2010 NSF Engineering Education and Centers Division Committee of Visitors' Report

Engineering Advisory Committee Meeting

COV Committee Members

- Co-Chairs
  - Steve Castillo, Colorado School of Mines
  - Ann Q. Gates, University of Texas at El Paso
- Engineering Education
  - Lead: Lorraine Fleming, Howard University
  - Terri Fiez, Oregon State University
  - Tim Anderson, University of Florida
  - Larry Richards, University of Virginia
  - Diane Rover, Iowa State
- Engineering Research Centers
  - Lead: Julie Chen, University of Massachusetts Lowell
  - Paul Sheldon, Sheldon Works
  - Kim Ogden, University of Arizona
  - Thomas Harris, Vanderbilt
- Human Resource Development
  - Lead: Theresa Maldonado, Texas A&M University
  - Lesia L. Crumpton-Young, University of Central Florida
  - John Ringo, Washington State University

Introduction

- EEC manages highly visible and critical programs for the engineering directorate, the NSF and the country
  - Engineering Education
    - Nanotechnology Undergraduate Education Centers
    - Innovations in Engineering Education Curriculum and Infrastructure
    - CAREER
    - Broadening Participation Research Initiation Grants in Engineering
  - Engineering Research Centers
  - Human Resource Development
    - REU
    - RET
- COV period of review: FY2007-2009

COV Charge

Address the following:

- Integrity, efficacy, and quality of the processes used to solicit and review proposals and the documentation of funding decisions.
- Quality of project management, monitoring, and evaluation of funded proposals.
- Quality and significance of the results of the Division's programmatic investments in terms of the NSF strategic goals (NSF 2006-2011 Strategic Plan).
- Opportunities to more fully realize the potential of the Division's current programs and future directions for the EEC Division (EEC Division Plan).

COV Process

- Briefings
  - Thomas W. Peterson, Assistant Director for Engineering
  - Allen Soyster, Division Director, EEC
  - Program Officers
- Information stored through e-jacket COV module
  - Random sampling of proposals: panel reviews and PO's review analysis
  - Briefings: Portfolio of awards, Reviewer Selection and Demographics, Quality and Effectiveness of Merit Review Process
  - All other information needed to complete review
- Sub-groups formed to conduct reviews and complete template report

2010 NSF EEC COV Outbrief

Part A: Quality and Effectiveness of Merit Review Process

A.1 Quality and Effectiveness of Merit Review Process-1

- Strengths
  - The merit review process improved since the last COV.
  - Review process
    - Panels were effective.
    - Site visits are done well.
  - Time to decision is exceptional for all the programs
  - Program officer's review analysis
    - Provides a complete summation of the project and expected results.
    - Documents justifications for recommendations.
- Concerns
  - In the Center review process, changes in weighting of criteria resulted in inconsistent feedback to PIs.

A.1 Quality and Effectiveness of Merit Review Process-2

- Areas for Improvement and Opportunities
  - Evaluative component of reviews is needed: consider adding "strengths and weaknesses" to the template
  - Panel review summaries should document the panel discussion and the findings/discussions of the panel, and not only summarize the proposal.
  - Concern about number of reviewers per Center proposal (3 substantive is too few; ad hoc reviewers need context).
  - Review processes should evolve as programs evolve, e.g., REU and RET awards involving participants from non-research I universities, community colleges, and lower divisions.

A.2 Selection of Reviewers

Review

- Reviewer distribution
  - High quality panels
  - Good effort on balancing diversity of panels by institution type, expertise, underrepresented groups, junior/senior researchers
  - Female reviewers well represented (32%)
- Demographics data collection
  - Need better than 25% response to evaluate
  - Need geographic data normalized by research population

Areas of Improvement and Opportunities

- Consider holding panels in a variety of locations or video conferencing
- Increase number of industry reviewers for appropriate programs (e.g., ERC)

A.3 Resulting Portfolio of Awards Under Review

- Overview
  - High quality, multi-disciplinary research
  - Good integration of research and education
  - NSF should highlight how programs directly address national priorities to make a case for more federal funding
- Leveraging
  - Good effort in EEC partnering with CISE and other ENG-disciplinary programs and researchers
  - EEC should continue efforts to work collaboratively with EHR on programs
  - Continue recent efforts to connect with small business through ERC-SBIR partnering
  - Partnering with other funding agencies is encouraged

