM in Rochester does have a sort of a science camp. It is principally for girls, which in some respects, is unfair to the boys, but we have talked a lot about on this committee about the need to keep young ladies interested in math and science, so I am a supporter of that program. There is another corporation that has a math and science program that they sponsor in Blooming Prairie, Minnesota, but beside that, we really haven't gotten a lot of employers or universities or others to take an interest in this.

And first of all, I just want to throw this out to the panel. A) do you think this is a good idea, and B) what can we do from a federal perspective to encourage more people to pick up on this? Because I really think it is a way to say to kids, this is interesting. This is fun. It is a good thing, and incidentally, long-term, there are a lot of good jobs available out there when you graduate.

Dr. BARTELS. Mr. Congressman, if I may, because that is an excellent question and an excellent point, and I would argue, actually, that there are hundreds of thousands of kids in science and math camps all across this country, but they are doing it inside all of those science museums, natural history museums, and informal places that we keep overlooking when we look at our national edu-

cation science infrastructure. And in fact, these programs are well attended and well loved, and I can speak personally about the programs at the Exploratorium.

One of the big opportunities that we have right now is \$1 billion in the 21st Century Learning Academies, which are all the after school programs that are funded by the Federal Government across this country. Most of them right now are focused on mathematics and reading. Science hasn't appeared yet, because it hasn't been a mandate from NCLB until this year, and now, they are all scrambling for help in science and science programming.

We have been a major part, with several other nonprofits, like Lawrence Hall of Science and TERC and others, trying to figure out what kinds of programs and materials could after school providers use to do exactly what you say, create that spark. Because what we have noticed about informal programs is they can't always teach Bernoulli's Principle correctly, but boy, can they really start that curiosity that goes on for a whole lifetime in a young boy or young girl, and if you talk to most Nobel laureates, they will tell you that their interest in science was first sparked by a museum or an informal experience, not a school one.

Dr. HEPPERT. To speak to the same issue, I think one of the things Ms. Snyder was trying to say is that very often, lecturing to somebody about how to do something isn't effective as actually doing it, and in some of the NSF-sponsored workshops that we have done for teachers, where we have very much blended pedagogy and science content, in order to enhance teacher capabilities, we have also hybridized that by bringing in groups of students, even during the summer, in these kinds of, in a sense, in a kind of informal learning environment, so the teachers can actually practice this before they go back into what professionally have been more high stakes environments, into the classroom, and actually use those skills and those resources, and teach that new content in the classroom.

And initially, I have got to say, the response to that, as you can imagine, during the summer is, oh, I have got to deal with more students here. This is what I do all year long. At the end of the day, though, when we do the assessments, that was one of the things that was uniformly thought to be the most useful, was actually getting down and practicing that with the students.

So, there are opportunities, I think, even in some of these more formal programs that NSF tends to do, workshops that NSF tends to favor in the Institute—MSP Institutes program, for example, to do exactly what you are talking about.

Ms. PRINGLE. I can't thank you enough for raising that issue, and to answer your question, as you are taking a look at the allocation of funding, that is absolutely essential. I will speak to an initiative that I had the opportunity to be involved in, and then, the funding was cut. It was specifically designed, the camp was specifically designed to encourage African-American students, both male and female, to go into careers in math and science, and I am sure I don't need to tell you that there is a huge gap there.

The focus primarily was on making sure that they had the kind of content that they needed to do to be competitive, to take higher level math and science courses, to prepare them for that. And once

again, it was a partnership between the school district and the Indiana University of Pennsylvania, that went on for about five years. It was a two week camp. My son got a chance to participate in it. I believe it led to him winning one of the awards from the American Chemical Society for his science fair project, but the funding was cut.

So, to answer your question, I would encourage you to make sure that funding is provided for organizations like, certainly, the National Science Foundation, who provide funds to support initiatives like that. So, thank you for that question.

Mr. ROHRABACHER. Well, thank you very much, and next, we have a very active Member of the Committee, Dennis Moore from Kansas.

Mr. MOORE. Thank you, Mr. Chairman, and again, welcome to the panelists here.

I want to just ask a question generally of all the panelists, I suppose. The recent report of the National Academy of Sciences, which was titled "Rising Above the Gathering Storm," found that America appears to be on a "losing path," and that is a quote, "losing path," with regard to our future competitiveness and standard of living.

I don't think we need to say this, but China and India are coming on very strong. We are the only superpower in the whole world right now, but they are not far behind us, I think, in terms of the next few years. The NAS report points out that 69 percent of middle school students in the United States are taught by teachers with neither a college major in math, or certification to teach math, and we have heard some statements by the panel, not only the panelists here, but the Committee Members here this morning to that effect, and the same thing with science, as well.

Many education experts have stated that K-12 STEM education will not be improved until math and science education is improved at the college level, and I guess my question to the panel generally is, what is being done at the institutions of higher learning to improve the undergraduate education of new teachers and to encourage students with majors in math and science arenas to pursue teaching careers after graduation? And how can current NSF programs and policies be improved to better allow you to provide for your students and accomplish these goals?

Those are the—if you can address those, please, starting with Dr. Bartels.

Dr. BARTELS. Thank you. Excellent questions.

A couple things I would point out. One is actually very near and dear to my heart, and that is that, in effect, now more teachers are starting their careers at two year institutions, and more teachers of color actually start their careers at two year institutions, and not our four year institutions, and if you look at the NSF portfolio, one of the places where they have been under-resourced is the support for innovative programs at community colleges. And this is a terrible oversight. You have the excellent program with the ATE, but it really is designed for workforce development of very specific occupational bands.

It turns out we have research now from Lumina Foundation in the mathematics community that the number one reason why most students do not graduate from a two year college is they never

make it through their developmental math course. You know, that is a fancy word for the remedial math that they don't take for credit, so they can take the regular math. It turns out that is the second biggest gatekeeper to technical careers after ninth grade algebra. The quality in who are teaching these courses, and who are teaching these courses in general has not been examined by the Federal Government or the National Science Foundation. If I could do anything, in terms of teacher preparation, and turning more people onto teaching careers and technical careers, I would have a major development program focused on two year colleges, those basic math and science courses, and what is going on with that remedial math course, because it can't be the warmed over high school program that the kid failed the first time.

Dr. HEPPERT. I think this question goes a bit to my comment about the culture of higher education, and the difficulty of changing the culture of higher education. I believe there are a couple of key areas where our culture needs to make a radical change, in order to bring about improvements in this area.

First, I think we need to work on introductory curricula in the sciences, in particular, that are more engaging, that reflect the reality of what scientists do more fully, and that engage students in understanding that scientific careers can be careers that serve the public, and that have the opportunity, to provide a tremendous standard of living for, not only for themselves, but also for the Nation as well.

I think we don't do a good enough job as scientists of really selling our own field to the students, and selling the potential benefit of it to society. Students are very, very altruistic, by and large. They are very interested in serving, especially at the freshman level, sophomore level, they are very interested in opportunities to serve society as a whole, and I think we need to reflect the fact that scientific careers hold that promise.

The other thing that we need to do, in a sustained fashion, and there have been NSF programs in the past that have been funded, particularly the Centers for Excellence in Teacher Preparation program that was funded about 10 years ago. It was the precursor, if you will, to some of the programs in the Math and Science Partnership program at NSF, that effectively look at the way we teach science at the university level, and think about reflecting both the reality of how science is done, the hands-on, really, interactive sense of discovering science, that we know scientific careers are all about, and the excitement of science, showing how it can connect to societal concerns, and address societal concerns.

So, I think those are two issues that will not only benefit and make the field attractive for science majors in general, but are things that are going to connect very strongly to the needs that we have for improving the way that we prepare science teachers as well.

Mr. MOORE. Thank you. Ms. Pringle or Ms. Snyder, any comments?

Ms. PRINGLE. I just could not agree more with Dr. Heppert, and it goes back to what I said earlier about the importance of that partnership between K-12 teachers, or prospective teachers, and

higher education. And so, we need to do all that we can to support that.

Mr. MOORE. Thank you.

Ms. SNYDER. I think you have hit on a really important problem, because there are so few students who are majoring in mathematics going into teaching, that it has become scary recently, and I asked Dr. Bement that exact question, and he pointed to the Noyce Scholarships that NSF has for teachers in science and mathematics who will commit to teaching, but I think it is kind of like a vicious cycle. If we have poor teachers, then students are not going to be interested in majoring in mathematics, and we are going to have fewer and fewer teachers, so I think this is a big issue, and it is something that we really need to think at the national level whether it is loans, you know, for teachers going into math and science, that can be forgiven, or whatever it is, we need to do something about it.

Mr. MOORE. Thanks to all the panelists for your service, as well.

Mr. INGLIS. Mr. Rohrabacher.

Mr. ROHRABACHER. Well, thank you very much, Mr. Chairman. Let me note that when it comes to education, that we have two purposes. I can see that one is to basically educate the American people in a general sense, and the other is an education system that can stimulate and effect the high achievers, that might go on and become the people who discover the cures for cancer, et cetera, and these are not necessarily the same goals. They are not necessarily accomplished in the same way, and maybe, there has to be programs designed specifically for high achievers.

Mr. Gutknecht's suggestion about science camps, or science/mathematics camps, I think is a very good idea. I would note that in my district, in Palos Verdes High School, participated in a challenge that was presented by DARPA, that was who could design and build a remote controlled automobile that would go a long distance, and I think it was all the way to Las Vegas or something, I forget exactly what the—it was a very long distance, and the kids in my school actually produced a car, and they actually engineered it, and participated in the competition. They didn't win, but it was a tremendous learning experience for them, and that seems to me that that was aimed more at the high achiever end than it was the general knowledge.

I mean, basically, I see that there is a general lack of understanding, of basic understanding of science at a general level. There is a general level of ignorance of history that education has to talk about, and there is also, of course, a basic skill level of writing and mathematics that people need, and these are general things we need to get by on.

I have got one really specific question here that I want to get to with those observations. All of you are here testifying that basically, math and science, and I have heard the words highest priority and most important, and of these things that I have just talked about, I would assume that you would agree, from what you have said, that math and science should have a priority in the importance of education planning and structuring for this country.

Is that right?

Dr. BARTELS. Uh-huh.

Ms. SNYDER. Yes.

Mr. ROHRABACHER. Okay. Now, to Ms. Pringle, then. You represent the—as well, the National Education Association?

Ms. PRINGLE. Yes.

Mr. ROHRABACHER. Why is it, then, that the National Education Association, backed up politically by certainly a lot of people in public office, refuses to permit teachers to be paid more money, who have higher skill levels in those areas, and can we succeed, in what your goal is, in setting a priority for science and mathematics education, if we continue paying teachers, and trying to draw these people with—paying them at the same level as you might have for people to teach poetry or home education or basket weaving, and things such as that?

Ms. PRINGLE. Let me begin by cautioning the Committee, the description that you started out with, in terms of two levels, you know—

Mr. ROHRABACHER. Right.

Ms. PRINGLE.—the basic and the more gifted. I really would want to caution the Committee that our goal, certainly the National Education Committee's goal, is that we raise the student achievement of every child.

Mr. ROHRABACHER. Right.

Ms. PRINGLE. That is first of all.

Mr. ROHRABACHER. Yeah, basic level. Okay.

Ms. PRINGLE. And we need to make sure that whatever programs that we put in place and that we fund, does just that, that we are focusing on the individual student.

Mr. ROHRABACHER. Right.

Ms. PRINGLE. And so, if we have an individual student that aspires to a career in math and science, that shows a particular aptitude for that, that we have programs in place that help that student.

Mr. ROHRABACHER. Okay. But the actual—these are two different goals, however, just to increase the basic level of skill in science is a different—and by the way, that is a laudable goal. Don't get me wrong. I mean, they say the Earth has four—I remember this, four elements. There is protons, neutrons, electrons, and morons, and I was always in the latter category, when it came to science and mathematics. So, I understand that it is important for people like myself to have a basic level of science, but that is different than the people, some of the kids I went to school with, who went on to do great things in math and science that, frankly, I would not have been able to comprehend, and would probably have been turned off of altogether, had people tried to get me to understand that.

Ms. PRINGLE. It is just important to make sure that we provide all of our students with that opportunity, because so often, when we separate them, especially at an early age, we do not allow for students that may not be blossoming as fast as others.

Mr. ROHRABACHER. Well, I am certainly with you. I think it is important for average people—

Ms. PRINGLE. I just—

Mr. ROHRABACHER.—to have that. However—

Ms. PRINGLE. That was just a caution. Let me answer your other question.

Mr. ROHRABACHER. All right. Why can't we treat people who you believe is a priority subject, why can't we recruit better teachers by offering them more pay than we do to others?

Ms. PRINGLE. And you are absolutely correct. The National Education Association does not believe in differentiated pay, based on the discipline that they are teaching in. And the reason that we support that, and believe that so strongly, is because we need to attract the best and the brightest in every, every classroom in this country.

Mr. ROHRABACHER. Well, then you aren't prioritizing math and—

Ms. PRINGLE. The best and the brightest in every classroom in this country. That is what we need to do. So—

Mr. ROHRABACHER. Okay. But you are not differentiating between the classrooms of basket weaving and the classrooms of science and mathematics.

Ms. PRINGLE. I don't know any basket weaving teachers, but—

Mr. ROHRABACHER. They are in—let me just note that they—

Ms. PRINGLE.—I will say this.

Mr. ROHRABACHER.—had that in my school, my high school, when I was there. But—

Mr. INGLIS. Those are the kind of courses that I took.

