

Overview of Programs that Promote Integration of Engineering Research and Education at the National Science Foundation

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Abstract

Integration of research and education is one of the “three core strategies that guides the National Science Foundation (NSF) in establishing priorities, identifying opportunities, and designing new programs and activities. NSF aims to engage researchers and educators in a joint effort to infuse education with the joy of discovery and to bring an awareness of the needs of the learning process to research, creating a rich environment for both. NSF fosters these natural connections through programmatic activity that brings out the synergy between research and education and that provides incentives for those who want to strengthen the connections. This approach emphasizes the strong bond between learning and inquiry. This paper provides an overview of the active and crosscutting programs strongly promoting integration of engineering research and education in several divisions at NSF that would be of interest to engineering researchers and educators.

Introduction

The National Science Foundation (NSF) is charged with ensuring the vitality of the nation's scientific and technological enterprise. One of the principal strategies in support of NSF's goals is to foster integration of research and education through the programs, projects, and activities it supports at academic and research institutions. These institutions provide abundant opportunities where individuals may concurrently assume responsibilities as researchers, educators, and students and where all can engage in joint efforts that infuse education with the excitement of discovery and enrich research through the diversity of learning perspectives. This approach emphasizes the strong bond between learning and inquiry. It recognizes the importance of building a solid understanding of math and science principles, as well as developing skills for formulating and solving substantive problems. It provides the foundation that will allow students to address complex situations they have not previously encountered.

NSF recognizes that most education takes place outside of a research environment, and that there are stresses in the system that makes it difficult to take advantage of the natural connections between research and education, even in our research universities. NSF encourages partnerships that introduce both research and education with new knowledge from multiple disciplines, take advantage of new understanding of how students learn, and focus on engineered systems. Effective integration of research and education at all levels infuses learning with the excitement of discovery and assures that the findings and methods of research

are quickly and effectively communicated in a broader context and to a larger audience.

Examples of activities that promote integration of research and education are:

- Integrate research activities into teaching of graduate students, undergraduate science majors, and general education students at all levels.
- Integrate research activities into guest lectures, case studies, and problem sets.
- Develop research-based educational materials and contribute to databases (e.g. K-16 digital library) useful in teaching.
- Partner with educators to research effective means of incorporating research into learning and education.
- Establish special mentoring programs for undergraduates, graduate students, and technicians conducting research.
- Involve graduate and post-doctoral researchers in undergraduate teaching activities.
- Develop links to special programs such as REU or RET. REU is particularly relevant, providing a platform where promising undergraduates can participate directly in cutting edge research projects. The RET program allows teachers to experience field research and relate these experiences to students and other teachers through the web, through their own lectures and through guest lectures by the sponsoring PI.
- Give science presentations to the broader community/promote life-long learning: e.g. at museums, and libraries, on radio shows and with other venues that reach broad audiences.
- Develop, adopt, adapt and implement effective models and pedagogic approaches to science, mathematics, and engineering teaching.

Each year, NSF supports researchers, teachers, and students at every educational level and across all disciplines in science and engineering. Embedded in all NSF programs are efforts to build a more inclusive, knowledgeable, and globally engaged workforce that fully reflects the strength of the nation's diverse population. The following provides an overview of active and crosscutting programs that strongly emphasize integration of engineering research and education in several divisions at NSF that would be of interest to engineering researchers and educators. A list of contacts and proposal target month for the following programs is provided in Table 1.

Division of Engineering Education and Centers (EEC/ENG)

1. Engineering Research Centers (ERC) - focus on the definition, fundamental understanding, development, and validation of the technologies needed to realize a well-defined class of engineered systems with the potential to spawn whole new industries or radically transform the product lines, processing technologies, or service delivery methodologies of current industries. ERC faculty, students and industry partners integrate discovery and learning in an interdisciplinary environment that reflects the complexities and realities of real-world technology. This environment adds an integrative dimension that is enabled by the critical size of ERCs. ERC innovations in research and education are expected to impact curricula at all levels from precollege to life-long learning and to be disseminated to and beyond academic and industry partners. ERCs fulfill NSF's strategic goal to increase the diversity of the scientific and engineering workforce by including all members of society regardless of race, ethnicity, or gender in all aspects of the centers' activities. Because ERCs play critical roles in academe by integrating research, education, diversity, outreach, and

industrial collaboration, NSF views ERCs as change agents for academic engineering programs and the engineering community at large.

