A National Science Board-Sponsored Workshop

Moving Forward to Improve Engineering Education

November 7, 2006
The Georgia Institute of Technology

Summary Notes

The following summary notes of the discussions and presentations reflect the views and opinions of the participants and not necessarily the positions of the National Science Board.

A National Science Board-Sponsored Workshop

Moving Forward to Improve Engineering Education

Introduction

This report summarizes the key themes and suggestions resulting from the National Science Board (the Board)-sponsored workshop *Moving Forward to Improve Engineering Education*, held November 7, 2006 at the Georgia Institute of Technology (Georgia Tech). The 2006 Workshop followed the *initial* workshop held October 20, 2006 at the Massachusetts Institute of Technology (MIT), entitled: *Engineering Workforce Issues and Engineering Education: What are the Linkages?* The 2006 Workshop engaged leading deans of engineering in elaborating on the issues and conclusions raised at MIT, and examined how programs and activities at the National Science Foundation (NSF) may specifically address the issues raised by the National Academy of Engineering (NAE) report, *Educating the Engineer of 2020.*[2]

The special focus of the second workshop on the role of NSF for engineering education addressed pressing issues in engineering education that included:

- Retention rates for students who enter universities to study engineering.
- Educational experience for engineering students that will prepare more well-rounded graduates who have skill sets to compete in a "flat world" economy.
- What the data on international engineering schools and graduates mean for American engineering programs, research, and careers, and how NSF can further develop cooperative research and joint programs between American and international universities.
- What NSF can contribute to an understanding of the social perceptions, the societal trends, and industrial practices that may discourage students from pursuing engineering.
- 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.
- How the Foundation can facilitate the perspectives of industry in engineering education and encourage the support of industry for innovative approaches to engineering education.

To prepare for this second Workshop, Board Members met with NAE President, Dr. William A. Wulf, in August 2006 to discuss and understand NAE plans for following up on the Engineer of 2020 activity. The NAE will focus on the hard issues of curriculum reform across engineering education. It was agreed that the NSB can contribute with the NAE to a "tipping point" in engineering education by focusing on complimentary issues. Board Members also met with the leadership of the NSF Engineering Directorate in August to discuss NSF's current and potential role in engineering education and to consider possible issues for discussion at the workshop.

Key Themes

Several key themes emerged at the Georgia Tech workshop. First, NSF has made substantial investment in programs to improve engineering education over the last 2 decades, but these investments have been small relative to the overall scope of the challenge. There have been many successful programs and substantial local change, but not systematic change.

[2] *The Engineer of 2020: Visions of Engineering in the New Century, and Educating the Engineer of 2020: Adapting Engineering Education to the New Century.*

Second, retention of students in engineering, especially in the first year, is a critical issue. Many groups are analyzing the issue and trying to address it. It is necessary to approach the retention issue as a systems problem. That is, one has to include the pipeline as well as the cultural perceptions of engineering, from scientists to the public. The pre-college preparation of entering students affects retention, as does the difficulty of the engineering curriculum relative to other academic tracks especially relative to the perceived value. Some steps to improve engineering retention in the first year may make it more difficult for students to transfer into engineering in their second or third year. Differential minority retention is a problem requiring special attention. There are no simple solutions and hard work is needed in several areas, but a variety of approaches and NSF programs can help.

Third, there are many examples of programs in engineering schools that make engineering more attractive to students and provide the broader education (including international experience, engineering practice, leadership, and service) that is needed. A barrier is the limited amount of faculty time and faculty culture. Adjustments in the reward system for faculty and other changes, such as greater involvement of industrial fellows or greater support staff, can help.

Fourth, the problems regarding the perception – or misperception – of engineering are very serious. The public perception of engineering must change in order to attract more students to engineering. Over the last 20 years, medicine and law have wrestled with changing the public attitudes toward these fields and in attracting women and underrepresented minorities to pursue degrees and careers in these fields. Similar changes need to occur in engineering, but much hard work will be required to convey the proper image and value of engineering to students, parents, guidance counselors, and others.

The following sections summarize the key points that were made with respect to each of these themes.

