NSB-05-41
Approved March 30, 2005

Committee on Education and Human Resources
Workshop on Engineering Workforce Issues and Engineering Education: What are the Linkages?

Purpose
An initial, single day NSB-sponsored workshop is proposed to focus on recent recommendations for changes in engineering education and implications for the engineering workforce. A foundation for workshop discussions will include the cross cutting issues in the recent National Academy of Engineering report, *The Engineer of 2020: Visions of Engineering in the New Century,* as well as the NSB reports that identified troublesome trends in the number of domestic engineering students, with potential impacts to U.S. preeminence in S&E based innovation and discovery. The major workshop objective is to move the national conversation on these issues forward in a productive way by calling attention to how engineering education must change in light of the changing workforce demographics and needs. The National Academy of Engineering (NAE), which sponsored the Engineer of 2020 study, has undertaken a Phase II study. The proposed NSB workshop would be in parallel to these NAE efforts. The NSB workshop would focus more substantially on the issues of the current and desired future engineering workforce in light of the Engineer of 2020 report.

Statutory basis
NATIONAL SCIENCE BOARD (42 U.S.C. Section 1863) SEC. 4 (j) (2) The Board shall render to the President for submission to the Congress reports on specific, individual policy matters related to science and engineering and education in science and engineering, as the Board, the President, or the Congress determines the need for such reports.

Link to National or NSF Policy Objective
It is widely recognized that our economy, national security, and indeed our everyday lives are increasingly dependent on scientific and technical innovation. Changes on a global scale are rapidly occurring for engineering, and Federal leadership is needed to respond quickly and informatively. The Board has issued several reports expressing concern about long-term trends that affect the U.S. workforce capabilities in engineering, including the dependence on international students and workers; the declining interest on the part of U.S. citizens in engineering studies and careers; weakness in the K-12 science, technology, engineering, and mathematics education system; and demographic trends that are unfavorable to increasing citizen participation rates in these fields. Engineers are the largest component of workers with college degrees in S&E occupations, with 39 percent of all S&E occupations in 1999. Almost half of S&Es in the labor force with bachelors' degrees as their highest-level degree are engineers. This field therefore has a huge impact on our national capabilities for S&T and deserves special attention.

There is a current high level of attention to engineering education from a variety of sources that converge to make engineering education an especially timely topic for the Board to address. These include the recent release of the National Academy of Engineering report, *The Engineer of 2020: Visions of Engineering in the New Century*, which calls for reform in engineering education; the National Science Board reports on unfavorable trends affecting long-term U.S. workforce capabilities in science and engineering and the need to address these trends along all points of the education pipeline; the concern of U.S. industry and the public sector in engineering capabilities in the workforce; and the poor progress in broadening participation in engineering.

Logistics
The NSB Office will be the focal point for providing all aspects of Board support in this NSB activity; coordinating NSF, other agencies and institutions involvement; and utilization of one or more NSB Office contractual agreement(s) to assist with meeting logistics. NSB/EHR will recommend full Board approval of the appointment of an *ad hoc* Task Group of EHR to provide oversight for, and actively engage in, this activity.

An agenda and a comprehensive list of potential participants in the event will be developed with input from Board Members, NSF management, contacts in other agencies, and the broader S&T research and industry community. Invitees would include young recently graduated engineers, more experienced engineers, a range of employers (spanning the range of engineering disciplines), university thought leaders on engineering, and experts on engineering demographics.

Timing: Fall/Winter 2005

Workshop Topics: A workshop on the linkages between workforce issues and engineering education would involve a large range of topics, such as:

1. What are different scenarios for engineering workforce development in the U.S.? What are the differences among engineering fields?
2. How successful have we been in predicting the engineering workforce needs in the past and what has happened to the engineers when we got it wrong?
3. What are the implications of the different scenarios for engineering education?
4. What are the roles of the different stakeholders in the development of the engineering workforce, particularly the professional societies, universities, working engineers (of differing ages) and employers?
5. What is a typical demographic for an engineer today, and what will it become? How do we broaden participation?
6. The past and future role of international students and engineers in the U.S. engineering workforce.
7. The changing role of engineering education in preparing for engineering workforce needs for the future, including graduate education and lifelong learning as career shifts occur, and the idea that engineering education might be to prepare students more broadly for employment in the public, nonprofit, academic, and industry sectors.
8. How do we ensure that the best and the brightest students pursue engineering studies and careers, and that their education quality, content, and teaching are of the highest caliber?

Workshop Product: The final output from the meeting will be a concise set of Board approved recommendations that tie back to what universities (with employers) and NSF can affect, published in paper and electronic formats.