Now, here is the—here is what we need to do, though. Could we come back to this after we give the opportunity for this open mike session? We want to have an opportunity to hear from the teachers who are the winners of this award, to have an opportunity for an open mike session, where we hear from them about the things that they think are the most important—

Mr. ROHRABACHER. And Mr. Chairman, thank you for letting me have my time, and I did use it up. I would love to hear from them, if they think that they should get a little more money if they are in math and science, as compared to other courses that are being taught in school. Thank you.

Mr. INGLIS. As the mike goes around, feel free to answer Mr. Rohrabacher's question. That would be very helpful.

So, these are people we want to hear from, the winners who can tell us about the NSF and the Federal Government's role in improving K-12 math and science education. What will happen now is the Science Committee staff members will hand around microphones. If you would, please tell us your name, and where you are from.

Mr. HONDA. Mr. Chairman.

Mr. INGLIS. And engage us in conversation.

Mr. HONDA. Mr. Chairman, I am just as anxious to hear from the teachers, but I hope that the rest of the Members who are here are able to ask their questions, pertinent to why our witnesses are here, and why these teachers are here, and not get off on the issue of salaries, but on the issue of pedagogy and content.

Mr. INGLIS. In fact, we will come back to that. The teachers must leave at 11:45, Mr. Honda, to go to the White House, so we want to give them the opportunity to interact with us now. At 11:45, we

will return to the regular order of questions here, so who has that microphone, and who would like to speak first?

Yes, sir.

Mr. BENSON. I am Steve Benson. I teach senior high mathematics in Minnesota at Owatonna High School.

Mr. INGLIS. Feel free to ask a question, or tell us what we need to do about something. Here is your opportunity. If you were a politician, you would know you never surrender the mike without getting your word in.

Mr. BENSON. Trust me, I don't want to be a politician. I guess one of the major conflicts that I have with school is the preparedness that students come to school with. If you were going to do something that benefited me most in my job, the thing that you could do is provide parents the ability to stay home with their kids, have a one income family that made things work, so that one parent, whether it was the father or mother who was at home, reading with kids, playing games with the kids.

But I know that is not possible in the world that we live in today. But that is one of the things that I see that is different. Education is not valued by everybody the same. The students that are high flyers in my school are the ones that have parents who value education. They come to school already knowing a lot of things that I want them to know, so I can take them above and beyond. So, it is kind of the two goals that you had talked about before, of educating everybody to a basic level. I have got a lot of those students that I need to bring up to a basic level. Many of the students that come into my school already have the basic level, and I get a chance to talk to them, and bring them up to a higher level of learning.

Mr. INGLIS. Thank you, and anybody that wants to grab that microphone, this is your opportunity. And if you want to direct any question to any of us up here, or comment, that is fine, too, to have an exchange between you and the panel up here.

Ms. YOUNG. My name is Paula Young. I am from Saint Charles, Missouri, and am very honored to be here today.

One thought that has occurred to me in this process, I have a husband that is an engineer, and I have discovered that engineers think very differently than the rest of us do, and we have two grandchildren, and they are little bitty copies of my husband, and I have observed that the way they learn is very different than certain other people. They like to learn by doing. I have a neighbor that has a child that is the same age as one of my grandchildren, and he follows everything with why, why, why. I notice my grandchildren never ask that, and they didn't ask it because they were busy exploring and finding out for themselves, and I would love to see an organization such as the National Science Foundation do research into how engineers learn best. It is not just a learning style. It is something a little more fundamental than that, and we need to produce more engineers to make our country more competitive, and that is something I would like to know more about.

Thank you.

Mr. INGLIS. Who is next?

Ms. LAS. Debra Las, Rochester, Minnesota. I am a science teacher at John Adams Middle School. Teachers can talk forever, so I will try and keep it brief.

To touch on components of a number of questions, yes, I do think one of the issues facing my particular school is the issue of diversity. As a science teacher, we like to teach with inquiry, but that does depend that the students have some kind of prior background knowledge, and with our diverse population, we have 26 different languages spoken at my school, sometimes that background knowledge is lacking, and that does hamper the teaching of science.

The idea of science clubs is important. I was one of the teachers involved in the first IBM Excite Camp, which is the worldwide camp for girls on science, technology, and math. And this is very important in bringing our diverse culture, and socioeconomic status that background knowledge. In our particular school, our science teachers run a volunteer camp. It is kind of interesting to hear the football coaches get paid, and they get days off, and we don't get paid, and we are taking our days off to help our students. And so, there are some issues there. I am not sure what level they need to be solved at.

I also do know that—you may have heard of a movie, this is going to date me, *The Breakfast Club*. We have this science club that we know the science teachers will be at the school on the weekends. We will be there, setting up labs. We will be there, our kids all know each other, we drag our families in, because it does require extra dedication. It is somewhat frustrating to sometimes hear a colleague say, well, I want to get paid and get a stipend if I do this, and I am thinking, I have to do that every weekend.

So, there are some issues, the issues you are touching upon do affect me in my classroom, as I have heard, meeting people from across the Nation here, we are seeing the same problems.

Thank you.

Ms. LYONS. Hello, my name is Lois Lyons. I am from New Jersey. I teach chemistry to high school students.

I would like to encourage you all today, and I thank you for this opportunity to do so, to fund every opportunity that you would have, financially and professionally, to increase collaboration, not only for students, for teachers, as well. Not only should no child be left behind, but no teachers should be left behind, either.

We need your help. We need your support, not only financially, but professionally, to increase those connections for ourselves and for our students, to the real world, to make their lives more interesting, so that they can go on ahead, and be standout citizens.

Our students are fortunate enough in New Jersey, in my school, to participate in mentorships during their senior year, but they shouldn't have to wait until they are eighteen years old to see if they like being a lawyer, or being a statistician, or being a scientist, or being a dentist, or whatever. They should have those opportunities, and NSF is one avenue to provide those opportunities. So, I would encourage you to increase those opportunities, if at all possible.

Thank you.

Ms. BROWN. Hi. My name is Susan Brown. I am from Maryland. I teach eighth grade science at Central Middle School, right south of Annapolis.

I am in a Ph.D. program at the University of Maryland, so I do consume science research. One of the things that we find out is that all the researchers that you have, the greatest effect on achievement in any classroom in this country is the teacher. You can give them great curriculum materials. You can give them a great administration. If the teacher is not good, achievement goes down. So, most of the finances that we have should go into the teachers, in training teachers in whatever way they need to be trained.

The second thing I have is that when we are teaching, we are teaching science and math, and that is what is dear to our hearts, and we are passionate about it, it is not something that when you tell people in our culture that we are doing, that they say oh, how wonderful, you know. I can't wait to be you. They say oh, I am so sorry, or I could never do that. And of course, they couldn't.

What we need is, we need to have a cultural paradigm shift, so that science and math become cool. If we are looking to have creative students, and that is what we are going to have to have in order to maintain our global economy, our global standard of living, and our global leadership, then we are going to have to train students to be creative. We have to give them the facts, give them the knowledge, and then push them to come up with those new ideas, and a curriculum will not do that. So, that is one of the important things that the National Science Foundation does, is they put their resources into teachers, and they give us the resources we need in order to be able to teach.

Thank you.

Mr. WHEELER. Good morning and thank you. I am Sam Wheeler. I am from Raleigh, North Carolina. I teach physics and AP physics in high school down there.

I want to add something that she was just talking about. I have had the opportunity to take part in some really exciting NSF-sponsored professional development programs, and in Raleigh, North Carolina, we have set up a Keenan, it is called the Keenan Institute, through NC State and UNC-Chapel Hill, that basically provides professional development opportunities for teachers to do actual science research in the laboratory, or with industry, such as IBM, Glaxo, or in my case, I worked with the North Carolina Science Museum. I was able to create an exhibit at the museum on carbon dioxide's role in global climate change, and I was able to go Belize in Central America.

Now, if I hadn't had that opportunity, I wouldn't be able to bring back inspiration for my kids, and for my community. And I was also able to do something which is also really cool, I always tell my kids about this. A couple of years ago, the Educator Astronaut Program was reinstated. I applied, got pretty far. My eyes kept me out of it, but you know, now I can tell my kids that you know, I was almost an astronaut. Of course, my wife says it is better that you lost out with the eyes instead of the psych exam. So, anyway, but this is something we need to do.

And to keep the other—we need to look at the other dropout rate, which is the dropout rate of teachers, and I think this can help keep teachers in, and inspire other people to become teachers.

Thank you.

Ms. SCHUNKE. Good morning. My name is Nancy Schunke. I am from Lubbock, Texas. I teach at Dunbar Middle School Math and Science Academy in Lubbock, which is a magnet campus, as well as our regular campus, and I cannot say enough, with everybody here, about the importance of informal education and mentoring type activities, such as the ones that NSF provide for teachers. And I teach engineering classes, as well as science classes.

When I started teaching, I started teaching in 1996, and I have a certification in composite science, and for that certification, I had a lot of hours in chemistry, but I had about eight hours in biology, eight in physics, eight in geology, and my biology class was in 1988, almost 10 years, you know, before I started teaching. And my physics classes were around in that range, and suddenly, I was thrust into a classroom where I was responsible for teaching a biology class, a chemistry class, some regular science classes, and with state curriculums the way they are right now, we are constantly asked to teach integrated approach, teach Earth science, life science, biological science, all within one course during the year.

And now, with the push of engineering, which I am very excited about—I am an engineering teacher—I had no idea what engineering was when I was in high school, or even when I entered college, until I heard some of, you know, my—the people that I worked with and went to school with—that were going into engineering, and—but I had no idea, and now, I am being asked to teach it. And I am having an absolute ball doing it, but I know that the way that I am learning the things, I am being able to teach the students how to apply math and science, and engineering problem-solving, is because of my relationships and partnerships with Texas Tech University and their engineers, with programs like DTEACH at University of Texas, that is one of the things that got me started as well, and those are impacting our students.

We—I have been key in helping Texas Tech University from the education standpoint, in developing their outreach program, and this program is being implemented in our—in the part of Lubbock that has our lower socioeconomic students, and also, high ethnicity, and the kids are eating it up, because they are seeing possibilities they never imagined. They never thought about going to college, but we have kids now that are aspiring to be engineers, because they are getting the opportunities to participate in Lego Robotics. They are going to Texas Tech and other places to visit the labs and work with engineers, and do hands-on experience.

Our girls are doing things like “Science: It’s a Girl’s Thing,” and they are getting to actually program and build things on their own, and this past year, our high school, Estacado High School, had their first student accepted to MIT. And it is because of programs like this, that are training the teachers, that are bringing that in to the universities, and the public schools, and getting these kids engaged. So, I would highly, highly, highly encourage you to continue to provide the resources for those programs.

Mr. NEUGEBAUER. Chairman, I just—point of personal privilege. I want to congratulate one of my constituents, Ms. Schunke, is from Lubbock, Texas, and I am delighted to have her today, and we want to wish her congratulations on her recognition. Thank you.

Mr. INGLIS. Certainly. Yes, sir.

Mr. NOLAN. Good morning. My name is Ed Nolan. I teach mathematics at Albert Einstein High School in Kensington, Maryland, just not that far from here.

I would like to echo what Steve was talking about, when it comes down to family. One of the things that my school deals with is not parent issues, but student issues, of students going to work, and that taking away from their educational experience, because they need to provide the resources for their family, whether that is at night, whether it is on the weekends, all of those experiences take away from—I have students who have difficulty staying awake, because they work so many hours, because that income is needed for their family. So, again, those kind of things that you can do to help the educational program that I deal with, that is one of them.

The other one is, is supporting programs that bring colleges and teachers together in so many different ways, whether it is the development of curriculum materials, whether it is creating mentoring relationships, all of those types of opportunities, where we connect those things together. We talked about having students prepared for college. When the teachers at the high school and the community colleges and four-year institutions get together, they find out, they open those line of communications, they find out more about what it takes to prepare students, and more about what it is for high school teachers to help prepare students. When they have that dialogue back and forth, it benefits both the teachers and students tremendously.

Thank you.

Ms. OWENS. Good morning. I am Julie Owens. I teach high school math in El Reno, Oklahoma.

Probably we all share common challenges, families, funding, programs. My high school is a Title 1 high school. We have 70 percent free and reduced lunch in our district, so we also have the challenge that Ed was talking about, of our kids work out of necessity, not so they can have a new car, but so they can have supper. And I am in competition with the basic need of food and shelter.

So, I have to have every resource available to me to compete with iPods, cell phones, cameras, technology, all the fast, cool things they would rather spend their time and money on, than math and science. So, the more funding and the more programs that I can be engaged in, and my teachers can collaborate with, not only at the university level, but other school districts, or any professional development, to bring math and science, real and engaging, using technology, using what appeals to them is going to help me promote math and science in my community.

As far as funding, our teacher pay, we all need more money. There is no question. But I can't teach math, and these teachers can't teach science, if they can't read. So, all of our educators are important, and we all need more funding for that.

Mr. INGLIS. And I might point out that you need to get to the White House very quickly, so if you want to be very brief, about—

Ms. GENDASZEK. Very brief. Bonnie Gendaszek. I teach eighth grade math at John Witherspoon School in Princeton, New Jersey.

One of my biggest concerns is the low percentage of elementary and middle school teachers who are trained to teach mathematics, and who enjoy teaching mathematics. I would like to see money restored to the National Science Foundation, to train teachers. I think no amount of curriculum development is going to change this problem.

Mr. INGLIS. Ms. Brown mentioned that STEM—we need to make STEM cool. Cool is the American Competitiveness Initiative, and cool is going to the White House to be recognized as a 2005 Presidential Awards winner for Excellence in Mathematics and Science Teaching. So, congratulations to all of you.