A.3 Resulting Portfolio of Awards Under Review-1

- Areas for Improvement and Opportunities
  - Higher funding levels
    - Engineering Directorate must obtain and invest greater funds for engineering education and HR
      - Education awards,: need longer duration awards (e.g., minimum 3 yrs for smaller awards; 5-10 yrs for large group/center/institutional awards) to expand beyond point solutions
      - Center-funding for Education would provide the critical environment to enable significant advances
    - Centers: need more awards to address breadth of national challenges and need sufficient funding of core research and new initiatives
  - Program Evolution
    - HR: long-term programs such as REU may need to revisit the scope and review of site proposals – e.g., are interdisciplinary research themes enabled by review process?

A.3 Resulting Portfolio of Awards Under Review-2

- Areas for Improvement and Opportunities
  - Program Evolution
    - Education: short-term funding and changing scope limit the ability of the education research community to respond with broad-based, innovative, collaborative concepts
    - Centers: use of supplements to explore new mechanisms (e.g., education, infrastructure, international collaboration, small business interaction) has been effective and should continue
  - Program Evaluation
    - More statistics/data (tied to specific evaluative targets) need to be collected to understand needs, direction, balance, and impact of programs and portfolio
    - Information could be used to support funding requests
  - Participants
    - Increased participation of underrepresented groups in the research leadership teams is needed

A.4 Management of the EEC Program-1

- Strengths
  - Engineering education program is well managed even with the significant increase in proposals to review and process.
  - NUE program director is complemented for establishing a web portal for dissemination.
  - PDs have done an excellent job of responding to concerns raised by 2007 COV.
  - REU/RET program staff is doing a superb job in managing their programs, especially with limited funding.
  - For ERCs, the ability to recognize new opportunities – including complementary activities such as international, technology transfer – and develop best practices is outstanding.

A.4 Management of the EEC Program-2

- Concerns
  - A well established plan for leadership succession is crucial for all programs particularly the ERCs (the ERC program needs permanent staff)
  - There is not enough information on the process that guided program planning and prioritization, although the portfolio outcomes are excellent (e.g., in terms of research topic, geographical distribution, research quality).
  - ERC annual review requirements (not including the Year 3 and 6 renewal) should be kept concise.

A.4 Management of the EEC Program-3

- Areas for Improvement and Opportunities
  - The call for engineering education (EE) proposals needs to be on a predictable perennial schedule
  - The division should return to the practice of accepting unsolicited EE proposals to better encourage innovative research and collaboration.
  - EE programs could further benefit by connecting to recent advances in cognitive psychology, learning theory, and evaluation research.
  - Partnerships with other funding agencies (e.g., DOE, NIH) are a plus and should be pursued.
  - As new emphasis areas (e.g., Nano, Energy) are defined (e.g., by Congress, by partner funding agencies), new Centers should be competed through the ERC process, rather than as a stand-alone process.

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Part B: Quality and Significance of Results

Outcome Goal for Discovery-1

- Education-EE
  - Commended for Its role in advancing engineering education scholarship. Among all divisions, EEC uniquely supports the scholarship of discovery in engineering education.
  - Commended for two CAREER grantees being awarded PECASE recognition in 2007 and 2008.
- Centers-ERC
  - ERCs make cutting-edge advances in a broad range of fields and are premier efforts for the Foundation
  - Structure encourages researchers to tackle challenges requiring multi- and interdisciplinary collaboration and encourages creativity and innovation in the research fields and process.
  - Extraordinary competitiveness and rigorous annual reviews ensures that centers produce world-class research results
  - Systems-level approach leads to the cultivation of basic research that translates to commercial opportunities.

Outcome Goal for Discovery-2

- HR-REU and RET
  - Participants make substantive contributions to funded research programs as attested to by their role as co-authors on refereed publications and as co-inventors.
  - Engaging students in the research process early in their educational careers can provide both an important foundation and motivation for them to pursue careers that involve research and discovery.
  - Engaging K-12 teachers in the process of research provides an experience and foundation that they can take to their classrooms to influence the career paths of their students.

