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# Opportunities for Engineering Education Funding at the National Science Foundation

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**Abstract**

NSF has become increasingly concerned with the need for changes in undergraduate engineering education to meet the challenges of the changing workforce as well as with the need for fostering more diversity of the student body in the STEM (Science, Technology, Engineering and Mathematics) disciplines and in the S&E (Science and Engineering) workforce in the country. During recent years several programs have been initiated with focus on learning and teaching and on improving the quality of undergraduate engineering education. In all NSF programs emphasis is on better integration research and teaching, assessment of outcomes as well as the broader impact of the outcomes. A particular focus of NSF is on recruiting and retaining youth from underrepresented groups into the STEM disciplines and on technological literacy of everyone.

Several programs at NSF encourage partnerships between higher education, K-12, industry and other agencies to address these serious issues of national concern. This presentation will provide an overview of some of these programs and set the stage for subsequent speakers in the session to provide details on some of them.

## Introduction

The Mission of NSF is to promote the progress of science in order to advance national health, prosperity and welfare; to secure national defense; and for other purposes. The Strategic Goals of NSF are to ensure that NSF investments produce outcomes at the core of the research and education enterprise: a world-class science and engineering workforce; new knowledge across the frontiers of science and engineering; and the tools to get the job done efficiently and effectively. Expressed simply as *People, Ideas,* and *Tools (PIT)* these long-term strategic goals reflect the changing role and increased significance of science and engineering in the 21st Century.

In particular, the emphasis on the People Goal, is relevant to engineering educators. This goal is to ensure a diverse, competitive and globally-engaged U.S. workforce of scientists, engineers, technologists and well-prepared citizens. Leadership in today's knowledge economy requires world-class scientists and engineers and a

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national workforce that is scientifically, technically and mathematically strong. Investments in *People* aim to improve the quality and reach of science, engineering, and mathematics education and enhance student achievement. Each year, NSF supports more than 200,000 people – teachers, students, and researchers 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. Integration of Engineering Research and Education is high priority for the National Science Foundation.

The following provides an overview of the programs in several divisions at NSF that would be particular interest to new engineering educators. Many of these programs are administered jointly by several divisions, emphasizing the fact that engineering education is a broad and interdisciplinary field.

**Division of Engineering Education Centers (EEC/ENG)**

The *Engineering Education and Centers (EEC) Division* seeks to stimulate new paradigms in engineering research and education that will accelerate technological and educational innovation and improve the quality and diversity of engineering graduates entering the technical workforce. To achieve its mission, EEC facilitates integrated partnerships that cross disciplines and focus on technological systems. The objective is to yield well-rounded, professionally oriented engineers with a global outlook and the ability to assume leadership roles in industry, academe, and society.

**Engineering Research Centers (ERC)** - provides an integrated environment for academe and industry to focus on next-generation advances in complex engineered systems, with synergy among engineering, science, and industrial practice. ERCs integrate research with education at both the graduate and undergraduate levels, producing curriculum innovations derived from the systems focus of the ERCs' strategic research goals. ERCs aim to build trusted partnerships with industry, develop shared infrastructure, and increase the capacity of engineering and science graduates to contribute to the U.S. competitive edge. They provide a system perspective for long-term engineering research and education, enabling fresh technologies, productive engineering processes, and innovative products and services.

**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 developing comprehensive plans to reformulate, streamline and update engineering and engineering technology degree programs, developing new curricula for emerging engineering disciplines, and meeting the emerging workforce and educational needs of U.S. industry.

**Research Experiences for Undergraduates (REU)** - provides support for proposals that seek to attract talented students into academic research careers in engineering. Proposals are in two major categories, REU Sites and REU Supplements.

**Research Experiences for Teachers (RET)** - utilizes the extensive network of Research Experiences for Undergraduates (REU) Sites as a platform for providing in-service and pre-service K-12 teachers with discovery-based learning experiences in the MPS disciplines that they can incorporate in their classroom activities. The EEC Division also funds RET sites. RET sites provide groups of in-service and pre-service K-12 teachers and community college faculty with discovery-based learning experiences in Engineering laboratories and facilities, which will then be incorporated into their classroom activities during the school year.