Ms. Snyder, you need to go with them, so we will dismiss you from the panel with our thanks.

Ms. JACKSON LEE. Would the distinguished gentleman yield?

Mr. INGLIS. Yes, ma'am.

Ms. JACKSON LEE. Even though my good colleague has claimed Lubbock, let me say that I am from Texas, and I want to congratulate fellow Texans that are there, and while you are the White House with another fellow Texan, ask for more money, more money, more money.

Mr. INGLIS. Thank you all for coming. Now, we are going to resume the questioning with Mr. Green, I believe.

Mr. HONDA. While these teachers are leaving, the classroom teachers, I just want to say thank you for your work. As a science teacher myself, I think I understand a bit of the challenge that you face, and the compensations probably should be more of a national burden, than just a local burden, and having said that, I will go into my questions, if I may, Mr. Chairman.

Mr. INGLIS. Actually, Mr. Honda, I believe that Mr. Green was—

Mr. GREEN. Oh. I will yield. I will yield, Mr. Chairman. I will be fine if I am next.

Mr. INGLIS. Okay. So, Mr. Honda is recognized.

Mr. HONDA. Thank you, Mr. Green and Mr. Chairman.

A couple of thoughts as a teacher. This thing we call No Child Left Behind is a phrase that is kind of passive. I think it should have been Leave No Child Behind, and that would have been more directive, and so, it is just a mindset.

I appreciated the discussion today on research and also talking about making sure that we have content, pedagogy, and then, the role of the NSF in research, professional development. Having said all that, and the thing that most of us here who are policy-makers, well, I am a teacher, so I am going to say this, the problem with education is everybody thinks they know what is going on, and what is best for teaching. But you know, we are here for the youngsters, and sometimes, we forget to design everything around youngsters, and we sometimes design the whole school system around adults' needs before we think about youngsters. I will get that off my chest.

Now that I said that, the issue about creativity and innovation, I have heard that, those two terms bounced around a bit, but it seems to me that including science and technology, and science and math, that innovation and creativity are skills that can be taught and are teachable, but what I would like to know is what is the role at NSF in taking these skills and insights, or what someone called the accumulation of wisdom, and converting that into teachable units, so that we can have professional development that is around teaching innovation and skills of creativity to all teachers, because I believe that besides science and technology, math, music, and art, and the performing arts, and social studies, all those things, all those activities need to have this thing that we call innovation and creativity.

I know that coming from Silicon Valley, I have met a lot of people. One was Dr. Michael Phelps. He was a boxer, and he was told that he can't be a champion boxer, so go to school, go to college, and he says why should I go to college, coach? And he says because there are women there. And he went, and he found out he was smart, and he developed the PET scan. Another fellow was a Rose Bowl football player for the community college, and he got a knee injury when he went to the four year college, and he said I can't play football any more, and he found out he was smart, and he ended up going to Stanford to get his Ph.D. in high energy physics, and he started and made Solectron, the largest fabrication globally. So, it doesn't matter whether we have football camps or not, because football players and other sports people are creative and innovative, by nature of their own skills.

So, if I could ask that question, what is the role of NSF in trying to develop a curriculum around innovation and creativity?

Dr. BARTELS. Congressman, if I might, that is an excellent, excellent question, and I think NSF is uniquely positioned to provide us with some of the very answers that you are seeking.

I want to first, though, push back gently a little bit on this notion that achievement and the basics are inversely related.

Mr. HONDA. All right.

Dr. BARTELS. There is a reason why this country has the best basketball players. There is a reason why Italy and Mexico have the best soccer players. There is a reason why Finland is overrepresented in the number of musicians at the world class level, and the reason is every one of those programs, every kid plays those games at the earliest ages, whether they are going to be a professional or not. And because their base is so deep of people who love soccer, they end up having the world championship soccer teams.

And so, if we keep sort of comparing these things and contrasting them, we miss the point, which is that if you let every kid play these games, and learn the basics as young as possible it, in fact, will produce those pinnacles of excellence we want. So, let us take your basketball example. If we had kids do nothing but dribble and pass for six years, practice the basics, how many kids would still be playing basketball six years later? We don't do that. Every good coach knows the last 15 minutes, you let them play the game. Do they break the rules? Do they tackle each other? Do they break every rule that James Naismith ever came up with? Absolutely. But you teach them those basics inside the game.

The game of creativity, the game of science and technology, is actually knowing enough of the basics so that, in fact, you can create like a beautiful guard in a basketball thing, he still knows how to dribble and pass, but he knows enough of those basic skills now to really open, you know, open up and be that creative person. So, one is that we still do need to do a better job of identifying and providing the basics, and what the NSF can do with this cognitive science revolution that is going to take place, connects things up, as for instance, we know, that a kid at the end of kindergarten, if they know which is more, which number is more, they have a much higher predictive success in third grade than a kid who leaves kindergarten not knowing that.

Mr. HONDA. If I may interrupt. I understand what you are saying, and it is kind of practicums.

Dr. BARTELS. Yeah.

Mr. HONDA. It is like your camps, but it is not addressing how you take and look at innovation, creativity, and break it down to teachable skills, regardless of whether they start in the first six years, because let us face it, the guys that I mentioned did not do this until they were adults. So, there has got to be something that we are able to create, and take out of what we call innovation and creativity, and break them down into teachable skills that we can start from, pre-kindergarten, but continue to postgraduate work, and it is about being able to take that, those two things that seem so like air.

Dr. BARTELS. Right. Again, I guess I was trying to suggest that an artist has to know a lot of art before they are truly creative in art. A writer needs to know a lot about literature before they are truly creative in literature. That, in fact, creativity is not a generic skill, and something which you teach separately from the disciplines in which we are practicing. And so, the NSF is actually doing a lot of cognitive research, trying to discover those very mechanisms that you are talking about. It is at the basic cognitive research level. What should follow soon are curricula, teacher programs, technology tools, and other stuff that reinforce those skills. It is coming, so long as NSF can stay consistent with this R&D mission that it has been given by Congress.

Mr. HONDA. And thank you, Dr. Bartels. Does Dr. Heppert or Ms. Pringle—

Mr. INGLIS. Be very brief, because the gentleman's time has expired.

Dr. HEPPERT. Sure, I understand.

I think the message that NSF has been engaging in this, and is prepared to engage in this in the future is an important one to bring home. NSF has preached in all of its teacher enhancement, teacher preparation programs over the years, this concept of having students engaged directly in getting in and discovering, not totally in discovering, because of course, we can't discover the whole of science in a lifetime, but getting in and getting their hands wet with the discovery and development of principles, so that they know what scientists really do.

Honestly, I think that has had an important collateral effect on those of us who have been involved in those programs, involved in working with teachers, because it has made us at the university

level think about how we portray science to our own students, and so, it has had an important side benefit in helping us look for ways to communicate scientific creativity to our own students, from the first years in college.

Mr. INGLIS. I thank the gentleman. Mr. Neugebauer.

Mr. NEUGEBAUER. Thank you, Mr. Chairman.

Ms. Snyder and Ms. Pringle, I guess we lost Ms. Pringle, didn't we.

Ms. PRINGLE. Mrs. Pringle is here, Mrs. Snyder is gone.

Mr. NEUGEBAUER. Yes, I am sorry. What role do mentors play in improving teaching and learning of math and science, and is mentoring mainly useful for novice teachers, or is there a place for mentoring programs for mid-level and veteran teachers?

Ms. PRINGLE. Yes, there is a role for mentoring, for both novice teachers and veteran teachers. They need that continued support and encouragement, and collegiality that mentoring provides.

Dr. HEPPERT. Now, as a veteran teacher, and you know, I thank Ms. Pringle for characterizing me as a teacher as well. I think that is—I am very honored to be put in that community. As a veteran teacher, I can say, as I tried to suggest to Mr. Honda, that idea that I have benefited from working with teachers, from working with educational professionals at the secondary level, who have been in the classroom for many years, and thought very carefully about how to effectively communicate their science to those students.

So, in a personal sense, as I have worked with people who are outstanding secondary teachers, they have taught me things about how to more effectively communicate science to students. So, I would answer enthusiastically yes.

Dr. BARTELS. I would put dollar for dollar into the new teacher, because they have their whole teaching careers ahead of them. When we ran the Mentor Teacher program at the Exploratorium, we actually had all the teachers go home one night and say, go back to your first year of teaching. Take a drink, a slug of whiskey if you need it, but go back to that first year of teaching, and write about it and come back, and we expect tons of horror stories, and we got a few, but we also had these beautiful stories of that colleague across the hall who that new teacher found in their desperate moment of need, when they thought about quitting. This is when teachers quit. This is why 50 percent disappear. And that colleague came and rescued them.

Why is that left up to chance? Why do some teachers get that, because they have a caring colleague across the hall, and why isn't there a system that says no, you know what. Every beginning teacher needs that mentor, because we want them to say if they are going to be great teachers, and so, yes, every teacher should get it, but ten to one, I would put it in the new ones.

Mr. NEUGEBAUER. I know the NSF programs, a lot of them involve research experiences for the teachers. So, how do these programs affect teachers' performance in the classroom, and are these programs doing a good job of including training on how to teach, as well as master that subject?

Dr. HEPPERT. Yeah, we have worked with research experience for teacher programs, in which we have specifically brought in to the

chemistry program that I have run both pre-service teachers and master teachers, people who have been in the public schools for a number of years, and paired them in research laboratories. So, not only are they getting a very intimate experience with the science that they are studying, but they also have the opportunity to interact with each other in a weekly seminar forum, to talk about issues in teaching, to talk about issues specifically of how would I translate the kinds of experiences I am having in the laboratory into excitement for the students, as well as into content material that I can communicate to my students.

So, and in fact, we, you know, some of the faculty involved in running that program were also engaged in that, so we brought together the content mentors and university faculty, the master teachers, who were also benefiting from the research experience, and pre-service teachers, who were getting a firsthand experience of what being in a laboratory was like. Again, it was one of those experiences where you see the individuals who are participating in it light up, because they are getting something special out of the experience.

Ms. PRINGLE. I can't emphasize enough how important it is to focus on the fact that teachers can be researchers as well, and the programs through NSF that promote that, teachers as researchers, provide an inordinate amount of real life information to that, to the research that is done. I believe one of our, I believe our award winner from Maryland talked about, as a teacher, using that research within her classroom, and it is so invaluable, when the teacher is the researcher themselves.

It is one of the areas that causes me great concern, when teachers are not respected as the professionals they are, and are often characterized as not being able to do or understand or use the research, which nothing could be further from the truth. However, I will say to you that through the National Science Foundation, they have worked very, very closely with our teachers to make sure that they are utilizing the most up to date research that is available, in terms of brain studies, and how we can teach more effectively, based on developmental stages and things like that. But I thank you for that question, and we would encourage continued support in that area.

Mr. NEUGEBAUER. Thank you.

Dr. HEPPERT. And I would just note for the record that we have the first major study of an NSF program that goes straight to your point.

It was done by Iris Weiss at Horizon Research, looking at the Local Systemic Change Initiative, and they found that in fact, teacher professional development did result in higher student test scores for those districts and workshops that focused on the specific curriculum that the kids were being asked to learn, and two, that were sixty hours or greater. That is when you saw the effects showing up, and that is, I think, the standard NSF has set.

Mr. INGLIS. I thank the gentleman. The gentleman—Mr. Green.

Mr. GREEN. Thank you, Mr. Chairman, and I thank the Ranking Member as well, and I do salute the people who have given their testimony today. This has been an outstanding group of panelists, and I appreciate greatly each of you.

I do believe that the best way to leave no child behind is to leave no teacher behind. I absolutely believe that teachers merit more pay, they merit better working conditions, and they merit more respect for what they do. Since I happen to be a fan of the NEA, I have to say this. I agree that we have to be careful when we start to single out some, and pay them more than others, because reading is important. Writing is important. We cannot overlook either of these, as we move toward arithmetic. So, I salute you for the position that you have taken, and I trust that we will be able to upgrade the pay for all of our teachers, not for just some of them.

With reference to what we have in our society as a culture, we truly do place our athletics above academics, and we truly have to have that paradigm shift that one of these teachers talked about, because we can go to a high school football game, and there will be standing room only. You go to a PTO or a PTA meeting, and you have unoccupied seats. If you have thirty people in attendance, you have a big crowd. So, there has to be some thought to a shift in paradigm, and that does not happen by accident. It has to happen by design. We have to, with intent, desire to have this manifest itself.

I am concerned about the number of minority persons who are in math and science. Dr. Pringle, did I just promote you? Okay. Well, you merit that term. I will tell you, you spoke well today. You really did. I was tempted to say let us give everybody a big hand today for what you have said, but I thought your words were well-placed, and they had significant meaning. You really covered a lot in that short period of time that you had.

But I am concerned about minority students, and I am concerned about all children, but given that we know that there is a dearth of participation in math and science, we need to do what we can to get more people of color involved. So, tell me, if you will, each of you, what can we do to cause more minority persons, persons of color, to become engaged, to attract them, if you will, to math and science?

Ms. PRINGLE. I will begin, thank you, first of all, for your comments. We cannot say enough times that all teachers deserve compensation and respect that is commensurate with the important job they do for this nation.