Outcome Goal for Learning-1

- Education-EE
  - Engineering Education is critical to:
    - Future of the nation's vitality
    - Future engineers' ability to compete in a global workforce
  - Broadened participation in engineering education is crucial to meeting the future workforce needs.
  - Engineering Education Research is essential in process of reforming engineering education.
  - EEC-funded projects has excellent outcomes that impact K-12 education, higher education and the general public, in particular:
    - K-12 curriculum and outreach
    - Undergraduate Service Learning
    - Sustainability
    - Nanotechnology
    - Understanding Capstone Design

Outcome Goal for Learning-2

- Centers-ERC
  - Trains students highly sought after by industry and are consistently rated much higher than their non-ERC peers.
  - Have made significant contributions to the integration of education and research.
  - Have developed robust outreach programs to precollege schools and teachers.
  - Have improved undergraduate instruction through REU's and development of new course materials drawn from center research.
- HR-RET and REU
  - Met objectives for attracting and retaining U.S. students in disciplines critical for maintaining a pre-eminent workforce in science and engineering.
  - Are highly successful in targeting the broad participation of underrepresented groups, including women.
  - Have broad geographic participation as individual sites and geographically dispersed participants at the given site.
  - Promote awareness with sites that have an international component.

Outcome Goal for Research Infrastructure-1

- Capability of the nation's engineering programs is greatly enhanced through funded programs.
- Education-EE
  - Has developed new infrastructure that supports learning, new methods for assessing learning, and communities of researchers.
  - Has contributed infrastructure tools that are exemplars of the integration of education and research:
    - Simulation
    - Large databases, analysis and modeling tools, and learning metrics
    - Virtual organizations, networking of researchers and students

Outcome Goal for Research Infrastructure-2

- Centers-ERC
  - Participation of a large percentage of the engineering colleges in active ERCs makes the program an effective investment for the Foundation.
  - Requirement of testbeds provide a significant research infrastructure platform.
  - Substantial contributions have been made in building extensive measurement, computing and simulation capabilities that are applicable across a broad range of fields.
- HR-REU and RET
  - Human resources are critical components of research infrastructure
  - Serious consideration should be given to providing additional funding to these programs.

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Part C

C.1. Please comment on any program areas in need of improvement or gaps (if any) within program areas.

- Centers
  - Increase **permanent** program staff
  - Challenges for EEC and entire technical community:
    - Education of the general public about science and engineering
    - Greater participation of underrepresented groups in the research leadership of centers
    - Transfer of technology to commercial application
    - Leadership training for junior faculty
- Human Resources
  - RET gaps: There is an opportunity to leverage efforts with the well-funded Robert C. Noyce and MSP programs

C.1. Please comment on any program areas in need of improvement or gaps (if any) within program areas.

- Education
  - It is imperative that the NSF increase funding of engineering education programs and return to annual unsolicited proposal RFPs
  - Sustained programs in engineering education are needed to establish and implement best practices, including those that address recruitment, retention, and advancement of women and URMs.
  - There is a need for a major program (collaborative, multi-PI, multi-university) effort to allow faculty to try high-risk ideas with the potential for high national impact.

C.2. Please provide comments as appropriate on the program's performance in meeting program-specific goals and objectives that are not covered by the above questions.

- Human Resources & Education:
  - Include specific language in program solicitations that detail expectations for including the participation of representatives from community colleges and non-research intensive universities

C.3. Please identify agency-wide issues that should be addressed by NSF to help improve the program's performance.

- More collaboration should be encouraged to leverage funds.
  - ADVANCE (HRD) and BRIGE (EEC) both address URM groups in the faculty.
  - IEECI (EEC) and CCLI (HRD) both address curriculum issues.
- Fastlane template should have specific headings for strengths and weaknesses in the Intellectual Merit and Broader Merit sections.
- NSF leadership should adopt the RET program as a Foundation-wide program by charging other directorates to develop and fund similar, but collaborative, programs
- Strategic planning should include plans to increase the funding to REU and RET programs as well as ideas to build upon the current successes and program impacts made over previous years

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- Continue efforts to encourage URMs to become involved in panel reviews.
  - Correspondence with deans and chairs may be one approach to broaden representation on review panels

C.4. Please provide comments on any other issues the COV feels are relevant.