Audiences: In addition to the President, Congress, and NSF:

- Engineering deans/departments/schools
- ABET
- Engineering thought leaders

Leaders in technical industry and the public sector that employ engineers.

Moving Forward to Improve Engineering Education

Workplan for a National Science Board Sponsored Workshop on Engineering Education November 7, 2006

With the support of the National Science Board (the Board) Committee on Education and Human Resources (EHR), the ad hoc group composed of Drs. G. Wayne Clough, Daniel E. Hastings, and Louis J. Lanzerotti have moved forward with plans for a second engineering education workshop to follow-up on the workshop held October 20, 2006 at MIT, entitled: Engineering Workforce Issues and Engineering Education: What are the Linkages? This follow-up workshop, scheduled for November 7, 2006 at Georgia Institute of Technology, will engage leading deans of engineering and elaborate on the issues raised at MIT, and examine how programs and activities at the National Science Foundation (NSF) may specifically address the issues raised by the National Academy of Engineering (NAE) Educating the Engineer of 2020 report.

NSF is an important leadership agency for engineering education and needs to respond to pressing issues, including retention rates, the educational experience of engineering students, international education and workforce issues, the current perception of engineering, the faculty of the future, and the perspective of industry.

- Retention Rates: What is the role of the Foundation in understanding the issues associated with retention of students who enter universities to study engineering and in developing approaches to address these challenges?
- Educational Experience: What is the best way to create an educational experience for an engineering student that will allow for more well rounded graduates who have skill sets that will allow them to compete in a "flat world" economy? How may co-op and internship programs, student professional societies, volunteer activities, student government, and/or study abroad programs contribute to the educational experience of engineering students? Is there a unique role for NSF in supporting the efforts of colleges and universities to enhance the educational experience of engineering students?
- International Perspective: In a broad sense, what do the data on international engineering schools and graduates mean for American engineering programs, research, and careers? How can NSF further develop cooperative research and joint programs between American and international universities?
- Engineering Perceptions: What can NSF contribute to an understanding of the societal trends and industrial practices that may discourage students from pursuing engineering?
- Engineering Faculty: What is the role of the Foundation in preparing the faculty of the future, particularly given the need to educate engineering students more broadly and to address the challenges caused by rapid changes in technology?
- Industrial Perspective: How can the Foundation facilitate the consideration of the perspective of industry, and to encourage the support of industry, for innovative approaches to engineering education?

To prepare for this second activity, the *ad hoc* engineering education group will meet with NAE President, Dr. William A. Wulf, in August to discuss what the Academy plans to do following the Engineer of 2020 activity. The *ad hoc* group will also meet with the leadership of the NSF Engineering Directorate in an informal roundtable discussion in August to discuss NSF's current and potential role in engineering education and consider possible issues for discussion at the fall workshop.

After this second workshop, the engineering education group plans to submit a draft report of both workshops, which could potentially be submitted to the full Board to consider issuing some recommendations to guide engineering education reform.

Cover Captions and Credits

1. Computational Fluid Dynamics

This graphic depicts the turbulent instability dynamics of large fire plumes, which have been modeled by Paul DesJardin, Department of Mechanical and Aerospace Engineering, on the University at Buffalo's Center for Computational Research (CCR) computers using Large Eddy Simulation techniques. The research was supported by an NSF Career Award to Professor DesJardin. Instability dynamics are responsible for the unsteady heat transfer in fire environments, which have been observed experimentally. The mesh superimposed on the bottom of the plume is the underlying computational grid utilized to carry out the calculation. An improved understanding of instability dynamics will result in more accurate predictions of fire intensity and growth.

Credit: Paul DesJardin, Department of Mechanical and Aerospace Engineering, University at Buffalo; visualization by Adam Koniak, CCR, University at Buffalo

2. Systems-on-a-Chip for Powerful Prostheses

A novel, mixed-signal system on a chip as a platform for implantable prosthetic devices, developed at the University of Southern California's Center for Biomimetic MicroElectronic Systems (BMES) Engineering Research Center (ERC). Researchers at BMES ERC, an NSF centers program, are developing entire platforms for a range of implantable devices that could one day restore vision to the blind, reanimate paralyzed limbs, and overcome certain cognitive impairments.

Credit: University of Southern California, BMES ERC

3. PIE Institute

A "Playful Invention and Exploration (PIE) Institute" Mindfest visitor constructs automata using gears, Legos, found materials, and a Cricket computer. The PIE Institute is a 3-year project designed to increase the capacity of museum educators and exhibitors to design and implement technology-integrated inquiry activities for the public. The collaborators include the San Francisco Exploratorium, the Massachusetts Institute of Technology Media Lab, the Science Museum of Minnesota, the Fort Worth Museum of Science and History, and the Explora Science Center and the Children's Museum of Albuquerque. Participating centers and museums will receive technology-rich activities, professional development institutes, online educator resources, and a handbook of pedagogical design principles for museum educators. The project builds upon prior NSF-supported work that developed the PIE Network, which among other things developed the "cricket," an inexpensive computer that makes informal learning inquiry activities more compelling.