To answer your question specifically, we need to find ways to support and fund programs at the local and the district level, that attract students of color into math and science. I had the opportunity to chair for many years our district's Math Science Challenge Program, which was designed to encourage African-American students specifically to go into careers in math and science, and we started early with them, in elementary school, and we identified them just because of their interest in science and math, but we not only brought them together, and exposed them to experiences at museums that designed specific programs for us, going to institutions of higher education, that designed special classes for them, but we brought in practicing scientists and mathematicians, so that they could see someone that looked like themselves that was successful in those professions.

So, that is the first step, and I am not sure whether you just were speaking about the students themselves, but I can tell you

that as a teacher, I did not do as good a job as I should have encouraging those students, then, to pursue a career in the teaching of math and science. And we struggle with this all the time, as we open—as we have been successful at opening up so many more doors for our minority students, that oftentimes, teaching takes a backseat to the opportunities that have been opened to them, and so, we need to, with them, just like with all of the other students that we are trying to encourage to pursue teaching as a career, do that by showing them that the career that they have chosen is a respected one, that they will be respected and valued as the professionals they are, and we need to do that for all of our students, but we especially need to reach back and make sure that our minority students have the support and the role models that they need to continue that pursuit.

Dr. HEPPERT. I could tell you about many programs that I have seen that have been successful, and that have contributed in this area, but let me tell you about a problem that I observed. In one NSF-funded program we worked with, a district in our area, which is a high minority district, and in that district, as we looked at the cohorts of teachers, as students moved up through the middle school years and into the high school years, and looked at the preparation of those teachers, we found in one case, from one entire cohort moving through middle school into high school, that the students would encounter three teachers who were actually certified in the area they were teaching. In another cohort, leading to a different high school, we found one teacher out of the entire group that was actually certified to be teaching science in the areas that they were teaching.

That illustrates, I think, what we have been talking about here today, how desperately those students need to have teachers who are adequately prepared, have high quality content background, so that those students, when they graduate from high school, will have the choice, will have the preparation to be able to move into careers in mathematics, science, technology, engineering.

I think that is the key thing we can do for students, is to make sure that they have very well prepared and qualified teachers.

Mr. INGLIS. The gentleman's time has expired, and—

Mr. GREEN. Mr. Chairman, may the final panelist give the response, please?

Mr. INGLIS. Briefly.

Dr. BARTELS. I will give you a very specific NSF example. NSF is funding TERC to take a look at third grade classrooms of diversity. One thing we noticed, here is a perfect example. It was a biology question. We see plants grow, but we can't see them grow. How do we know we grow?

And one of the girls raised her hand, and she said, oh, because we can measure it over time. And how an eight-year-old came up with that was pretty surprising, but of course, the teacher honored that answer, because it was a scientifically correct one. But you could tell that there was another girl who happened to be African-American, who didn't speak up much in that class, who was bothered by that answer. It didn't jibe. So she thought about it and she thought about it, and finally, she said you know, Mrs. Johnson, I don't know about that, but I know that after a while, my shoes get

crinkly. And the teacher almost missed the moment, and then, she said what do you mean by that? And of course, what she meant is that she can't see herself grow either, but she knows she is, because she outgrew her shoes. Scientifically speaking, that is just as valuable and authentic answer of how you can tell if things grow or not, even if you can't see it, as the correct answer, well, you can measure it over time. Well, because the teacher spotted that, she asked how other kids figured out how you could tell things grew, and every kid gave their answer from their own perspective. That research now has to be turned into how does every teacher now notice that, that that sort of response was scientifically just as correct as the other one. It just needed to be moved more towards the formal language of science, and what are the tools and videotapes and other things teachers have, so that they don't always honor the kid who came up with the right answer, but the other kid, who actually came up with a more scientifically interesting one.

Mr. GREEN. Thank you, Mr. Chairman.

Mr. INGLIS. Thank you. Ms. Jackson Lee.

Ms. JACKSON LEE. Thank you very much, Mr. Chairman, and let me thank the Ranking Member for what is a very important hearing. We are glad we are having this hearing, because it expresses affirmatively the concern we have with the deemphasizing of the K-12 STEM program funding that is seemingly not a part of the President's anti—not anti, but pro-competitiveness, or anti-competitiveness from the other side, but pro-competitiveness from our side, effort that has just recently been announced. How you eliminate seeding the future engineers and scientists of America is baffling to all of us, so I am truly hoping that these very brilliant teachers will take their message back to the White House about the funding issues that we are speaking of. We can't really survive without solutions to our problems.

So, I will start off, because I have a mountain of paper here, because I believe that this is so crucial, that it bears on being a crisis. So, I will just simply say, and I think we have a crisis. One of the reasons why we have a crisis is because we have two nations that I applaud. I am not going to be so selfish as to be envious of those who seem to be capturing the real essence of this world, and that is India and China, and as they educate individuals, they are surmounting, if you will, any of the numbers that we could imagine, only because of size.

So, what you all are speaking about, really, is the scientific survival of America, and starting in the Science Committee, some years before the turn of the century—isn't it interesting to be able to say that—I started out by saying that science is the work of the 21st Century. We are in the 21st Century, and more than with your hands, though I miss manufacturing, we will be producing the workforce of the 21st Century on the basis of science.

So, gentleman and distinguished educators, and might I add my applause to the National Education Association for lifting up teaching throughout America, and fighting the good battle of what disincentives really are, when you eliminate the recognition that all teachers should be made excellent, and so, I understand the basis of your theory on a merit-based teaching, if you will.

But let me have each of you comment, do we have a crisis? And the value of teacher development, and let me throw out something that I have done, and I would like you to comment on this issue, and Ms. Snyder, tell us when teachers sign—teacher incentives may be relevant? And I think maybe in the instance, I think I heard one of the teachers in the instance of math and science teachers, or maybe some bonuses? But I know NEA has been a thinker on these issues, and I think you should get it out on the table.

When I first came to Congress, I passed legislation dealing with the sharing of old equipment from our laboratories with primary and secondary schools. I am about to ask my agencies, my science labs, have you done that, and give me your full report, and show me the schools where you have done so, because this is what happens when Congress passes bills that get into action. But the point that I want to ask you, we need to be a leader on this whole question of exposure and excitement to teachers and students, so I am going to be crafting, with I hope the help and interest of my colleagues, the ability for our science agencies, governmental agencies, because I did this on the local level with corporations and high school students, to have exposure internships, intern is sort of a big word, but exposure by way of either primary, middle, or secondary, still in the thought processes, to our science labs, NASA, any number of subsets of science that goes on in the United States, why aren't we in the lead of embracing schools, having youngsters come through two weeks, and not just the youngsters who are Ph.D. candidates, but get them at that level, because I think I heard one of the teachers say, you have got to excite young people. You have got to excite children, if you will, and I don't think high school is too late, even though we should be dealing with our primary schools.

But I think that high school helps propel that ninth, tenth, eleventh grader, saying yes, this is what I want to do. So, I would appreciate your expanding on the crisis issue, teacher development, and what about this program that could then be translated into the corporate science community.

Dr.—my eyes are not seeing it, so I want to pronounce it—Bartels?

Dr. BARTELS. Yes.

Ms. JACKSON LEE. Thank you.

Dr. BARTELS. I think that is a terrific idea. I would only urge you, in all due respect to universities and national labs, not to forget the New York Hall of Science, the Exploratorium, the Franklin Institute of Technology.

Ms. JACKSON LEE. Excellent.

Dr. BARTELS. The Montshire. Because in a lot of ways, these institutions, which again, are 1,500 strong in this country, are better prepared to interest kids and teachers in science, in authentic science. In a lot of ways, then, the Department of Energy researcher who was really interested in that last question about particle physics, and so, I would really count on the informal infrastructure to take up that challenge.

Ms. JACKSON LEE. Great. And crisis, do you want to say yes or no?

Dr. BARTELS. Oh, absolutely. And I think the crisis isn't, frankly, the number of scientists and engineers. We argue about that. India and China, they are going to have more. But for every scientist that works at Genentech Laboratory, they need 20 technicians. What I hear from most corporations is that the technical class, the traditional class, the middle class jobs, that is in the most desperate need, where are we training those nurses, those lab techs, those med techs, and frankly, even the traders, entrepreneurs, and the people who will create jobs in the next 30 years. They need math and science, too.

Ms. JACKSON LEE. May I have the—finish the answer, Mr. Chairman. Thank you, Mr. Chairman.

Dr. HEPPERT. The answer is, I think, is we need more of all of the above. There is a crisis. At the same time, I have to say I applaud you all for being out in front of this. I mean, you have really started to design programs and take up this issue before this has become a crisis that has actually affected our economic future.

With regard to the issue of laboratories, the American Chemical Society has worked to really support legislation recently that has come out about improving laboratory facilities in high schools, and trying to support those. I have had personal experience with setting up programs where Department of Energy researchers of the laboratories have had the opportunity to work by webcast with classrooms, and again, as we have looked at teacher response to those, and student response to those, as well as the enthusiasm of the researchers at the Department of Energy labs, they have been tremendous.

Ms. JACKSON LEE. Excellent.

Dr. HEPPERT. So I think you are on the right track with all of your ideas.

Ms. JACKSON LEE. Thank you. Ms. Pringle, thank you. Thank you very much, Dr. Heppert.

Mr. INGLIS. Thank you.

Ms. JACKSON LEE. You are the last.

Mr. INGLIS. Oh, yes.

Ms. PRINGLE. I would say yes, yes there is a crisis, and especially, as we talked about earlier, in our minority communities.

There are a couple of things that I wanted to address, and I use the title of Jonathan Kozol's book, *Savage Inequalities*, to really capture and reflect the fact that the crisis is more so realized in our urban, especially our urban schools, that service poor and minority students, and when you talk about the lack of resources, most especially in science, where when I started teaching science in the Philadelphia public school system, my resources consisted of a ream of paper, 500 sheets, for the whole year. I didn't say anything about the science, so I went out and bought materials just like so many of us do.

So, I would implore the Committee to explore that. We all know that it exists, and it is criminal for us to turn a blind eye to the fact that we have schools in this country that do not have microscopes in a biology classroom, and that is real.

I would also like to comment on the question you asked around additional pay. One of our award recipients talked about having a science camp breakfast club on Saturdays, and she said that you

know, she just got up and did it, and that is absolutely typical, that teachers in this country are so altruistic as to give up their time, or spend money on resources, but it is unacceptable. If this is a crisis, then as a nation, we need to stand up and provide the resources, so that if our children need additional time on Saturdays to complete a lab, that we have the resources to pay professionals to do that job.

Ms. JACKSON LEE. So you agree it is a crisis.

Mr. INGLIS. Well, thank you to the witnesses for your excellent testimony today. We appreciate you being with us.

I would point out to Members that if they have any additional questions, they can submit them in writing, and I would hope that our witnesses would be willing to response.

Otherwise, with appreciation for the witnesses and the Members, the hearing is adjourned.

[Whereupon, at 12:20 p.m., the Committee was adjourned.]

Appendix 1:

ANSWERS TO POST-HEARING QUESTIONS

ANSWERS TO POST-HEARING QUESTIONS

Responses by Dennis M. Bartels, Executive Director, The Exploratorium

Question submitted by Representative Eddie Bernice Johnson

Q1. Earlier this year I advocated for increased funding for NSF's "HBCU-UP," or undergraduate program for Historically Black Colleges and Universities.

What programs administered by NSF increase diversity in our STEM workforce, particularly in K-12 education?

A1. All of them.

But more or less well depending on the specific grant project idea or design of program or experiment.

The lasting legacy of Dr. Luther Williams (NSF EHR Director from about 1990 through 1999) was integrating questions of diversity and equity into nearly every NSF K-12 education program. It was an explicit strategy of his not to separate out central questions of equity from the main program strands. As a result, no specific program was developed with an exclusive focus on increasing diversity—all of them were supposed to.

This resulted in different approaches and strategies at the program level. For instance, all the systemic initiatives were required to treat equity as central and favor districts and geographic areas with greater educational challenges. The Urban Systemic Initiatives and Rural Systemic Initiatives were direct derivatives of that approach.

The solicitations for Instructional Materials Development likewise needed to demonstrate that these materials were especially effective for students within lower achievement levels (no matter how defined). Proposals in the Research on Learning and Education (ROLE) program favored studies aimed at understanding issues of equity and increasing student diversity on measures of achievement, and a number of projects focused explicitly on why privilege appears to replicate itself at the earliest grade levels. Much has been learned from these studies and I described one of those studies in my hearing testimony.

Several of the centers in the Centers for Learning and Teaching program made equity and increasing diversity the central focus (DIME, etc.). Finally, the Informal Science Education program does more to fund after school and community centers located in high impact areas to spark scientific curiosity at the earliest ages. The impact of these programs on minority achievement is well-documented.

For the record, there is something to be said about NSF's pre-college approach of not separating these questions from the general program and on insisting on program integration.

Nonetheless, those programs with the greatest immediate success of increasing diversity in the STEM workforce are those which provided direct service in geographic areas with the greatest number of students of color, namely the systemic initiatives (now defunct) and informal centers such as after school. More sophisticated approaches, such as the effective use of more challenging NSF-sponsored curricula, for example the dramatic increase in achievement levels for minority students in Boston, Austin and Charlotte, required very high capacity districts who knew how to use those materials well (including quite substantial investments in teacher professional development).

However, it is these more complicated approaches which show the greatest promise of reaching the largest number of students when pulled-off successfully. It is one of those classic policy dilemmas.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Joseph A. Heppert, Chair, Department of Chemistry, University of Kansas; Chair, Committee on Education, American Chemical Society

Question submitted by Representative Eddie Bernice Johnson

Q1. Earlier this year I advocated for increased funding for NSF's "HBCU-UP," or undergraduate program for Historically Black Colleges and Universities.