Summary of Key Points and Suggestions

Review of Previous and Current National Science Foundation Programs

NSF has supported a wide range of activities that contribute to engineering education. These include:

- Engineering Education Coalitions focused on broad reforms. Coalition members obtained local improvements, such as improved retention rates for first-year students and underrepresented groups. The coalitions, however, did not lead to the comprehensive and systematic new models for engineering reform that were expected.
- Engineering's department-level reform program supported departments to comprehensively reform curricula.
- Investments in curriculum improvement, with both planning and implementation grants.
- Engineering Research Centers, leading to many new degree programs and curricula, and to graduates whom companies recognize as better prepared for the practice of engineering.
- Model Institutions of Excellence focused on increasing the number of undergraduate minorities graduating in all areas of science, math, and engineering. The program has increased grade point averages (GPAs) and graduation rates of minority students.
- Centers for Teaching and Learning address learning and teaching across the fields of science, math, and engineering, and how to prepare future faculty.
- Graduate Fellowships and Traineeships include a variety of different fellowships and training programs, including Integrative Graduate Education and Research Traineeship (IGERT), Graduate Teaching Fellows in K-12 Education (GK-12), and Graduate Research Fellowships.
- Research Experiences for Undergraduates (REU) encourages U.S. students to pursue doctoral studies by engaging them in research activities as undergraduates. Studies have shown that REU experiences increase interest in science, technology, engineering, and mathematics (STEM) careers.

- Research Experiences of Teachers (RET) supports K-12 teachers and community college faculty to be involved in research activities at universities. Studies indicate that RET experiences increase teacher motivation and confidence in teaching math and science, and that teachers gain a better understanding of engineering.

In summary, NSF has made significant investments in activities related to engineering education, and many of these programs show positive results and change at institutions. However, the complexity of the system does not allow for quick and easy solutions. Still, greater success is needed to increase U.S. citizen participation in engineering studies and careers.

Retention

There was widespread agreement among workshop participants that retention of engineering students is a key issue. There is substantial attrition in engineering, especially in the first year. Most of the students who leave engineering continue in college but change their major. Attrition is higher among women and traditionally underrepresented minorities.

Reasons Why Engineering Students Leave

Some of the students who leave engineering are among the best students, with high grades. That is, it is not the case in general that students who leave engineering could not have made it. Those with high verbal SATs are more likely to leave than those with lower verbal scores, perhaps because they have more options. Also, women with good grades drop out at a higher rate than men. There are many reasons why students drop out of engineering. Some of the key reasons discussed at the workshop are:

- Poor teaching – which when combined with a lack of exposure to engineering in the first and second years can lead to discouragement and departure from engineering.
- Poor performance in the first math courses.
- Poor advising from faculty who see their role as weeding people out of engineering.
- Lack of connection between what students study and what they perceive as exciting engineering practice.
- Fear that engineering jobs may disappear in the United States due to offshore outsourcing.
- Perception that friends in other majors are having easier classes and more fun.
- Coursework too restrictive for students' more varied interests.
- Lack of a comfortable social environment in engineering classes.
- Perception of engineering as a competitive and uncaring field.
- Lack of role models, especially for women and underrepresented minority engineers. Many students see women and underrepresented minority faculty as overworked because of the challenges they face as pioneers. Thus, students do not find models of what they want to be.
- Rising cost of education – tuition, fees, room and board – which has a disproportionate impact on students from low income families.
- A feeling of isolation from the rest of the university due to amount of the workload. Engineering students without cross-disciplinary education may not see themselves as part of the university.

Participants in discussion of these issues recognized the need for caution in interpreting the reasons that students give for leaving engineering. For example, poor math performance has diverse causes. Some students are under-prepared when they enter college. Others are rusty in their basic math skills because they take advanced math earlier in high school, and may not take math in their last year of high school. Some students are overconfident, and are either placed in a college math course that is too advanced or skip classes because they think they know the math. Students may not be willing to admit they are leaving because they do not have the talent for engineering or do not want to work hard. Students do not perceive the value of working hard in engineering classes.

Programs That Improve Retention

Getting students through the first year is critical. To do this, it is important to approach retention as a systems problem. Addressing the issue requires starting with students before they come to campus and then engaging the whole university.