Credit: Karen Wilkinson, Exploratorium, San Francisco

4. BMES REU Program

Research Experiences for Undergraduates 2004 participant, Brittney Perry, at the Biomimetic MicroElectronic Systems (MBES) Engineering Research Center (ERC), with mentor Ashish Ahuja, is shown working in Armand Tanguay's laboratory at the University of Southern California, Los Angeles. BMES ERC offers a summer program for undergraduate students funded by NSF that allows students to contribute to the development of novel biomimetic microelectronic systems based on fundamental principles of biology in one of three testbeds: retinal prosthesis, neuromuscular prosthesis, and cortical prosthesis. BMES ERC invites talented undergraduates to participate in active research projects and work alongside world-renowned researchers and students.

Credit: University of Southern California, BMES ERC

5. Mixing of Fluorescent Dye in Stirred Tank Reactor

A fluorescent dye injected into a tank of stirred liquid creates a pattern that resembles a green apple. The demonstration, conducted by Rutgers University researchers from the NSF Engineering Research Center on Structured Organic Composites (C-SOC) shows how liquids mix in a typical pharmaceutical manufacturing operation. Engineers will use such studies to help drug makers improve product uniformity. In this view, a four-blade impeller attached at the bottom of the vertical shaft, visible at the center of the image, draws fluid from above and creates outgoing ripples in the flow. Dye injected from above is rapidly advected around a toroidal shell, but penetrates slowly into the interior: this separation between the outside and the inside of mixing regions represents a bottleneck to processing and a challenge to the generation of reproducible product uniformity. The NSF Engineering Research Centers (ERC) program established C-SOC to study the nature of finely ground granular materials and other substances that form the core of drug tablets, processed foods, agricultural chemicals, and other "composite organic" products. In addition to improving the quality and consistency of such materials, the center will develop more consistent and cost-effective manufacturing techniques than methods based largely on trial and error.

Credit: M. M. Alvarez, T. Shinbrot, F. J. Muzzio, Rutgers University, Center for Structured Organic Composites

6. "Torus II"

This image, from the Eric J. Heller Gallery, is a three-dimensional image (plotted in two dimensions) of a four-dimensional object. When classical motion of particles is not chaotic, it is integrable; it can be confined to the surface of donut-shaped objects or "tori," which live in four or more dimensions. The torus appears to intersect itself, because the viewer pretends it exists in three dimensions. In the four-dimension space, it does not intersect. The surface of the torus was made partially transparent to reveal the structure within. Heller's work was included in the exhibit "Approaching Chaos," shown at NSF, as part of "The Art of Science Project."

Credit: Eric J. Heller, Harvard University

7. Robotics Competition

Students from "McKinley Robotics - Team Kika Mana" at President William McKinley High School in Honolulu, Hawaii. Pictured from left to right are: Iat Ieong (co-captain), Jinny Park (co-captain), Calvin Ing, and James Park. The robot is "Hot Lava," and was part of the 2007 Robotics Competition called "Rack 'n Roll."

Credit: National Science Board Office

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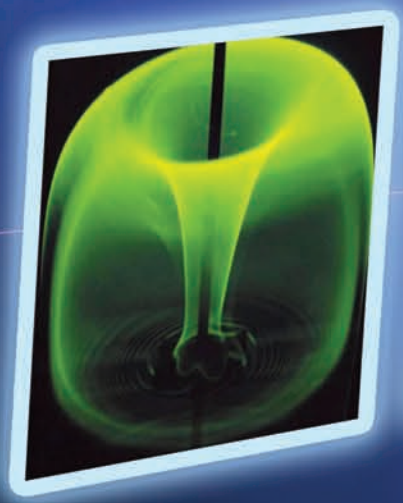
Obtaining the Board Report

The report is available electronically at:
http://www.nsf.gov/pubs/2007/nsb07122/index.jsp

Paper copies of the report can be ordered by submitting a Web-based order form at:
http://www.nsf.gov/publications/orderpub.jsp or contacting NSF Publications at 703-292-7827.

Other options for obtaining the documents: TTY: 800-281-8749; FIRS: 800-877-8339.

For special orders or additional information, contact the National Science Board Office:
NSBOffice@nsf.gov or 703-292-7000.



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