**Nanotechnology Undergraduate Education (NUE) -** program has an emphasis on:

- introductory undergraduate courses presented through the development of text, software, laboratory and demonstration experiments, and web-based resources;
- development and dissemination of new teaching modules for nanoscale science and engineering that can be used in existing undergraduate courses;
- incorporation of undergraduate research opportunities based on nanoscale science and engineering into the curriculum at any level, particularly during first and second year studies;

**Engineering Education Program** - has the goal to increase the quantity and quality of U.S. citizens who earn BS degrees in engineering. We welcome unsolicited proposals from faculty with cutting edge new ideas for undergraduate engineering education improvements.

**Division of Undergraduate Education (DUE/EHR)**

NSF is determined that all students at all levels will be exposed to programs with high standards for understanding and accomplishment; that all students have the opportunity to advance to high levels; that all students who enter advanced training at the professional level are well and broadly trained; and that the process of learning does not end with the classroom. Meeting this goal requires efforts from all parts of the Foundation. The *Division of Undergraduate Education (DUE)* has the responsibility for undergraduate level which plays a pivotal role.

**Advanced Technological Education (ATE) -** Jointly managed by the Division of Undergraduate Education (DUE) and the Division of Elementary, Secondary, and Informal Education (ESIE), the ATE program promotes improvement in technological education at the undergraduate and secondary school levels by supporting curriculum development; the preparation and professional development of college faculty and secondary school teachers; internships and field experiences for faculty, teachers, and students; and other activities. With an emphasis on two-year colleges, the program focuses on the education of technicians for the high-technology fields that drive our nation's economy. The program also promotes articulation between programs at two-year colleges and four-year colleges and universities--in particular, articulation between two-year and four-year programs for prospective teachers (with a focus on activities and disciplines that have a strong technological foundation) and between two-year and four-year programs in science, technology, engineering, and mathematics (also with a focus on disciplines that have a strong technological foundation).

**Computer Science, Engineering, and Mathematics Scholarships (CSEMS) -** This program supports scholarships for academically talented, financially needy students, enabling them to

enter the high-technology workforce following completion of an associate, baccalaureate, or graduate-level degree in computer science, computer technology, engineering, engineering technology, or mathematics. Academic institutions apply for awards to support scholarship activities and are responsible for selecting scholarship recipients.

*Note:* It appears unlikely that the program will hold a competition in fiscal year 2005 and beyond, since the current funding through H-1B visa fees has ended. Any change will be announced on this Web page.

**Federal Cyber Service: Scholarship for Service (SFS) -** This program seeks to increase the number of qualified students entering the fields of information assurance and computer security and to increase the capacity of the United States higher education enterprise to continue to produce professionals in these fields. The program has two tracks:

- The Scholarship Track provides funding to colleges and universities to award scholarships in information assurance and computer security fields. Scholarship recipients will become part of the Federal Cyber Service of information technology specialists who ensure the protection of the U.S. Government's information infrastructure. Upon graduation after their two-year scholarships, the recipients will be required to work for a federal agency for two years in fulfillment of their Federal Cyber Service commitment.

- The Capacity Building Track provides funds to colleges and universities to improve the quality and increase the production of information assurance and computer security professionals through professional development of information assurance faculty and the development of academic programs. Partnerships designed to increase participation by underrepresented groups are particularly encouraged.

**Robert Noyce Scholarship Program -** This program seeks to encourage talented science, technology, engineering, and mathematics majors and professionals to become K-12 mathematics and science teachers. The program provides funds to institutions of higher education to support scholarships, stipends, and programs for students who commit to teaching in high-need K-12 schools.