A major strategy for improving retention is to design a curriculum that offers the excitement and relevance of engineering early in the student's experience and, therefore, accelerates the student's ability to identify with the profession of engineering. There are many successful approaches:

- Moving design and systems courses and practical engineering laboratories earlier in the curriculum rather than waiting until the junior or senior year, by which time many students have already left engineering. This of course means changes in the traditional cumulative practice of engineering education.
- Offering a socially relevant curriculum that emphasizes service learning; a strategy especially attractive to underrepresented groups and women.
- Providing a first-year seminar on what engineering is, with examples from each discipline and discussions of engineering problems and applications led by invited engineering practitioners.
- Having a weekly symposium with speakers from industry.
- Inviting industry partners to work on team projects.
- Developing multi-year team-based projects that involve participants from other disciplines (sciences, humanities, social sciences).
- Working with math and physics professors to add engineering context to math and physics courses.
- Introducing undergraduate research experience as early as possible to students.
- Financial aid for students who have demonstrated need.
- Cooperative education.
- Intervention programs that address academic preparation and performance issues.

To address the problems associated with poor math preparation, it is important to do early assessment in math courses and to make available extra resources for students who need them – the University of Texas, El Paso (UTEP) was mentioned as a model, including math diagnostics, remediation, and clustering students in classes and study groups. It was noted that a successful strategy in computer programming separates students with no prior programming background from those with extensive programming background.

Workshop participants emphasized the importance of working with other units in the university to improve the educational and social environment for engineering. The sciences are responsible for teaching many of the fundamental courses in the engineering curriculum; interaction between faculty in engineering and faculty in the arts and social sciences can help put engineering in a social or business context. In addition, it is important that engineering students do not become isolated from the rest of the university. They need exposure to different disciplines to help them decide their major and career path or to give them the necessary career clarity.

To address issues of affordability, more need-based scholarships were considered necessary. Moreover, universities should develop and maintain good partnerships with community colleges to ensure their courses provide the right preparation for engineering. Two-year colleges provide a pathway for less affluent students to enter engineering and can help increase minority participation in engineering. Transfer students from community colleges have a good record of completing degrees after transferring to an engineering school.

Flexibility in the curriculum is important for people to transfer into engineering after the freshman year. It was cautioned that if more engineering courses are moved into the first and second years of a university engineering program, it might be more difficult for transferring students, either from community colleges or from other majors.

Diverse role models and mentoring have been effective in improving retention. Student organizations can play a part by bringing in role models as speakers or mentors. Peer-to-peer advising (pairing upper division students with new students) also has been especially helpful.

Research experiences too can help improve retention; it would be beneficial to provide more exposure to research in the earlier years. Research experiences expose students to the challenge of solving ambiguous problems in a setting where they interact with a faculty member.

The Educational Experience of Engineering Students

Workshop participants described a wide range of programs that enhance the educational experiences of students, especially with regard to preparing students for the "flat world paradigm" in which the research, design, and production of goods and services are often sourced around the world in response to market forces. These programs are intended to prepare engineering students to be aware of the world, technically grounded, creative, innovative, and versatile; to develop leadership skills; and to work effectively in teams.

Approaches

Since traditional curricula are so full, it is difficult to add traditional courses to the curriculum. Thus it may be necessary instead to integrate experiences throughout the curriculum and extracurricular activities. Experiential learning can take place in many forms (in the curriculum, non-curricular activities, coop programs, and internships); can motivate student learning in the fundamentals; and can create opportunities to bring design and analysis together, rather than segregating design and analysis. There is also a need to create long-term experiences, such as projects that span years and make connections between different skills and applications. Students working on open-ended projects under expert mentoring will learn unanticipated things. Another topic is how to modify the educational experience to provide global educational opportunities.

Participants identified a range of programs or extracurricular activities to provide international experiences:

- Study abroad programs, which are increasingly recognized as valuable for engineering.
- Classes with an international focus, such as an "engineering in China" seminar.
- A global design course, in which students interact on teams with students from other countries for a semester.
- A course on innovative design, entrepreneurship, and leadership, co-taught by industry practitioners, and involving cross-national teams with international clients.
- A global engineering internship program that places students in other countries for the summer.