What programs administered by NSF increase diversity in our STEM workforce, particularly in K-12 education?

A1. My impression of NSF's commitment to increasing diversity in the STEM workforce is that the Foundation works extremely hard to ensure that students and professionals from under-represented groups have the opportunity to benefit from all NSF programs. I believe that this impression would be shared by all of my colleagues on the Society Committee for Education. NSF has pursued this policy by ensuring that researchers leading funded projects develop detailed plans to involve and recruit persons from under-represented groups into positions as leaders, staff and participants in educational and scientific programs. Furthermore, NSF has insisted that these plans 1) present a reasonable opportunity for success, 2) have resources adequate to ensure that they are fully implemented, and 3) include ongoing assessments of their effectiveness. This is certainly moving the agency from a situation where 20 years ago many federal programs paid lip service to diversity, to a situation today where more and more programs at NSF are experiencing success in increasing the participation of minority individuals in all aspects of funded programs.

I would particularly point out the following programs that serve diverse populations, particularly populations that directly or indirectly support K-12 education:

MATH AND SCIENCE PARTNERSHIPS. MSP projects are expected to both raise the achievement levels of all students and significantly reduce achievement gaps in the mathematics and science performance of diverse student populations.

STEM TALENT EXPANSION PROGRAM (STEP). Nine awards increase number of and diversity of graduates in STEM fields.

SCHOLARSHIPS IN SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS (S-STEM). This program makes grants to institutions of higher education to support scholarships for academically talented, financially needy students, enabling them to enter the workforce following completion of an associate, baccalaureate, or graduate level degree in science and engineering disciplines.

ALLIANCES FOR BROADENING PARTICIPATION IN STEM (ABP); LOUIS STOKES ALLIANCES FOR MINORITY PARTICIPATION (LSAMP); BRIDGE TO THE DOCTORATE (BD); ALLIANCES FOR GRADUATE EDUCATION AND THE PROFESSORiate (AGEP). The two programs and one supplemental activity included under the Alliances for Broadening Participation in Science and Engineering (ABP) solicitation seek to increase the number of students successfully completing quality degree programs in science, technology, engineering and mathematics (STEM). Particular emphasis is placed on supporting groups that historically have been under-represented in STEM: African Americans, Alaskan Natives, American Indians, Hispanic Americans and Native Pacific Islanders. ABP support begins at the baccalaureate level with the Louis Stokes Alliances for Minority Participation (LSAMP) program. For eligible students, significant financial support is continued for two years of graduate study via the Bridge to the Doctorate (BD) activity. Rounding out the ABP cluster are Alliances for Graduate Education and the Professoriate (AGEP), which further the graduate education of minority students through the doctorate level, preparing them for fulfilling opportunities and productive careers as STEM faculty and research professionals.

RESEARCH EXPERIENCES FOR TEACHERS (RET) AND RESEARCH EXPERIENCE FOR UNDERGRADUATES (REU) PROGRAMS. Both RET and REU programs provide under-represented students and teachers who serve under-represented secondary students with substantial access to research facilities supported by NSF programs. These are valuable experiences because they provide undergraduate minority students with direct life-changing practice in cutting edge science, and with confidence that they can succeed in advanced scientific study. The RET experiences also immerse secondary teachers in the excitement and reality of scientific research. They, in turn, have the opportunity to take this infectious enthu-

siasm back to students in their classrooms who would otherwise never make a connection to science or engineering as potential career pathways.

ROBERT NOYCE SCHOLARSHIP PROGRAM. The Noyce Program has been responsible for placing many STEM career changers in mathematics and science teaching positions in at risk schools. In Kansas City, Kansas, an urban district where our institution runs a Noyce Award, half of the new teachers who have entered the district over the last three years have been supported by Noyce funding and related sources of incentive funding! This illustrates how effective this program has been at increasing the population of science and mathematics teachers with excellent STEM content backgrounds in schools where they are desperately needed.

NSF's commitment to building a more diverse STEM workforce is clearly genuine and longstanding.

The one cautionary note in my estimation is the continuing reduction of NSF programs and funding directed toward the K-12 educational level. Improving science education, particularly for middle/secondary students, and addressing problems that under-represented students encounter as they transition from the secondary level into colleges and universities is essential for creating a more diverse workforce. Scientists, mathematicians, engineers and technology professionals need to remain actively engaged in improving K-12 STEM education and in devising solutions to barriers under-represented students encounter as they progress along STEM career pathways. The only way that this will happen is if NSF intensifies its commitments to improve K-12 education. Recent budget recommendations and planning documents leave the role of NSF in addressing the needs of secondary teachers in doubt.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Rebecca Pringle, Physical Science Teacher, Susquehanna Township Middle School; Member, Executive Board, National Education Association

Question submitted by Representative Eddie Bernice Johnson

Q1. Earlier this year I advocated for increased funding for NSF's "HBCU-UP," or undergraduate program for Historically Black Colleges and Universities.

What programs administered by NSF increase diversity in our STEM workforce, particularly in K-12 education?

A1. The National Education Association believes that diversity is a critical element in a strong math, science, and technology teaching force. A diverse teaching staff helps ensure a broader perspective in teaching and learning and provides critical role models for minority youth in these traditionally under-represented fields.

NEA supports programs that encourage active recruitment and retention of ethnic minority educators into math, technology, and science education. The National Science Foundation administers a number of such programs, including:

- **Alliances For Broadening Participation In Science and Engineering (ABP).** These alliances include two programs—**Louis Stokes Alliances For Minority Participation (LSAMP) and Bridge To The Doctorate (BD)**—and one supplemental activity—**Alliances For Graduate Education And The Professoriate (AGEP)**. These initiatives seek to increase the number of students successfully completing quality degree programs in science, technology, engineering and mathematics. Particular emphasis is placed on supporting groups that historically have been under-represented in these fields: African Americans, Alaskan Natives, American Indians, Hispanic Americans and Native Pacific Islanders.

ABP support begins at the baccalaureate level with the Louis Stokes Alliances for Minority Participation (LSAMP) program. For eligible students, significant financial support is continued for two years of graduate study via the Bridge to the Doctorate (BD) activity. Rounding out the ABP cluster are Alliances for Graduate Education and the Professoriate (AGEP), which further the graduate education of minority students through the doctorate level, preparing them for fulfilling opportunities and productive careers as science, technology, and math faculty and research professionals.

- **Math And Science Partnerships.** The NSF Math and Science Partnership (MSP) awards competitive, merit-based grants to teams composed of institutions of higher education, local K-12 school systems, and their supporting partners. These partnerships develop and implement pioneering ways of advancing math and science education. The program is based on five pillars: Partnership-Driven, Teacher Quality, Quantity and Diversity, Challenging Courses and Curricula, Evidence-Based Design, and Institutional Change and Sustainability. MSP projects are designed to raise the achievement levels of all students and significantly reduce achievement gaps in the mathematics and science performance of diverse student populations.
- **STEM Talent Expansion Program (Step).** Nine awards increase number of and diversity of graduates in science, technology, and math fields.
- **Scholarships in Science, Technology, Engineering, And Mathematics (S-STEM).** This program makes grants to institutions of higher education to support scholarships for academically talented, financially needy students, enabling them to enter the workforce following completion of an associate, baccalaureate, or graduate level degree in science and engineering disciplines.

We look forward to working with Congress to increase funding for these critical programs.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Judy D. Snyder, Mathematics Teacher, Eastside High School, Taylors, South Carolina

Question submitted by Representative Eddie Bernice Johnson

Q1. Earlier this year I advocated for increased funding for NSF's "HBCU-UP," or undergraduate program for Historically Black Colleges and Universities.

What programs administered by NSF increase diversity in our STEM workforce, particularly in K-12 education?

A1. I cannot answer this question directly because I do not have direct knowledge of all NSF programs. I can attest to the fact that the NSF program that had the most effect on my teaching was open to all teachers in this area of the state and minority teachers participated. The goal of the program was not to target minorities, however. I can also speak to the importance of having good minority teachers in our public schools. Not only do good minority teachers create role models for minority students but they garner respect from all students as well as their colleagues and their administrators. This kind of respect helps break down racial barriers and creates an atmosphere where all students and teachers are equally respected and where all students are expected to achieve at high levels. It is becoming more and more difficult to find good mathematics and science teachers and even more difficult to find minority teachers in those fields. I certainly concur with Representative Johnson's concern in this area.

Appendix 2:

ADDITIONAL MATERIAL FOR THE RECORD

STATEMENT OF NIEL TEBBANO
VICE PRESIDENT
PROJECT LEAD THE WAY

Project Lead The Way is pleased to provide this testimony on behalf of the organization as well as, the schools, universities and corporate partners that participate in *Project Lead The Way* nationwide (see appendix), the thousands of educators who have gone through our professional development program and the 175,000 young people who have been affected by our efforts.

Background

Project Lead The Way (PLTW), shares the interest of this panel and countless other public officials who are attempting to address the issues surrounding the Nation's concern regarding global competitiveness. We firmly believe that a better-educated and prepared workforce is crucial to securing this nation's place as a global economic leader and innovator.

To address this challenge, PLTW was created in 1996 by the Charitable Leadership Foundation of Clifton Park, New York as a nonprofit organization designed to create and proliferate a pre-engineering program for our nation's high schools and middle schools. Since 1996, PLTW has developed sequences of middle and high school courses which, when combined with appropriate mathematics and science courses, introduces students to the scope, rigor and discipline of engineering and technology prior to entering college.

Started with the humble goal of being in 50 high schools in upstate New York by 2005, the program is currently found in over 1,300 schools in 45 states. The program is funded using a variety of local and federal sources and also relies on public-private partnerships.

In Tennessee *Project Lead The Way* has forged dynamic partnerships with the University of Tennessee at Chattanooga and the National Energy Laboratory at Oak Ridge to support the 20 state high schools enrolled in the program. This partnership model brings higher education and business into the high school in direct focused ways from informing rigorous teacher professional development to student mentoring on original engineering research projects.

Beliefs

While PLTW believes that its curriculum and program are exemplary, there are a number of fundamental assumptions that belie its formulation and success. First and foremost, PLTW strongly advocates for reliance on hands-on, project-based learning. Engineering is a field and profession based on the success of projects, and this should be reflected in any measure of an engineering curriculum's success.

PLTW also believes that success in the science, technology, engineering and mathematics (STEM) disciplines begins the moment a child walks into a classroom for the first time. It is crucial that any federal endeavor in this area address this fact. It is not enough to engage young people in middle and high school. Interest in these studies must be nurtured from day one. In particular, girls and other under-represented groups must find STEM appealing at a young age if we can reasonably expect them to pursue them successfully in later years. So, while secondary education is where one might intuitively look to focus on post-secondary preparedness for the pursuit of STEM disciplines, PLTW believes it is important that elementary students receive similar focus.

Further, PLTW's rigorous and relevant curriculum is based on the premise that bringing engineering curriculum and concepts to students through practical application while they are still forming opinions about interests and careers is crucial. No one can deny that these interests are formed at a very early age. As a result, it is important that young people are exposed to curricula that go beyond math, science and technology, and educators are explicitly encouraged to include engineering in elementary education.

Recognition and Elements of PLTW's Success

In October 2005, *Project Lead The Way* was cited in the report *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Educational Future* by the National Academy of Sciences, The National Academy of Engineering, and the Institute of Medicine of the National Academies. Among the report's recommendations was that K-12 curriculum materials for science, technology, engineering and mathematics (STEM) education modeled on world class standards foster "high-quality teaching with world class curricula, standards and assessments of student learning." It further went on to say that "The model for this recommendation is the *Project Lead The Way* pre-engineering courseware (page 4)."

In addition, the report noted, “*Students participating in PLTW courses are better prepared for college engineering programs* (page 5–15).”

PLTW is understandably proud of this distinction. It does beg a number of questions, however.

Why has the program grown so quickly and what has been its effectiveness?

The answers to these questions are grounded in the attributes of the program’s organization, and in its curriculum and professional development.

Partnership—The mission of *Project Lead The Way* is simply to “*create dynamic partnerships with our nation’s schools to prepare an increasing and more diverse group of students to be successful in engineering and engineering technology programs.*” Partnerships with state departments of education and labor, colleges and universities of engineering and engineering technology, and major industries and corporations (see attached listings) have been reached to validate and support the program throughout the country. Local, State and regional ownership of the program with the engaged collaboration and support from the national *Project Lead The Way* program has created a vibrant and responsive network of stakeholders that keeps the initiative vitally active and strong.

As an example, in Tennessee and other states, *Project Lead The Way* has brought together elements of higher education and business with the state education department, to validate the rigor and relevancy of its high school curriculum and teacher professional development program. Seven of the eight high school *Project Lead The Way* courses are eligible for college credit to qualified students. Industry and higher education sit together on the *Project Lead The Way* State Leadership Team overseeing the quality of its implementation statewide, and also collaborate with teachers and school counselors at the local level to assure high learning standards and program support.

Curriculum—As has been repeated countless times on Capitol Hill, curricula needs to be rigorous and relevant to meet the interests and expectations of today’s students. PLTW agrees. The attributes of the program curricula that have contributed to *Project Lead The Way*’s success are:

- Contextual project/problem based instruction.
- Integration of recognized national learning standards including those of the National Academy of Science, The National Council of Teachers of Mathematics and the International Technology Education Association.
- Breadth and depth of content, updated and revised regularly.
- Supported by comprehensive professional development for teachers and school counselors.
- Prepares students for successful transition to two- and four-year college programs.
- Written to standards of quality and consistency so as to carry college credit that is recognized by over 30 post-secondary engineering and engineering technology schools nationwide.