**Science, Technology, Engineering, and Mathematics Talent Expansion Program (STEP) -** This program seeks to increase the number of students (U.S. citizens or permanent residents) receiving associate or baccalaureate degrees in established or emerging fields within science, technology, engineering, and mathematics (STEM). Two types of proposals are solicited: *Type 1* proposals provide for full implementation efforts at academic institutions, and *Type 2* proposals support educational research projects on associate or baccalaureate degree attainment in STEM.

**Course, Curriculum, and Laboratory Improvement (CCLI)** - The CCLI program seeks to improve the quality of science, technology, engineering, and mathematics (STEM) education for all students, based on research concerning the needs and opportunities that exist and effective

ways to address them. It targets activities affecting learning environments, course content, curricula, and educational practices, with the aim of contributing to the relevant research base. The program has four tracks:

- **Educational Materials Development (CCLI-EMD)** projects are expected to produce innovative materials that incorporate effective educational practices to improve student learning of STEM. Projects to develop textbooks, software, or laboratory materials for commercial distribution are appropriate. Two types of EMD projects will be supported:
    - those that intend to demonstrate the scientific and educational feasibility of an idea, a "proof of concept" or prototype; and
    - those based on prior experience with a prototype that intend to fully develop and test the product or practice. Such materials are expected to be disseminated nationally for adoption and adaptation.

- **National Dissemination (CCLI-ND)** projects are expected to provide faculty with professional development opportunities to enable them to introduce new content into undergraduate courses and laboratories, and to explore effective educational practices to improve the effectiveness of their teaching. Projects should be designed to offer workshops, short courses, or similar activities on a national scale in single or multiple disciplines.

- **Adaptation and Implementation (CCLI-A&I)** projects are expected to result in improved education in STEM at academic institutions through adaptation and implementation of exemplary materials, laboratory experiences, and/or educational practices that have been developed and tested at other institutions. Proposals may request funds in any budget category supported by NSF, or may request funds to purchase only instrumentation.

- **Assessment of Student Achievement (CCLI-ASA)** projects are expected to develop and disseminate assessment practices, materials (tools), and measures to guide efforts that improve the effectiveness of courses, curricula, programs of study, and academic institutions in promoting student achievement, particularly in STEM. This program track also promotes the full integration of assessment with these educational efforts. Projects may be integrated with research on learning, particularly research focused in the STEM disciplines. Three types of ASA projects will be supported:
    - *New Development:* developing and validating new assessment materials (tools) and practices for use in single or multiple undergraduate disciplines.
    - *Adaptation:* adapting assessment materials and practices that have proven effective for one setting or audience for use in a new setting or with a different audience.
    - *Dissemination:* spreading the use of effective assessment practices through workshops or Web-based materials that have been validated and are thoroughly documented with detailed instructions.

**National Science, Technology, Engineering, and Mathematics Education Digital Library (NSDL) -** Building on work supported under the multi-agency Digital Libraries Initiative, this program aims to establish a national digital library that will constitute an online network of learning environments and resources for science, technology, engineering, and mathematics (STEM) education at all levels. In FY2003, the program will accept proposals in three tracks: (1) *Collections* projects are expected to aggregate and manage a subset of the library's content within a coherent theme or specialty. (2) *Services* projects are expected to develop services which support users, collection providers, and the Core Integration effort and which enhance the impact, efficiency, and value of the library. (3) *Targeted Research* projects are expected to explore specific topics that have immediate applicability to collections, services, and other aspects of the development of the digital library.

**NSF Director's Award for Distinguished Teaching Scholars (DTS)** - recognizes and rewards individuals who have contributed significantly to the scholarship of their discipline and to the education of students in science, technology, engineering, or mathematics (STEM), and who exemplify the ability to engage productively in both research and education. This award is part of NSF's efforts to promote an academic culture that values a scholarly approach to both research and education. The Director's Award is the highest honor bestowed by NSF for excellence in both teaching and research in STEM fields, or in educational research related to these fields.