- Centers
  - The ERC program continues to be a showcase for NSF
  - The ERC and NUE programs are best practices of integrating research and education
- Engineering Education
  - IEECI provides national leadership in engineering education research
  - Require nuggets (e.g. as a part of the annual report) and provide template
- Human Resources
  - The REU and RET programs are exemplary programs and have a considerable impact on participants
  - Broaden REU and RET award portfolio across institutional type and size by a tiered approach
  - Evaluation metrics should be aligned with the program activities, be measurable, and appropriate to the size of the investment, e,g., caution in use of change in SAT and ACT scores

C.5. NSF would appreciate your comments on how to improve the COV review process, format and report template.

- Education: Prepare a summary table of reviews that could help the COV members understand how decisions were made, in particular cases when there are mixed review
- Centers: The number of COV reviewers could be increased by 2-3 more people
- General
  - The COV report template was helpful.
  - Two teleconferences would have been helpful to orient the group to the COV process and to discuss observations

C.6. Centers-team specific issues

Stronger interactions between centers and industry are important, but not all of the efforts listed below would be viewed as priorities over funding of core center needs or funding more centers.

- Professors of Practice -- Bringing high-level (e.g., PhD in R&D lab, technical leader) industry people to the university and the centers is of value. The funding should come from sources other than ERC.
- Postdoc Fellows in Industry (Corporate Postdoctoral Fellowships for Engineers) – The goal of providing potential faculty with experience in industry is good, but the panel does not have enough information to evaluate the effectiveness of this effort.
- Design-Build Facilities and Testbeds to speed translation of ERC technology – these should be supported through partnerships with industry
- Subsidizing graduated centers – Graduated ERC components should be subjected to the same review process as non-ERCs.

EEC Strategic Plan (2007-2011) and 2020 Objectives

1. Enhance the K–12 pipeline

   Goal: 10% of all students matriculating at four-year colleges will study engineering.

   - EEC clearly supports the K-12 engineering pipeline through RET, ERCs, and other programs.

2. Promote the success of the undergraduate engineering learning experience

   Goal: Three of four students who begin the study of engineering will complete at least a B.S. in engineering.

   - The EEC supports the undergraduate engineering learning experience through its entire portfolio.
   - The COV encourages the EEC to reevaluate this goal given the size and scope of its programs

3. Improve the pathway into graduate programs for U.S. and permanent residents

   Goal: 5,000 Engineering Ph.D.s granted annually to U.S. and permanent residents.

   - The EEC supports this primarily through the ERCs

4. Build a culture of discovery and innovation in our Engineering Research Centers

   Goal: 1,000 students working in the Engineering Research Centers (ERCs) will graduate annually with ERC-related research and development experience.

   - The EEC supports this primarily through the undergrad and grad students in the ERCs.

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Summary

COV Recommendations

The COV strongly encourages the Foundation, the Engineering Directorate, and the EEC Division to **elevate engineering education alongside the core engineering science disciplines** given its strategic importance in maintaining the United States' pre-eminence in the world.

The COV encourages the EEC Division to make investments to expand access to engineering education for members of under-represented groups.

COV Observations

- The critical review cycle for the ERCs of three years and six years is particularly effective and should be considered as a best practice for large programs throughout the National Science Foundation.
- The COV encourages the EEC to provide broader access to large infrastructure investments to further leverage NSF's investments when appropriate, e.g., Network for Computational Nanotechnology.
- The COV encourages the EEC to move towards a systematic program of assessment to support better investment evaluation.
- The COV encourages the Division and Directorate to give priority to the NSB suggestion to develop programming to capitalize on the NAE effort to improve the public's image of engineering.

Engineering Education Areas in Need of Improvement

- Given the EEC's unique role in engineering education & research, it must continue to drive the community to increase research rigor, similar to discipline research, including potential for transformative results, sound assessment and evaluation methods, concise review of the literature, and knowledge transfer and dissemination.
- Sustained programs in engineering education are needed to establish and implement best practices, including programs that specifically address recruitment, retention, and advancement of women and URMs.
- There is a need for a major program (collaborative, multi-PI, multi-university) effort to allow faculty to try high-risk ideas with the potential for high national impact.

Acknowledgements

The COV congratulates the EEC for their management of highly visible and critical programs for the Engineering Directorate, the Foundation and the country. It is clear that the EEC is making outstanding contributions to the NSF's strategic goals. The COV appreciates the well-organized process put in place by the EEC staff.