Professional Development—Rigorous, relevant professional development for teachers, presented in immersed and ongoing formats, is essential to breed and assure student success. The attributes of the *Project Lead The Way* professional development program are:

- Pre-Training Teacher Assessment
- Two week Summer Training Institute required for each course a teacher might teach (80 hours seat time) at 30 university sites nationwide.
- On-going teacher training and reinforcement through the *Project Lead The Way* on-line *Virtual Academy*.
- Required school counselor professional development at university sites.

Not-For-Profit Benefits to Schools—As a not-for-profit, *Project Lead The Way* provides at no charge to schools:

- Contemporary, rigorous, project/problem-based curricula, updated regularly, for eight (8) full year, high school courses and six (6) middle school units.
- Access for trained instructors to the *Virtual Academy*.
- Teacher and counselor professional development protocols for use by university and college partners.

- Use of an optional Purchasing Manual, developed under the procedures of the New York State bidding laws, for lowest pricing on all equipment and supplies for all *Project Lead The Way* courses.
- Information and promotional materials for use by school counselors with parents and students.

Program Evaluation—PLTW believes that unbiased, critical examination of its curriculum and program elements is crucial to its goals and success. Initial research findings on the effectiveness of the *Project Lead The Way* program include:

A study by the Southern Regional Education Board (2005) which found that *Project Lead The Way* students:

- Achieved significantly higher in mathematics than students in comparable career/technical programs.
- Achieved significantly higher than all students in career/technical programs in mathematics, science and reading.
- Completed significantly more, higher level mathematics and science courses.

A study by True Outcomes of York, Pennsylvania (2005) showed that:

- 80 percent of seniors in *Project Lead The Way* planned on attending college or community college compared to 65 percent nationwide.
- 54 percent planned to enroll in engineering or engineering technology compared to 10 percent nationally.
- 19 percent planned on attending community college or Technical School.
- Overall schools offering PLTW were representative of their state's population.
- Minority student participation met or exceeded the proportion of Bachelor's Degrees awarded in Engineering in 2004 to minority students by race.
- The representation of Hispanics and African-Americans in PLTW courses was double their representation in post-secondary engineering programs nationwide.
- Female student participation in *Project Lead The Way* was comparable or exceeded the total proportion of females earning Bachelor Degrees in Engineering in 2004, in the fields of Mechanical, Electrical and Computer Engineering, and in Engineering Technology, but less than the percentage in biomedical and environmental fields.

Conclusion

In 1985, "*A Nation at Risk*" was published alerting the country to an impending crisis due to perceived significant inadequacies of the existing K–12 education system. Since then these sentiments have been echoed in many subsequent research papers, most calling for reform, but with no real innovative solutions or recommendations. With few exceptions, these reports have instead focused on increasing the quantity of more of the same traditional courses and approaches—approaches that have proven limited in their scope and overall effectiveness.

The latest proposals from Washington do the same: increasing AP course participation, expansion of the IB Program, increased foreign language instruction, more math at all levels, and more math teachers. While well intended and even valiant, the reality is that if these proposals move forward, students will continue to ask, "Why do I need to know this?" and "Where will I ever use this?"

Raised in an age where interactive technology has influenced almost all of their life experiences, traditional passive learning models fall far short for the majority of today's students. Today's student thrives on curricula that are contextual and which invite their engagement in project/problem based activity. In short, they do best with school curriculum that is BOTH rigorous AND relevant; where they understand why they need to know something, and where and how they can use it.

Don't forget the majority of students in this great country whose learning styles and interests are not met in traditional settings and course work. Contextual, project-based learning, where students can apply what they have learned in mathematics, science and English classes, supported by rigorous and relevant curricula and professional development, must be part of the solution that any federal legislation or investment pursues.

Appendix**Project Lead The Way Courses****Gateway To Technology** (Middle School)

- Design and Modeling
- The Magic of Electrons
- The Science of Technology
- Automation and Robotics
- Flight and Space
- Technology in Motion (in development)

Pathway To Engineering (High School)

- Principles of Engineering
- Introduction to Engineering Design
- Digital Electronics
- Computer Integrated Manufacturing
- Civil Engineering and Architecture
- Biotechnical Engineering
- Aerospace Engineering
- Engineering Design and Development

University Affiliates

Arkansas Tech University
 Duke University, Pratt School of Engin.
 Eastern Michigan University
 Milwaukee School of Engineering
 New Hampshire Technical Institute
 Old Dominion University
 Oregon Institute of Technology
 Penn State University
 Purdue University
 Rochester Institute of Technology
 San Diego State University
 Sinclair Community College
 So. Seattle Community College
 Univ.of Colorado at Colorado Springs
 University of Texas at Tyler
 University of Illinois-Urbana
 University of Maryland at Baltimore County
 University of Missouri-Rolla
 University of New Haven
 University of Minnesota
 University of South Carolina
 University of South Florida
 University of Tennessee at Chattanooga
 Weber State University
 Worcester Polytechnic Institute

Strategic Partners

Autodesk, Inc.
 Intel Corporation
 Kern Family Foundation
 NASA
 Rolls-Royce Corporation

Science Education Policies for Sustainable Reform

AMERICAN CHEMICAL SOCIETY

INTRODUCTION

The American Chemical Society (ACS) is the world's largest association of individual chemical scientists and engineers. To fulfill its mission as a congressionally chartered scientific and educational society, ACS has developed nationally acclaimed programs that support ongoing reform efforts in science education at all levels. ACS education programs begin at the pre-school level, continue through elementary, middle, and high school, and include undergraduate and graduate instruction in chemistry. ACS also offers continuing professional development workshops, short courses, and Internet courses for elementary and high school teachers and for mid-career chemists working in industry and academia.

The Society continues to play an important role in the development of national policies related to science education by providing advice to Congress and various federal agencies. The Society also provides comments on the annual budgets of the National Science Foundation (NSF) Education and Human Resources Directorate, and the U.S. Department of Education. This ACS involvement stems from the recognition that the increasing role of science and technology in the U.S. economy necessitates a modern and effective science education system.

This document, summarizing the science education policies of the Society, is directed toward practitioners and policy-makers throughout the U.S. educational system. These policies are organized by educational level and topic of concern. Since the first version of this ACS policy document was published in 1989, many changes have occurred in science education. Nationally and at the State level, the standards-based movement is attempting to bring coherence to science curricula at the K–12 level, with mixed results. There has been an acceptance that standards-based science instruction should include an emphasis on hands-on, inquiry-based instruction to help K–12 students develop a knowledge and understanding of scientific ideas. They also need to understand how scientists explore and make sense of the natural world. Specifically, they need to understand how scientists use inquiry methods that involve making observations; posing questions; examining the literature to see what is already known through experimental evidence; proposing answers and explanations; testing hypotheses through experimentation; and communicating the results orally, in writing, and by other appropriate methods. However, while all states have developed content standards, few have developed science education assessments that are congruent with their state content standards.

The *No Child Left Behind (NCLB) Act* appears to be having an unintended negative impact upon the practice of hands-on science at the elementary and middle school levels in particular. Since science is not yet a federally mandated assessment, schools are emphasizing, and therefore funding, activities that they expect will directly affect student performance in reading and math, both of which are currently being assessed in compliance with NCLB. The impact that national testing of science knowledge will have in future years must certainly be closely monitored.

Efforts continue at the undergraduate and graduate levels to ensure that courses reflect the vitality and challenges of modern chemistry and that instruction methods model the most effective pedagogical techniques. The funding of the Undergraduate Chemistry Systemic Reform initiatives and the subsequent Adapt and Adopt program by NSF continue to influence reform efforts. In particular, the Peer-led Team Learning approach pioneered by the City University of New York continues to gain support.

Of special concern at the undergraduate level, as at all levels of education, is the need to develop new assessment instruments consistent with new instructional pedagogy to evaluate student learning outcomes, faculty effectiveness, and the curriculum. At the graduate level, there is a need to broaden the graduate experience to include more specific training in, for example, green chemistry and sustainability ethics, toxicology and safety issues, statistics, economics, communication skills, and working on team and multi-disciplinary projects. There is also a need to provide mechanisms through which the graduate student interacts with a functioning advisory committee throughout the student's graduate career.

The year 2003 saw the release of the National Academy of Sciences study, *Beyond the Molecular Frontier*, delineating the exciting directions in which the chemical sciences and engineering will develop over the next 10 years. The ACS began a major effort to re-examine the chemistry education process at the undergraduate and graduate levels, through an invitational conference, "Exploring the Molecular

Vision.” This conference confirmed the view that a consideration of content reform cannot be separated from pedagogy.

ACS recognizes that the major strength of the U.S. education establishment resides in the educators, K–12 teachers and college faculty, who bring the excitement of science and learning to students. It is critical that our nation recruit and retain the most talented people from our diverse population for these roles and that they be supported and recognized for their efforts.

ACS has been involved in the educational reform movement for many years. Yet, for educational reforms to succeed, we must all recognize the long-term nature of the reform process. Reform must be sustained; it must not be viewed as a one-time or cyclical activity. Recognizing the importance of a sustained effort, ACS will continue to support nationwide efforts to:

- Implement standards-based science education at the K–12 level;
- Promote the systemic reform of undergraduate and graduate chemistry programs;
- Provide lifelong professional development opportunities for science teachers and those who practice the chemical sciences;
- Encourage schools to use assessment instruments that measure a student’s understanding of science and use of the methods of science, not just the student’s ability to recall science facts;
- Develop national assessments of science achievement at the K–12 level that are in-line with the National Science Education Standards in terms of scope, content, and assessment of the broad range of understanding and abilities expected from effective science learning;
- Ensure that the resources are available within schools, colleges, and universities to encourage and support excellence in laboratory-based courses;
- Recruit and retain the best possible people, including members of under-represented groups, for example, women, African Americans, Native Americans, Hispanics, and persons with disabilities), into the scientific disciplines; and,
- Promote a scientific curriculum that emphasizes scientific reasoning and scientifically validated data at all levels.
- Develop introductory chemistry courses for both general students and science students that emphasize the current and future solutions of real-world problems.
- Integrate chemistry core courses for undergraduates and graduates on an intra-disciplinary unifying concept basis that reflects how chemistry is actually practiced.
- Demonstrate the “enabling” concepts of chemistry useful for 21st century, team-centered, multi-disciplinary research through interactive courses and research at the undergraduate and graduate levels.

PRE-HIGH SCHOOL (K–8)

Students make many decisions regarding future course work and career options during their pre-high school years. Even their pre-school experiences can have an influence on future choices. Thus, the curiosity and wonder shown by the youngest of learners about the natural world must be carefully nurtured. Teachers (supported and reinforced by school systems, communities, and policy-makers) play a pivotal role in this nurturing process. Teachers need to be confident in teaching science through interactive and inquiry-based modern courses, as defined in the *National Science Education Standards*.

I. Teacher Development

Recruitment and retention of teachers who are well prepared in science is of the highest priority for the future of our technology-based society. These teachers must represent our diverse population. Elementary and middle school teachers need a firm grounding in physical, biological, and Earth/space sciences, as well as an understanding of science education research. Their exposure to pedagogical techniques should promote a familiarity with hands-on, inquiry-based instruction, and provide them with significant pedagogical content knowledge. They also need preparation and practice in integrating science with other subjects, especially mathematics. If they do not have this background, teachers may be unable to implement hands-on, inquiry-based science instruction.

To ensure that teachers with a science background teach science, some school systems use science specialists, even at the earliest grade levels, to deliver regular instruction in science subjects. As a result, science and mathematics may be taught

as completely separate, rather than mutually supporting, subjects. To ensure that K–8 students receive quality science instruction, ACS supports:

- Requiring all elementary school teachers to complete at least three college-level semesters of laboratory-based, inquiry-oriented science, including physical science, to meet minimum certification standards. Courses in mathematics and mathematics education should be parallel and complementary to the science courses. These courses should be developed as cooperative and creative efforts among departments of science, mathematics, and education.
- Requiring all middle school science teachers to complete at least three one-year, laboratory-based, inquiry-oriented college-level science courses, including physical science, to meet minimum certification standards. Courses in mathematics and mathematics education should be parallel and complementary to the science courses. These courses should be developed as cooperative and creative efforts among departments of science, mathematics, and education.
- Enhancing federal, State, and local funding of teacher in-service professional development programs to ensure that elementary and middle school teachers have access to programs that help them to expand and update their science knowledge base. These programs could take many forms, including technology-based remote learning. However, they must be designed to enhance teacher content knowledge in the sciences through the perspectives and methods of inquiry. This support should be directed at the courses most appropriate for building the skills needed. Most often, these will be undergraduate rather than graduate-level courses.
- Providing regular compulsory, teacher-led, in-service professional development programs in science and mathematics through the school system that include content, laboratory experience, and pedagogy. One effective way to accomplish this is to prepare and support groups of leadership teachers and scientists to operate statewide as teams of in-service facilitators.
- Requiring elementary and middle school teachers of science to take education courses that emphasize pedagogical content knowledge, peer-reviewed science education research, new knowledge on human cognition, and ways of reaching students with different learning styles, including the use of technology.
- Using science specialists and resource teachers where elementary teachers lack science knowledge, to motivate and assist non-specialist teachers in the presentation of science and its integration with other subjects, especially mathematics and reading.
- Making use of mentors and master teachers to aid and encourage new teachers.
- Using only certified science teachers to teach science at the middle school level.
- Increasing the involvement of high school teachers and students, and scientists from academe, business, and industry, as mentors for both teachers and students at the K–8 level. Partnerships with ACS local sections can be particularly useful in this regard.