Some programs change the traditional paradigm and put design at the center of the curriculum and applied science around the edge, rather than vice versa. Design courses serve to identify gaps in student knowledge and in the curriculum. Other programs emphasize service learning, such as volunteer leadership. One example is an engineering leadership development minor. Other programs focus on entrepreneurship. Some schools have an engineering entrepreneurship minor while others have entrepreneurship embedded throughout the curriculum and extracurricular activities. Kauffman Foundation programs in entrepreneurship provide examples of weaving entrepreneurship throughout the entire curriculum rather than narrowly embedding it in the business school.

Research experiences for undergraduates, including freshmen and sophomores, was also recognized as an effective program for getting students to understand the joys of engineering while broadening their education. These experiences also bring the students into contact with the faculty.

Professional societies, such as student chapters of the Institute of Electrical and Electronics Engineers, Inc. (IEEE), and other student activities are also important. They can build on relations with industry to provide lecturers, mentors, internships, and award programs.

Challenges

Participants identified a number of challenges for reform of engineering education. One challenge is assessment – how does one measure the learning that occurs in nontraditional settings where each student's experience is different? For example, how does one assure that leadership training is effective? Engineering schools may need to adopt a portfolio approach to assessment, which is common in the arts but not in engineering.

Another challenge relates to accreditation and professional engineering (PE) licensing. It is not possible to teach everything that students need to learn. A key issue is: What do students need to know, and what can be pared back to make room for new material? How will accrediting and licensing bodies view such changes? Professional engineering exams may need to be modified.

Concern was expressed about proposals to require additional credit hours beyond the BS degree before an individual can take the PE exam, with potential negative impacts on attracting students to engineering if certification requires a master's degree.

Another challenge is the increased burden that many of the activities for enriching the engineering education experience would place on faculty. Faculty members have a finite amount of time, and if they devote more time to these kinds of activities, what can get dropped from their workload? The issue is the culture of academic engineering which emphasizes research, teaching, and service, in that order. Workshop participants offered several suggestions for addressing the issue of faculty time:

- Get industry involved to provide advisors on a pro bono basis.
- Use engineers recently retired from industry as "Professors of Practice."
- Use upper-class students for assistance in classes and extracurricular activities.
- Hire facilitators/assistants to complete administrative work that faculty do not need to do.
- Conduct a review of how faculty spend their time to see if time can be freed up.
- Submit proposals for funding to do innovative things.
- Ask the college administration to define goals for each department, but let the department decide how to meet the goals – by distributing research, teaching, and service activities among the faculty, considering faculty members' interests and priorities at different stages of their careers.

Engineering Perceptions

Common Perceptions of Engineering

Engineering loses students because they cannot see themselves as engineers. There are major problems with the way engineering is perceived. Survey data indicate that the public associates engineers with economic growth and defense, but less so with social concerns such as improving health, the quality of life, or the environment. Outside of academic institutions**,** engineers are commonly perceived as nerds without personal skills, doing narrowly focused jobs that are prone to being outsourced. A recent widely circulated Dilbert cartoon emphasized the notion that engineers are without social skill. In addition, students do not understand or appreciate the use of an engineering education as a springboard into other fields.

High school girls believe engineering is just for people who love math and science, and just for guys. They do not have an understanding of what engineering is or show an interest in the field. At historically black colleges and universities (HBCUs), students see engineering as unfriendly, hard, difficult to afford, and requiring extra preparation. They may not see a direct benefit to their community and may believe that they would have to leave their community to succeed in an engineering career.

Such perceptions attract to engineering the people who are good in math and science and are interested in "things" rather than people, but not people with creativity who like to work with others on teams and who want to contribute to solving social problems. The current perceptions of engineering make it difficult to attract women and minority students, in particular, to the field. It has been shown, however, that when students learn more about engineering, especially its historical contributions as well as its social relevance, they react more positively about the field.