2. Department-Level Reform of Undergraduate Engineering Education (DLR) - provides an opportunity for institutions to compete for planning and implementation grants to assist departmental and larger units in engaging faculty in the scholarship of learning and teaching on a department wide basis, in developing, implementing, assessing and disseminating comprehensive plans to reformulate, streamline and update engineering degree programs, in developing, implementing, assessing department wide transformational change of student learning experiences, in incorporating Service Learning opportunities into engineering programs, in meeting the emerging workforce and educational needs of U.S. industry, and in incorporating methods for integration of research and teaching.

3. Research Experiences for Teachers (RET) - supports the active involvement of K-12 teachers and community college faculty in engineering research in order to bring knowledge of engineering and technological innovation into their classrooms. This announcement features two mechanisms for support of in-service and pre-service K-12 teachers and/or community college faculty research: RET Supplements and RET Sites. RET Supplements may be included in proposals for new or renewal NSF Directorate for Engineering (ENG) grants or as supplements to ongoing NSF/ENG funded projects. RET Sites are based on independent proposals to initiate and conduct research participation projects for a number of K-12 teachers and/or community college faculty.

Division of Human Resource Development (HRD)

4. Centers of Research Excellence in Science and Technology (CREST) - makes resources available to significantly enhance the research capabilities of minority-serving institutions through the establishment of centers that effectively integrate education and research. CREST promotes the development of new knowledge, enhancements of the research productivity of individual faculty, and an expanded diverse student presence in STEM disciplines. CREST supplements support the establishment or strengthening of partnerships and collaborations between CREST centers and nationally recognized research centers in areas of mutual research interest and high priority for the CREST institution.

Division of Research, Evaluation, and Communication (REC)

5. Research on Learning and Education (ROLE) - seeks to capitalize on important developments across a wide range of fields related to human learning and to STEM education. It supports research across a continuum that includes (1) the biological basis of human learning; (2) behavioral, cognitive, affective and social aspects of STEM learning; (3) STEM learning in formal and informal educational settings; (4) STEM Policy research; and (5) The diffusion of STEM innovations. The ROLE Program aims to advance the knowledge base within and across the intersections of these multidisciplinary areas. It encourages projects that reconcile and integrate basic research and educational practice, and generate hypotheses from one disciplinary area that can be tested and refined in another.

Division of Ocean Sciences (OCE)

6. Centers for Ocean Science Education Excellence (COSEE) - facilitate collaborations and communications between ocean science researchers and educators. These Centers for Ocean Science Education Excellence (COSEE) foster the integration of ocean research into high quality educational materials, allow ocean researchers to gain a better understanding of educational organizations and pedagogy, provide educators with an enhanced capacity to understand and deliver high-quality educational programs in the ocean sciences, and provide material to the public that promotes a deeper understanding of the ocean and its influence on each person's quality of life and our national prosperity.

Crosscutting and NSF-Wide Programs

7. Biocomplexity in the Environment (BE): Integrated Research and Education in Environmental Systems - promotes comprehensive, integrated investigations of environmental systems using advanced scientific and engineering methods. The concept of biocomplexity stresses the richness of biological systems and their capacity for adaptation and self-organizing behavior. By placing biocomplexity studies in an environmental context, this competition emphasizes research with the following characteristics: (a) a high degree of interdisciplinarity; (b) a focus on complex environmental systems that includes non-human biota or humans; and (c) a focus on systems with high potential for exhibiting non-linear behavior.

8. Faculty Early Career Development (CAREER) - recognizes and supports the early career-development activities of those teacher-scholars who are most likely to become the academic leaders of the 21st century. CAREER awardees will be selected on the basis of creative career-development plans that effectively integrate research and education within the context of the mission of their organization. Such plans should build a firm foundation for a lifetime of integrated contributions to research and education.

9. Integrative Graduate Education and Research Traineeship (IGERT) - meet the challenges of educating U.S. Ph.D. scientists and engineers who will pursue careers in research and education, with the interdisciplinary backgrounds, deep knowledge in chosen disciplines, and technical, professional, and personal skills to become, in their own careers, leaders and creative agents for change. The program is intended to catalyze a cultural change in graduate education, for students, faculty, and institutions, by establishing innovative new models for graduate education and training in a fertile environment for collaborative research that transcends traditional disciplinary boundaries. It is also intended to facilitate diversity in student participation and preparation, and to contribute to the development of a diverse, globally-engaged, science and engineering workforce.