II. Assessment

Individual states are developing instruments to assess student achievement and teacher competence in the sciences. Consultation with those professional organizations that have either already developed such instruments, or have the expertise to do so, must be encouraged. However, it must be recognized that assessment instruments do not always address the broad range of understanding and abilities expected from effective science learning. To address these concerns, ACS advocates:

- Evaluating students' science achievement at all grade levels, during each grading period. Classroom evaluation should assess not only fact recall and concept comprehension, but also higher-level cognitive skills, including the ability to apply science knowledge in new situations. Evaluation tools should assess process skills using hands-on activities and computers, as well as paper-and-pencil exercises.
- Using the self-assessment guidelines for elementary school science teachers developed by the National Science Teachers Association and other professional organizations as a means of encouraging teacher self-reflection.
- Evaluating elementary teacher competence in science, in multiple ways and with carefully designed instruments, as a means of helping teachers identify

areas in their science background that need additional professional development.

- Developing national assessment instruments designed to identify factors in the school community that lead to successful student learning of science, and working to strengthen those factors in every community.

III. Curricula

Informed by the content sections in the *National Science Education Standards* and the American Association for the Advancement of Science's Project 2061, *Benchmarks for Science Literacy*, all states now have state standards or frameworks for science curricula.

However, the quality of these standards varies from state to state. Even within a state, there may still be inconsistencies in the development of content from one grade to the next, or from one school district to the next. Science in elementary and middle schools should be a hands-on, inquiry-based exploration of the natural world, using multiple resources: teachers, the laboratory, the library, the wider community, books and magazines, multimedia sources, and the Internet. Chemical phenomena should be introduced in the early grades as a part of students' observations of their surroundings. To address these issues, ACS supports:

- Developing inquiry-based K–8 curricula that reflect the conceptual frameworks provided by the content sections in the *National Science Education Standards*, the Project 2061 *Benchmarks*, and their State and local counterparts. Elementary, middle, and high school teachers should work together to make certain that science content is articulated and implemented throughout the K–12 system.
- Including some chemistry component at each grade level (K–8) developed by teachers and scientists working in partnerships.
- Developing safe, hands-on, inquiry-based science activities in which science as a problem-solving endeavor is placed within the societal context of the student, using concrete examples of science and technology and various technological resources.
- Using the computer for simulations, drills, access to multimedia and Internet resources, and enhancing data collection, but not eliminating laboratory experiences.
- Expanding efforts to integrate science with other curricular areas such as reading, mathematics, and social studies.
- Developing appropriate science experiences for very young children working with their parents.

IV. Resources

All schools at the K–8 level should consider science as an essential component of basic education. When the school administration, the school system, business and industry, and the local community (including parents) work in collaboration, effective elementary and middle school science instruction becomes more relevant. Adequate facilities and resources necessary to teach science at this level are essential. To ensure that adequate resources are available for teaching K–8 science, ACS urges:

- Restructuring the elementary and middle school curriculum to allow time for daily, inquiry-based science activities and for teacher preparation of these activities.
- Furnishing elementary classrooms to permit safe, hands-on, inquiry-based science instruction (at a bare minimum, a sink and running water) and, at the middle school level, providing laboratory workstations. Access to adequate educational technology, including calculators, computers, and connection to the Internet, is a high priority. Of necessity, hands-on, inquiry-based science must be supported by adequate budgets for supplies, online access, and equipment and equipment maintenance.
- Involving parents in their children's science education by establishing both school- and community-based out-of-classroom science experiences for the family.
- Establishing school system/business/government/ACS local section alliances to introduce current science and technology information into the classroom on a regular basis. Such partnerships could include sabbatical leave programs, industrial and government laboratory summer employment, and other arrange-

ments that permit exchanges of personnel between schools and the science-rich sectors.

SECONDARY SCHOOLS (9–12)

For many students, high school represents the single most significant period in their science education and a time when tentative career choices are made. Developing both a scientifically literate public and the science specialists needed to advance our nation in an increasingly complex technological world, demands intellectually challenging yet developmentally appropriate curricula taught by well-qualified teachers.

The ACS strongly supports a variety of approaches to the structure and the continuous evaluation and improvement of high school science curricula. We call attention to the ongoing changes that are taking place in the sciences and we believe that all students, college-bound and otherwise, should be well educated in the sciences and in the mathematics that are the driving engines of 21st century society throughout the world. We are cognizant of the national standards in science and mathematics that are providing models for state standards. Therefore, we strongly support developing new science curricula that are based upon a core three-year science program that:

- Presents science in a logical and coherent sequence that reflects the connections among the disciplines,
- Stresses the relationships between mathematics and science,
- Strives for a balance between content and process, and
- Emphasizes inquiry and laboratory experience.

Teachers need to be comfortable teaching science through interactive and inquiry-based modern courses, and they need to be appropriately recognized and rewarded for their successes.

I. Teacher Supply

Many of our nation's teachers are reaching retirement age, and some are leaving teaching for other careers. Attracting well-prepared graduates into teaching careers will be a challenge. To encourage the brightest of our students among our diverse population to consider careers in teaching, ACS supports:

- Establishing state and federally supported scholarships to assist undergraduates interested in teaching secondary school science or mathematics. These scholarships should be renewable for up to four years and include support of education-related, paid professional activities during the summers. After graduation, the students should be required to teach one year for every year of scholarship support.
- Establishing state and federally funded scholarships to support individuals holding a discipline-centered academic degree who need pedagogical courses for secondary school teacher certification. Scholarship recipients should be required to spend at least one year teaching science or mathematics in a secondary school.
- Modifying existing teacher certification programs to permit experienced scientists to teach in secondary schools after completing a suitable teaching internship, with the understanding that education course credits would be required for permanent certification.

II. Teacher Development

The ability to deliver quality instruction, and the professional status of secondary school science teachers, may be undermined by heavy teaching loads and limited opportunities for teachers' professional growth, especially in acquiring a stronger scientific background. The release of the *National Science Education Standards* and the Project 2061 *Benchmarks* challenges current teachers, and those preparing to teach, to achieve new levels of excellence in their teaching. To help meet these challenges, ACS advocates:

- Requiring teachers to meet content area qualifications for the courses they are required to teach by taking appropriate undergraduate courses. Enhanced cooperation between departments of different disciplines and schools of education will be essential to ensure that teachers are well prepared in science content, pedagogy, and standards-based assessment techniques.
- Encouraging college and university education and science departments to develop programs that include content and pedagogy, to allow potential teachers

to complete their certification requirements within a typical Bachelor's degree program.

- Enhancing federal, State, and local funding of professional development to ensure that secondary school science teachers have access to programs that allow them to expand and update their science knowledge base. These programs could take many forms, including technology-based remote learning. They must be designed to enhance teacher content knowledge in the sciences through the perspectives and methods of inquiry and hands-on experience.
- Requiring high school science teachers to take education courses that emphasize pedagogical content knowledge, peer-reviewed science education research, new knowledge on human cognition, and ways of reaching students with different learning styles, including the use of technology.
- Changing state requirements for continuing education of teachers to include more content-area subject matter. At present, teachers may be required to take graduate-level courses in pedagogy to maintain their certification, when undergraduate courses in the sciences might be more effective in enhancing classroom performance. College and university science departments should develop and offer appropriate classroom and/or distance learning courses for practicing teachers throughout the calendar year.
- Improving the work conditions of science teachers to reduce attrition from the profession, to help improve the quality of instruction, and to ensure that safety concerns are met. Conditions for chemistry teaching should be consistent with the recommendations in the ACS documents *Safety in Academic Chemistry Laboratories* and *Model Chemical Hygiene Plan for High Schools* and with the *National Science Education Standards*.
- Providing financial incentives to encourage the participation of teachers in summer research and other educational activities at college, university, industrial, and government laboratories.
- Providing mechanisms for more experienced teachers to mentor new teachers.

III. Curricula

Science curricula need to be challenging to the students, and based on the “real world” of student interactions with nature. The *National Science Education Standards* and the Project 2061 *Benchmarks*, together with State and local frameworks, present a consensus on which to build such curricula. The 2002 NRC report on improving advanced study of mathematics and science in U.S. high schools provides appropriate guidance on higher-level chemistry courses for second-year instruction. Inquiry-based learning and laboratory experiences are essential components of chemistry instruction at all levels (see addendum). To help meet consensus standards of excellence, ACS supports:

- Developing science courses based upon inquiry-based learning, as defined in the *National Science Education Standards* and evaluating performance using standards-based assessment techniques. Classroom evaluation should assess not only fact recall and concept comprehension, but also higher-level cognitive skills, including the ability to apply science knowledge in new situations.
- Redesigning chemistry courses to present a broad view of the scope of modern chemistry by including such topics as organic, polymer, biochemistry, and materials science. The courses should include numerous examples of the interactions of science, technology, and society at all grade levels. They should also reinforce the role of the computer and laboratory instrumentation as scientific tools.
- Integrating within the laboratory experience an emphasis on environmental protection (including green chemistry) and laboratory safety.
- Integrating coverage of scientific ethics into the curriculum.
- Mandating at least three years of laboratory-based science for all secondary school students.
- Enrolling in Advanced Placement, the International Baccalaureate, or similar advanced programs as a second-year chemistry option.
- Exploring other logical sequences of science courses, for example, physics, then chemistry, then biology), organized in a manner that recognizes the dependence of each course in the proposed sequence on the content and concepts presented in the previous one.
- Integrating science content across disciplines and throughout the years of the secondary school experience.

- Enhancing articulation between high schools and two-year colleges, especially for students entering vocational training programs for technician level jobs in science and engineering.
- Increasing the availability of out-of-school science activities for young people to reinforce interest in science and mathematics achievement and careers. Especially needed are out-of-school programs to attract under-represented groups into the quantitative disciplines.
- Providing incentives such as scholarships to encourage the participation of all students in summer research activities at college, university, industrial, and government laboratories.

IV. Resources

All high schools should consider science as an essential component of basic education. When the school administration, the school system, business and industry, and the local community (including parents) work in collaboration, high school science instruction becomes more effective. Adequate facilities and resources are essential to teach high school science effectively. Business and industry in particular have a stake in ensuring that the educational system produces both scientifically literate citizens and technically trained/trainable personnel. To ensure that adequate resources are available for high school science, ACS urges:

- Providing laboratory workstations that permit safe, hands-on, inquiry-based science instruction. Access to adequate educational technology, including calculators, computers, and connection to the Internet, is a high priority. Of necessity, hands-on, inquiry-based science must be supported by adequate budgets for supplies, equipment, online access, and maintenance.
- Establishing school/business/government/ACS local section alliances to introduce current science and technology information into the classroom on a regular basis. Such partnerships could include teacher sabbatical leave programs, industrial and government laboratory summer employment opportunities, and other arrangements that permit exchanges of personnel between schools and the educational and business sectors.
- Using tax incentives to encourage business and industry to become more involved in high school science education.
- Providing broad experiential programs for students during the academic year and summer, for example, ecological field experiences, participation in science fairs and science Olympiad events, science mentorship programs, and summer research programs like Project SEED.

TWO-YEAR COLLEGES

The Nation's two-year colleges play an important role in providing access to careers in science, engineering, and technology, especially for students from groups currently under-represented in the sciences. Two-year colleges provide the curricular paths for students who will transfer to baccalaureate programs in four-year colleges and universities. They also prepare technicians and technologists to assume active roles in research and development in industry, government, and academia.

I. Faculty Development

Faculties at two-year colleges have heavy teaching responsibilities that include lecture sections, laboratory teaching, and recitations. They need adequate time and opportunities for professional growth. Two-year college faculties need an understanding of both modern chemistry and new pedagogical techniques to ensure that students are exposed to the most stimulating and effective learning environments. Therefore, ACS supports:

- Making teaching responsibilities and working conditions in two-year colleges consistent with ACS guidelines for two-year programs.
- Providing two-year college chemistry teachers with ready access to professional development opportunities, including summer institutes, workshops, and conferences; weekend seminars; satellite broadcasts; and short courses. Faculties also need opportunities to develop networks and mentoring systems and to participate in faculty-faculty and faculty-industry exchanges.
- Establishing school/industry/government/ACS local section alliances to introduce current science information into the classroom and laboratory on a continuing basis. Such alliances could include sabbatical leave programs, industrial and government laboratory summer employment opportunities, and both

formal and informal arrangements. The alliances should also participate in curriculum revision and development as well as implementation activities.

- Limiting the use of part-time or adjunct faculty in two-year colleges, but providing those faculty members with appropriate professional benefits as outlined in the *ACS Academic Professional Guidelines*.
- Allocating government and institutional resources to develop a dialogue, and establish cooperative activities, with faculty at other institutions of higher learning. Joint activities could involve fostering collaboration on research and demonstration grants, planning seminars, resolving articulation issues, and developing and implementing curricula.