Solutions

Engineering needs a marketing facelift. There is a need to craft messages that will attract students, parents, counselors, and teachers. The messages should emphasize that engineers work in teams, create jobs and value, are global innovators and leaders, and start companies like Intel, Yahoo!, and Google as well as Boeing and Hewlett Packard. Engineering graduates succeed in many fields, from investment banking to medicine, and engineers will play a role in addressing the world's biggest problems, from global warming to poverty to nuclear proliferation. Engineers create cool devices like Xboxes and iPods. Opportunities to learn from business schools and medical schools were acknowledged. Business schools have a fully integrated project-based learning program. Both medical schools and business schools have succeeded in transforming their culture from 100 percent male to 50:50 male/female.

The NAE is supporting the development of themes to communicate the role, importance, and career potential of engineering to a variety of audiences. Some sample themes being tested include:

- Limitless imagination – engineers imagine things and see possibilities.
- Freedom to explore – engineers are never bored; they are constantly being challenged.
- Ideas in action.
- Life involves engineering, from medical equipment to safer water to microchips.

The messages should be targeted to specific fields. Concerns about offshore outsourcing mostly affect computer science. Some fields of engineering, such as bioengineering and environmental engineering, already attract many women, whereas other fields have a dearth of female engineering students.

Workshop participants offered a variety of concrete suggestions that could help improve the image of engineering:

- Work with the Nobel Prize committee to create a Nobel Prize for engineering. While there are existing large prizes for engineering (such as the NAE's Charles Stark Draper Prize), none as yet have the visibility of the Nobel Prizes or the Oscars.
- Work with Fortune 500 CEOs who are engineering graduates to put together ad campaigns that will affect both perceptions of the engineering community and their company.
- Support industry-community-university partnerships that inform pre-college students and parents about engineering. K-12 schools are a particularly important venue for changing the views of students about engineering. The Research Experiences for Teachers (RET) program can contribute much to changing perceptions.
- Have college engineering students do internships in K-12 that will provide role models for K-12 kids.
- Teach engineering in high school. The high school engineering curriculum developed through the Infinity project at Southern Michigan University (*http://vab.infinity-project.org/home.html*) and coursework developed by the Boston Museum of Science have been successful. Some concern was expressed, though, that high school engineering classes may not meet the current science requirements for entrance to college engineering courses.
- Develop more movies (e.g., "October Sky") and TV shows to present engineering in a positive light. Shows like "Pimp My Ride" on MTV provide ways to talk about engineering to students.
- Find spokespersons to whom high school students can relate.

Suggestions for NSF

The workshop generated a large number of specific suggestions for NSF. Many of these involved support for continuing and expanding existing programs. These include:

- Substantially expand the REU program to make it more available to college freshmen and sophomores, as well as to community college and even high school students. (A few REU sites are already open to college freshmen and sophomores and to community college students.)
- Explore expanding REU to include support from additional Federal agencies. There is already a partnership with the Department of Defense (DoD), which supports REU Sites in DoD-relevant research areas. This could be expanded to the National Aeronautics and Space Administration (NASA), the Departments of Energy, Transportation, Agriculture, and others.
- Provide a path for REU students to get fellowships for graduate school. Tie this to strong mentoring in this direction.
- Expand the RET program. Provide opportunities to keep teachers connected to the program.
- Expand support for the GK-12 program.
- Expand the Integrative Graduate Education and Research Traineeship (IGERT) concept to the undergraduate level with a focus on integrative engineering.
- Build on IGERT to create a broader program "ISEAHSS" (Interdisciplinary Studies in Engineering, Arts, and Humanities and Social Sciences) to train well-rounded dynamic engineers who can understand not only the technology, but also the economic, political, and historical context for what they are learning.
- Continue the ADVANCE program (Increasing the Participation and Advancement of Women in Academic Science and Engineering Careers),[3] and create a similar program focused on developing the minority professoriate.
- Expand full-ride scholarships, which are important to all students but especially minority students.
- Continue to support engineering education research and experimentation, in order to create a scholarship of engineering education. NSF should also expand dissemination of engineering education best practices through a database and Web site that would provide details on successful programs and lessons learned.