10. Materials Research Science and Engineering Centers (MRSEC) - supports interdisciplinary materials research and education while addressing fundamental problems in science and engineering. MRSECs require outstanding research quality and intellectual breadth, provide support for research infrastructure and flexibility in responding to new opportunities, and strongly encourage the integration of research and education. These centers foster active collaboration between universities and other sectors, including industry, and they constitute a national network of university-based centers in materials research. MRSECs address problems

of a scope or complexity requiring the advantages of scale and interdisciplinary interaction provided by a campus-based research center.

11. Nanoscale Science and Engineering Education (NSEE) - supports fundamental research and catalyze synergistic science and engineering research and education in emerging areas of nanoscale science and technology, including: biosystems at the nanoscale; nanoscale structures, novel phenomena, and quantum control; nanoscale devices and system architecture; nanoscale processes in the environment; multi-scale, multi-phenomena theory, modeling and simulation at the nanoscale; manufacturing processes at the nanoscale; and studies on the societal and educational implications of scientific and technological advances on the nanoscale. This program provides support for Nanoscale Interdisciplinary Research Teams (NIRT), Nanoscale Exploratory Research (NER), and Nanoscale Science and Engineering Centers (NSEC).

12. Major Research Instrumentation Program (MRI) - designs to increase access to scientific and engineering equipment for research and research training in our Nation's organizations of higher education, research museums and non-profit research organizations. This program seeks to improve the quality and expand the scope of research and research training in science and engineering, and to foster the integration of research and education by providing instrumentation for research-intensive learning environments. The MRI program encourages the development and acquisition of research instrumentation for shared inter- and/or intra-organizational use and in concert with private sector partners.

13. Research Experiences for Undergraduates (REU) - supports active research participation by undergraduate students in any of the areas of research funded by the National Science Foundation. REU projects involve students in meaningful ways in ongoing research programs or in research projects specially designed for the purpose. This program features two mechanisms for support of student research: REU Supplements and REU Sites. REU Supplements may be included in proposals for new or renewal NSF grants or cooperative agreements or as supplements to ongoing NSF-funded projects. REU Sites are based on independent proposals to initiate and conduct undergraduate research participation projects for a number of students. REU Sites projects may be based in a single discipline or academic department or be based on interdisciplinary or multi-department research opportunities with a strong intellectual focus.

Summary

This paper is intended to help engineering researchers and educators obtain a better understanding of the different programs at NSF that strongly emphasize integration of research and education. These programs help to accelerate technological and educational innovation and improve the quality and diversity of engineering graduates entering the technical workforce. We need graduate engineering leaders with a global outlook and the ability to adapt to the rapidly evolving technical environment in industry, academe, and society. Additional information about abstracts of new awards and success stories for the above programs can be found at www.nsf.gov.

Table 1. List of Programs, Contacts, and Proposal Deadlines

No.	Programs	Contact	Proposal Target Month
1	Engineering Research Centers (ERC)	Lynn Preston lpreston@nsf.gov (703) 292-5358	June
2	Department Level Reform (DLR)	Patrick Carriere pcarrier@nsf.gov (703) 292-8492	March
3	Research Experiences For Teachers (RET)	Mary Poats mpoats@nsf.gov (703) 292-5357	June
4	Centers of Research Excellence in Science and Technology (CREST)	Victor Santiago vsantiago@nsf.gov (703) 292-4673	March
5	Research on Learning and Education (ROLE)	James Dietz jdietz@nsf.gov (703) 292-5156	March
6	Centers for Ocean Science Education Excellence (COSEE)	Elizabeth Rom erom@nsf.gov (703) 292-7709	March
7	Bio-complexity in the Environment (BE)	Bruce Hamilton bhamilton@nsf.gov (703) 292-7066	December
8	Faculty Early Career Development (CAREER)	Linda Blevins lblevins@nsf.gov (703) 292-5147	July
9	Integrative Graduate Education and Research Traineeship (IGERT)	Bruce Hamilton bhamilton@nsf.gov (703) 292-7066	August
10	Materials Research Science and Engineering Centers (MRSEC)	Maija Kukla mkukla@nsf.gov (703) 292-4940	January
11	Nanoscale Science and Engineering Education (NSEE)	Mary Poats mpoats@nsf.gov (703) 292-5357	November
12	Major Research Instrumentation Program (MRI)	Dragana Brzakovic Dbrzakov@nsf.gov (703) 291-8040	January
13	Research Experiences for Undergraduates (REU)	Gary Gabrielle ggabriel@nsf.gov (703) 292-5346	August

Biography

Dr. Patrick Carriere is a Program Director at NSF with joint responsibility in the Division of Engineering Education and Centers (EEC/ENG) as well as the Division of Undergraduate Education (DUE/EHR).