II. Facilities and Instrumentation

Although some two-year colleges (especially those that offer chemistry-based technology programs) have the equipment and resources needed to provide outstanding instruction, many lack the necessary equipment and resources for modern laboratory-based instruction in chemistry. To ensure that all two-year institutions have the resources they need to teach chemistry, ACS recommends:

- Expanding federal and State funding of instructional laboratory equipment and instrumentation, including faculty training, for two-year college chemistry programs. This will assist those institutions with a strong technology focus to maintain their state-of-the-art programs and help needy institutions upgrade equipment and instrumentation.
- Sharing resources and instrumentation locally through the establishment of alliances between two-year colleges and business, industry, and government, as well as between two-year and four-year colleges and high schools.
- Increasing the availability of funds to provide undergraduate instructional courses and research laboratories with modern equipment, maintain that equipment, and train faculty in their use and pedagogical applications.
- Increasing the resources available for faculty training so that they can acquire, adapt, maintain, and update educational technologies, including computers, CD-ROMs, and Internet access, for classroom and laboratory use. The appropriate use of educational technology should enhance, rather than supplant, the laboratory experience.
- Establishing and maintaining the growth of on-line library resources and information retrieval services, which will permit access to current developments in chemistry at all campuses within a given college system.
- Making funds available to needy institutions to support consultant review of their chemistry programs to improve chemistry instruction.

III. Curricula

Two-year colleges accommodate a large, diverse population of students who enter with varying educational backgrounds. As home to many “nontraditional” students, including older and working students, two-year colleges need to maintain flexible schedules and multiple levels of introductory chemistry. To meet the special needs of students in two-year colleges, ACS supports:

- Developing, through consensus building, articulation agreements and other mechanisms at the local, regional, and statewide levels to facilitate the efficient transfer of students between two- and four-year institutions.
- Improving articulation between high schools and two-year colleges for both college-transfer courses and technician or other terminal degree programs. This can be best accomplished through local alliances, “tech prep” initiatives, and similar activities that help increase the level of mutual understanding between two-year colleges and secondary schools. It is critical that articulation ensure that students transferring from two-year colleges can compete effectively at the four-year college/university level.
- Using alternative approaches to teaching and appropriate assessment of introductory chemistry tailored to the specific needs of students, especially under-prepared students, groups under-represented in the sciences, working students, older students, non-science majors, and students preparing for the technician fields. All such approaches must include a strong laboratory component as described in *ACS Guidelines for Chemistry in Two-Year Colleges*.
- Integrating into the laboratory curriculum concepts of environmental protection (including green chemistry) and laboratory safety.
- Integrating coverage of scientific ethics into the curriculum.

- Ensuring that continuing education courses for elementary and secondary school teachers provided by two- and four-year institutions are equivalent and receive similar recognition by the school districts.
- Developing programs of content review and pedagogy to involve mid-career and retired scientists in the service of science, engineering, and technology education (see also Secondary Schools).
- Providing programs to heighten the public understanding of science targeted not only toward students, but also toward the public at large.

IV. Undergraduate Research

Research can provide significant and stimulating experiences within the undergraduate curriculum and may influence career choices. To support a high-quality experience in the experimental component of the curricula at all levels, ACS recommends:

- Expanding available funding for undergraduate research to summer as well as academic-year projects, to support the involvement of as many chemistry majors as possible in research, at as early a stage as feasible.
- Recognizing that creditable research can involve work other than classical laboratory projects, including, for example, research in chemistry education. This would be appropriate for those who already have a strong basis in the discipline and plan to pursue a career in teaching.
- Developing opportunities for undergraduate students to participate in external experiential research programs.

V. Under-represented Populations

A number of groups are under-represented in science, engineering, and technology careers. These include women, African Americans, Native Americans, Hispanics, and persons with disabilities. Proportionately more minorities are enrolled in two-year institutions than in four-year institutions. To ensure that all under-represented groups have access to careers in science, engineering, and technology, ACS urges:

- Targeting public funds to develop, within two-year colleges, model projects and activities designed to attract and retain students from under-represented groups in the science disciplines. This will involve interactions with local pre-high and secondary school systems as well as four-year institutions, the wider public, and local business and industry.
- Developing incentives to foster the establishment of active partnerships between two-year colleges and surrounding schools, to identify at risk youth, and to provide them with enrichment programs to facilitate their transfer into four-year institutions.
- Providing incentives to foster partnerships with employers for the training and retraining of the community's workforce.

FOUR-YEAR COLLEGES AND UNIVERSITIES

The study of chemistry is central to an understanding of the natural world and is essential for understanding a range of sciences other than classical chemistry and biochemistry. Advances in biotechnology, materials science, and engineering, as well as the applied sciences such as health care, nutrition, aviation, and environmental studies, have expanded the borders of chemistry. It has never been more important that chemistry be taken by all undergraduates to complete a liberal education or to begin a lifelong study. Thus, faculty must get involved in curriculum innovation that will excite and stimulate a broad spectrum of students, recognizing the importance of a multi-disciplinary approach to chemistry, the enabling science, while still maintaining the rigor of the discipline.

I. Faculty Development

Undergraduate faculty members need an understanding of both modern chemistry and new pedagogical techniques to ensure that students are exposed to the most stimulating and effective learning environments. Guidance and mentoring are an important aspect of the overall instructional mission. Institutional recognition and rewards for these kinds of professional activities must be a part of faculty evaluation. To encourage high-quality teaching in four-year colleges and universities, ACS supports:

- Developing tangible institutional rewards for high-quality undergraduate instruction. Current rewards for instruction have too little impact on faculty prestige, particularly at research universities.
- Requiring professional development programs for teaching assistants and new faculty. These programs should include assignment of a mentor, frequent (at least quarterly) performance feedback from the appropriate senior faculty member(s), and preparation of a development plan. The focus should be on improvement and development rather than weeding out.
- Providing support, through institutional and outside funding, for continuing faculty development, including appropriate professional development for temporary, adjunct, and part-time faculty. This should include providing faculty with the tools necessary to address assessment issues related to student learning outcomes, faculty effectiveness, and the curriculum.
- Developing policies to promote a balance between teaching and research activities, including research in chemistry education. Possible programs include the funding of joint research and teaching activities, or supporting young scholar-educators as post-doctoral students and new faculty members.
- Providing opportunities for faculty development in industry and in government agencies, and integrating those experiences into the curriculum. Since the majority of baccalaureate and doctoral students will be employed by industry, faculty need a broad exposure to chemistry in an industrial setting to prepare their students for the workplace.
- Ensuring that those part-time, adjunct, and temporary faculty members receive reasonable compensation, including benefits outlined in the *ACS Academic Professional Guidelines* and opportunities to participate in activities that foster continued professional growth.

II. Curricula

Curricula must be thoughtfully designed for the intended audience of students, which may include chemistry majors, other science majors, applied science majors, or non-science majors. The course content must reflect the breadth and vitality of chemistry—the central and enabling science. The pedagogy employed must utilize knowledge from cognitive science research on how students best learn chemistry. To support high-quality curricula in colleges and universities, ACS recommends:

- Adopting the most appropriate pedagogical and assessment techniques to enhance and evaluate student learning.
- Modifying and developing current courses to reflect modern chemistry and cutting-edge developments in our broadening discipline. This should include industrial and business components within courses since most chemistry graduates will enter business and industry.
- Reflecting the interdisciplinary character of chemistry within all courses, as the centrality of chemistry provides a valuable basis for understanding other areas of study.
- Integrating oral, written, and other appropriate methods of communication, as well as information management and retrieval technologies into all aspects of the curricula.
- Integrating within the laboratory component concepts of environmental protection (including green chemistry) and laboratory safety.
- Integrating coverage of scientific ethics into the curriculum.
- Developing courses for non-science majors, strong in content and high in appeal to the non-major, to reflect the relevance of science to solving social problems, and the science knowledge needs of the general population.
- Developing degree programs in chemistry for those who will become pre-college teachers. Teachers in the K–12 sector must be educated in both basic science principles and pedagogy. A well-designed chemistry education program would permit students to acquire the necessary science and educational background within a four-year degree program. The ACS Committee on Professional Training has defined one such program through its offering of an ACS-approved degree in chemistry/chemistry education, and now also offers a minor in chemistry education.
- Ensuring that students' course articulation between two- and four-year colleges can be accomplished with a minimum of disruption and time loss, and without sacrificing academic credit.

- Developing asynchronous programs, for example, Internet based distance learning) to serve those unable to participate in regular campus courses. Education must be available to those who wish to benefit from it, even when they are not able to attend a traditional college campus.
- Providing funding to faculty for curricular development, implementation, and assessment.

III. Facilities and Instrumentation

New or remodeled facilities provide the basis for the most effective learning, which includes modern technology and the latest in safety considerations. Modern instrumentation is required to expose students to the methods and equipment that they will use as working chemists and to carry out meaningful undergraduate laboratory research. To ensure the necessary physical infrastructure for modern chemistry instruction, ACS supports:

- Increasing funds for the construction of new, and remodeling of existing, chemistry facilities.
- Increasing the availability of funds to provide undergraduate instructional courses and research laboratories with modern equipment, maintain that equipment, and train faculty in their use and pedagogical applications.
- Designing new laboratory experiences that include the use of appropriate instrumentation, even at the freshman level. While it is important to use sophisticated instrumentation relevant to the instructional goals of a given laboratory course, the development and use of cost-effective instrumentation may also be pedagogically sound.
- Including the use of modern computer equipment and appropriate Internet access in the lecture and laboratory curricula. Computer simulation of experimentation must be used as a supplement to and extension of, not as a replacement for, hands-on experiences in chemistry.
- Developing partnerships between colleges and local industry, government, and other organizations to maximize utilization and availability of sophisticated instrumentation.

IV. Undergraduate Research and Experiential Learning Opportunities

Research can provide significant and stimulating experiences within the undergraduate curriculum and may influence career choices. To support a high-quality experience in the experimental component of the curricula at all levels, ACS recommends:

- Expanding available funding for undergraduate research to summer as well as academic-year projects, to support the involvement of as many chemistry majors as possible in research, at as early a stage as feasible.
- Developing programs that allow majors in other sciences and non-science majors to experience first-hand research in the chemical sciences.
- Recognizing that creditable research can involve work other than classical laboratory projects, including, for example, research in chemistry education. This would be appropriate for those who already have a strong basis in the discipline and plan to pursue a career in teaching.
- Developing opportunities for undergraduate students to participate in external experiential research programs, as well as the understanding by students that this is a valuable and important part of their educational experience.

V. Under-represented Populations

A major resource of our country is the talent of our citizens. Every effort must be made to encourage and provide opportunities for the education of all those who are qualified and willing to benefit from this experience. To support the maximum use of our personnel resources, ACS recommends:

- Developing and supporting programs designed to attract and retain women, African Americans, Native Americans, Hispanics, and disabled students into undergraduate programs in chemistry. Many in these groups are unaware of career options in chemistry and of funding opportunities for undergraduate and graduate study in chemistry.
- Providing connections for these students to work with the community and local schools to bring the message of the excitement of science and career opportunities to their populations.

- Providing guidance and support for newly hired faculty from under-represented groups. These faculty members are often under special pressure in their early academic years since they are often serving as mentors themselves.

POST BACCALAUREATE EDUCATION

Post baccalaureate (graduate) education in the chemical sciences includes the doctoral and Master's level of formal education and, for some, a subsequent postdoctoral experience. There is strong support that graduate education, particularly at the doctoral level, continues to stress original research as the basis of the graduate experience. In addition to the problem solving skills students develop through focused research, they should be encouraged to recognize the broader applicability of these skills, particularly with respect to the interdisciplinarity of science, and topics such as economics, management, ethics, and oral and written communication. Mentoring by the graduate faculty must be an integral part of the education sequence. Recruiting to attract and retain under-represented populations will provide the broadest possible resource of professional chemists. The diverse objectives of programs at the post-baccalaureate level call for caution in prescribing educational practices, but with this caveat, the ACS recommends:

- Ensuring that graduate education at the doctoral level continue to provide students with the opportunity to engage in creative research, pure or applied, in the chemical sciences.
- Broadening the graduate experience to include more specific training in, for example, communication, ethics, safety, and functioning in team and multidisciplinary projects.
- Providing mentoring and career guidance programs for students throughout their graduate experience.
- Expanding funding for graduate student support through traineeships and fellowships, in addition to direct faculty research funding.
- Developing special programs to recruit and retain under-represented minorities and women in graduate school.
- Encouraging federal and State support to improve the infrastructure for graduate chemistry education through grants for instrumentation, as well as funds for building new, and remodeling existing, facilities.
- Providing incentives for industry to contribute research support to colleges and universities and to develop university—industry research partnerships. The participation of industry in graduate education can enhance the interactions between these two sectors and provide enhanced employment opportunities for students.
- Recognizing that a variety of approaches to research support can encourage greater creativity, a healthy balance between individual investigator grants, small and large group grants, and research centers should be maintained.
- Developing opportunities for graduate students to participate in external experiential programs in government and industry.
- Developing opportunities that include appropriate pedagogical components and practice for those students who will become college and university faculty.
- Promoting programs for professional Master's degrees, including professional degrees such as for those who are, or will become, teachers.
- Ensuring that graduate teaching assistants and postdoctoral fellows are accorded appropriate compensation and recognition as outlined in *ACS Academic Professional Guidelines*.

CONTINUING EDUCATION

The strong technology base of the United States economy depends on the continuing education of its entire workforce, including those currently under-represented in chemistry such as women, African Americans, Native Americans, Hispanics, and persons with disabilities. ACS recommends:

- Establishing tax incentives to encourage individuals to enhance their technical competence through continuing education.
- Developing and supporting programs to reach segments of the workforce that do not have access to classical education institutions. This might include de-

veloping courses and instruction at industrial sites or finding other ways to reach a broad audience.

- Tailoring the content and scheduling of appropriate chemistry courses to the continuing education needs of the local workforce.
- Encouraging the direct participation of the industrial sector in continuing education in chemistry.
- Designing programs to retrain individuals whose livelihoods have been disrupted by the economic restructuring and outsourcing of business and industry.