There were also a variety of suggestions for new activities:

- NSF could examine and leverage the success of various design competition programs, such as the For Inspiration and Recognition of Science and Technology (FIRST) robotics competitions (*www.usfirst.org*) and the Sally Ride Science Toy Challenge (*www.toychallenge.com*). NSF could review these programs and determine if there is a role for NSF to help support them, expand them to allow broader participation, or fill gaps in the programs (such as making them relate to different types of engineering or appeal to different demographic groups).
- NSF could focus attention and programs on the complete U.S. engineering pipeline, K-12 through Ph.D., through research experiences, with an emphasis on helping students make the transition to the next stage. The community college-engineering school transition deserves special attention. The Facilitating Academic Careers in Engineering and Science (FACES) program at Georgia Tech, which supports students to continue to the next level, is a model.
- NSF could state national goals for engineering education, such as a desired number of engineering graduates, percentage of graduates in engineering, demographic mix, or retention and graduation rates. It was acknowledged, however, that this might be difficult to do and might invite blame to be put on NSF for engineering shortages or surpluses. However, NSF should be visible on this.
- The NSF Directorates of Education and Human Resources (EHR), Mathematics and Physical Sciences (MPS), and Engineering (ENG) could collaborate to introduce an application-oriented capstone math program with engineering connections for senior high school students.
- The Board Chairman should ask the Commission on 21st Century Education in STEM to address the role of engineering education in high school.

[3] *ADVANCE includes Institutional Transformation Awards, Leadership Awards, and Partnerships for Adaptation, Implementation, and Dissemination Awards, to advance women in academic science and engineering careers.*

- NSF could sponsor workshops to heighten awareness, exchange ideas, encourage implementation, and share practices. Examples might include mentoring and how to incorporate non-technical skills, such as ethics, in technical courses. NSF could also sponsor workshops that draw together high school guidance counselors and math and science teachers to exchange information regarding the career messages they are providing to students. This allows high school counselors to be well-informed and provide better guidance.
- NSF should look to minority-serving institutions (MSI) for leadership in broadening participation. NSF should engage MSIs for research on recruitment, preparation, and retention.
- NSF could provide support for programs that fund cross-disciplinary education and seminars, such as symposia that would focus on the intersection of technology and the economy.
- NSF could support international programs in engineering schools by collecting data on universities with programs overseas, and perhaps providing support for students who otherwise would not have the resources to participate in such programs.
- NSF and industry can support educational programs to address the perceptions issues in engineering. These programs should deal with the realities of how industry handles jobs and career stability issues.

Summary and Conclusions

The workshop focused on the issues faced by deans of engineering in reforming engineering education, primarily in three areas: (1) retention rates in engineering undergraduate programs; (2) the educational experience of engineering students; and (3) the public perception of engineering.

Participants showed general agreement on the changing context of engineering and the challenges facing engineering education. There also seemed to be general agreement, or a least a lack of disagreement, on most of the points made regarding the benefits or effectiveness of most of the programs and solutions discussed. There was agreement on the importance of retention in the first year of college, but some disagreement on the reasons for high attrition from engineering. While students may state that they leave engineering because of poor teaching, participants noted that early courses are often taught in science and mathematics departments, rather than engineering. Some suggested that students may blame the teaching when the real reason may be that students do not have talent for engineering or do not want to work hard. Underlying disagreement about causes of attrition may be associated with disagreement about what skills and traits are necessary for engineers, e.g., are strength in math and science fundamental to success in engineering, or should students who are not as strong in math and science but are creative, socially engaged, and good communicators also be retained in engineering?

With regard to the educational experience of engineering students, workshop participants seemed to be in general agreement on the desirability of providing a broader engineering educational experience. Several alternative general approaches to this were discussed, including:

- Dropping some of the existing traditional engineering curriculum (e.g., Fourier transforms) in favor of material related to soft skills such as communication, leadership, and entrepreneurship, etc.. This would have to be done in concert with graduate schools and employers.
- Embedding social and global context, leadership, and other broader skills as themes throughout the curriculum.
- Developing extra skills through extracurricular activities, rather than through the curriculum.
- Completely revising the curriculum, with design and student engagement at the center.
- Adding courses to the curriculum to make, in effect, the master's degree become the professional degree.

Each approach was seen as having some drawbacks, and there was no consensus on a best approach. Revising the curriculum with design at the center and with a focus on student engagement was viewed as impractical for large schools. This approach, as well as adding extracurricular activities, was seen as putting a large burden on faculty time. While there seemed to be a benefit to having universities use different or multiple approaches, participants recognized that reforms must take into account standards set by accrediting and licensing organizations for engineers. With regard to a proposal to require a master's degree for professional certification, participants expressed great concern that the additional hurdle would result in a decline in student interest in engineering.

There seemed to be consensus on the problems with the way engineering is perceived. There also seemed to be widespread agreement on appropriate solutions, which involved developing and communicating new messages about the excitement and value of engineering to students, parents, counselors, and teachers. Ad campaigns, internship experiences for students and teachers, and the mass media could be helpful in spreading positive messages about and deepening public understanding of engineering. There was discussion about the need to target messages to focus on specific fields that are having greater difficulty than others in attracting underrepresented populations or because some of the concerns about engineering, such as offshore outsourcing, affect only specific fields.

Many suggestions were made to expand or add to NSF programs. Although participants did not prioritize proposals, expanding the REU and IGERT programs and extending to make these programs available to younger students, even in high school, received strong support, as well as modifying the RET program to provide a way to keep teachers connected to the program after they return to their schools. There also was strong support for expanding financial support for engineering students and continued engineering education research and experimentation, combined with a database and Web site that would be easy to access and provide details on successful programs and lessons learned. It was also recommended that NSF sponsor workshops to improve engineering education, including discipline-specific workshops on incorporating soft skills into technical coursework and to heighten awareness of the importance of mentoring, especially by students. NSF also could be effective in raising awareness of math and science teachers and guidance counselors about engineering education and careers to help change public perceptions. There also seemed to be wide support for NSF to explore ways to support or expand engineering design competitions as a way of exciting students about engineering. Participants acknowledged that NSF cannot have sufficient impact acting alone, and that the National Science Board might undertake a role to involve more Federal agencies that employ engineers to help expand successful programs.

In sum, participants agreed on the need for engineering education reform and on very broad cooperation to be successful. The NSF was seen in a supportive role, through leadership in the Federal sector, increased development and dissemination of research-based scholarship on engineering education, expanded student financial support, support for programs that involve students and teachers in research and in broader experiences outside the scope of traditional disciplinary education, and outreach activities to generate greater public and student understanding and excitement about engineering.

National Science Board Workshop

Moving Forward to Improve Engineering Education

Georgia Institute of Technology

Monday, November 6, 2006

7:00 p.m. Reception and Registration

Tuesday, November 7, 2006

8:30 a.m. **Welcome**

Steven C. Beering, Chairman, National Science Board

G. Wayne Clough, President, Georgia Institute of Technology

8:45 a.m. **Overview of the Workshop and Self-Introductions of Participants**

Michael P. Crosby, Executive Officer, National Science Board

9:00 a.m. **Summary of the October 20, 2006 National Science Board sponsored workshop, *Engineering Workforce Issues and Engineering Education: What are the Linkages?***

Daniel E. Hastings, National Science Board

9:15 a.m. **Review of Previous and Current National Science Foundation (NSF) Programs and Activities in Engineering Education**

Richard O. Buckius, National Science Foundation

9:30 a.m. **Panel 1: Retention Rates in Engineering Undergraduate Programs**

Moderator: Dr. Clough, National Science Board

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?

Ilesanmi Adesida
University of Illinois at Urbana-Champaign

Esin Gulari
Clemson University

Kristina M. Johnson
Duke University

10:00 a.m. Group Discussion among Workshop Participants

10:30 a.m. Questions and Comments from the Audience

10:45 a.m. **Break**

11:00 a.m. **Panel 2: The Educational Experience of Engineering Students**

Moderator: Dr. Hastings, National Science Board

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? How may larger university environments best leverage opportunities for 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? How can larger university environments be used to leverage opportunities for engineering students?

Leah H. Jamieson
Purdue University

Richard Miller
Olin College of Engineering

David N. Wormley
The Pennsylvania State University

11:30 a.m. Group Discussion among Workshop Participants

12:00 noon Questions and Comments from the Audience

12:15 p.m. **Lunch**

Speaker: Bryan Moss, President, Gulfstream Aerospace

1:30 p.m. **Panel 3: Engineering Perceptions**

Moderator: Louis J. Lanzerotti, National Science Board

What can NSF contribute to an understanding of the societal trends and industrial practices that may discourage students from pursuing engineering?

Don Giddens
Georgia Tech

Eric J. Sheppard
Hampton University

Belle Wei
San Jose State University

2:00 p.m. Group Discussion among Workshop Participants

2:30 p.m. Questions and Comments from the Audience

2:45 p.m. **Break**

3:00 p.m. **Breakout Sessions**

Session Chairs: Drs. Clough, Hastings, and Lanzerotti

How can NSF assist in moving the agenda forward on engineering education reform and address the issues of retention rates, educational experience, and engineering perceptions?

4:30 p.m. **Reports From Breakout Groups**

4:45 p.m. **Roundtable Discussion among Workshop Participants**

Moderator: Dr. Hastings

5:15 p.m. **Summary of Major Findings and Conclusions**

National Science Board-Sponsored Workshop

Moving Forward to Improve Engineering Education

Georgia Institute of Technology
Atlanta, Georgia
November 7, 2006

Invited Workshop Participants

Participant	**Affiliation**
	National Science Board
Dr. Steven C. Beering	NSB Chairman
Dr. G. Wayne Clough	NSB Member
Dr. Patricia D. Galloway	NSB Member
Dr. Daniel E. Hastings	NSB Member
Dr. Elizabeth Hoffman	NSB Member
Dr. Louis J. Lanzerotti	NSB Member
Dr. Michael P. Crosby	NSB Executive Officer
	National Science Foundation
Dr. Richard O. Buckius	NSF Assistant Director for Engineering
	Participants
Dr. Ilesanmi Adesida	University of Illinois at Urbana-Champaign, Dean, College of Engineering
Dr. William Baeslack III	The Ohio State University, Dean, College of Engineering
Dr. Joseph Barba	The City College of New York, Dean, The Grove School of Engineering
Dr. P. Barry Butler	The University of Iowa, Dean, College of Engineering
Dr. Steven L. Crouch	University of Minnesota, Dean, Institute of Technology
Dr. Eugene M. DeLoatch	Morgan State University, Dean, School of Engineering
Dr. Don Giddens	Georgia Institute of Technology, Dean, College of Engineering
Dr. Esin Gulari	Clemson University, Dean of Engineering and Science
Dr. Laura Huenneke	Northern Arizona University, Dean, College of Engineering and Natural Sciences
Dr. Leah H. Jamieson	Purdue University, John A. Edwardson Dean of Engineering
Dr. Kristina M. Johnson	Duke University, Professor and Dean, Pratt School of Engineering

Dr. Richard K. Miller	Olin College, President
Dr. David C. Munson, Jr.	University of Michigan, Robert J. Vlasic Dean of Engineering
Dr. Kevin J. Parker	University of Rochester, Dean, School of Engineering and Applied Sciences
Dr. Paul S. Peercy	University of Wisconsin-Madison, Dean, College of Engineering
Dr. James D. Plummer	Stanford University, Frederick Emmons Terman Dean of the School of Engineering
Dr. John R. Schuring	New Jersey Institute of Technology, Dean, Newark College of Engineering
Dr. Eric J. Sheppard	Hampton University, Dean, School of Engineering and Technology
Dr. Stephen W. Stafford	The University of Texas at El Paso, Dean, College of Engineering
Dr. Ben G. Streetman	The University of Texas at Austin, Professor and Dean, College of Engineering
Dr. Satish S. Upda	Michigan State University, Dean, College of Engineering
Dr. Belle W. Y. Wei	San Jose State University, Dean, College of Engineering
Dr. David N. Wormley	Pennsylvania State University, Dean of Engineering
	Lunch Speaker
Mr. Bryan Moss	President, Gulfstream Aerospace