**Division of Elementary, Secondary and Informal Education (ESIE/EHR)**

*The Division of Elementary, Secondary, and Informal Education (ESIE*) supports the National Science Foundation's mission of providing leadership and promoting development of the infrastructure and resources needed to improve preK-12 science, technology, engineering, and mathematics (STEM) education throughout the United States. ESIE's comprehensive and coherent, research-based program portfolio develops the nation's capacity to support high-quality STEM education. The program areas targeted are:

**Teacher Professional Continuum (TPC) –** Jointly administered by ESIE and DUE, the TPC program addresses critical issues and needs regarding the recruitment, preparation, enhancement, and retention of science, technology, and mathematics (STM) teachers for grades K-12. Its goals are to improve the quality and coherence of the learning experiences that prepare and enhance STM teachers; to develop innovative resources that prepare and support STM teachers and school and district administrators; to research and develop models and systems that support the teacher professional continuum; to research teacher learning and its impact on teaching practice; and to disseminate this research as well as innovative models and resources to a national audience. The TPC program succeeds ESIE's Teacher Enhancement (TE) program and DUE's Science, Technology, Engineering, and Mathematics Teacher Preparation (STEMTP) program**.**

**Centers for Learning and Teaching (CLT)** - focuses on the advanced preparation and development of STEM practitioners and establishment of meaningful partnerships among education stakeholders.

**Informal Science Education (ISE)** - provides stimulating experiences for STEM learning outside of formal classroom environments through media, exhibits, and community-based programming.

**Information Technology Experiences for Students and Teachers (ITEST)** - managed under the ISE program, designed to increase the opportunities for students and teachers to learn about, experience, and use information technologies.

**Instructional Materials Development (IMD)** - emphasizes the development, dissemination, and implementation of instructional materials and assessments for STEM education.

**Presidential Awards for Excellence in Mathematics and Science Teaching (PAEMST)** - administered on behalf of the White House, recognizes exemplary careers of K-12 math and science teachers.

**Nanoscale Science and Engineering Education (NSEE)** represents a comprehensive effort on the part of the National Science Foundation to enhance nanoscale science and engineering education. Its goals are to form strong partnerships between researchers in science and engineering and those in science education; to develop effective strategies and interventions for integrating nanoscale science and engineering that will inform other emerging areas of science and engineering, into formal education in grades 7-16; and to increase public awareness of advances in nanoscale research and technology and their impact on society. Among the activities that will be supported are doctoral programs in science education, the development of instructional materials and courses for adoption and implementation in classrooms, grades 7-16, and research on the cognitive and implementation aspects of the educational interventions. The goals are carried out through partnerships involving institutions with the requisite expertise in nanoscale science and engineering and in education.

NSEE encompasses four independent components:

- **Centers for Learning and Teaching (NCLT)**: Centers are intended to create educational leadership for emerging areas of science and engineering by creating doctoral programs, representing collaborations of researchers in nanoscale science and engineering, education, and cognitive and behavioral sciences.

- **Informal Science Education (NISE)**: This national effort is intended to foster public awareness and understanding of nanoscale science and engineering through development of media projects (film, radio, television) and exhibits.

- **Instructional Materials Development (NIMD)**: This effort is intended to support development of prototype instructional materials that promote student learning and interest in nanoscale science, engineering, and technology concepts for grades 7-12.

- **Nanotechnology Undergraduate Education (NUE)**: This effort continues an existing program to introduce nanoscale science and technology through a variety of interdisciplinary approaches into undergraduate education, particularly in the first two collegiate years.

**Other Funding Opportunities for Undergraduate STEM Education:**
Given below are short descriptions for programs in other NSF divisions which are relevant to engineering education.

**Bioengineering and Bioinformatics Summer Institutes (BBSI)** - provides research and education experience to students majoring in the biological sciences, computer sciences, engineering, mathematics, and physical sciences with interdisciplinary bioengineering or bioinformatics.

**Supplemental Funding for Support of Women, Minorities, and Physically Disabled Engineering Research Assistants** - provides funding for investigators who wish to include women, underrepresented minorities, and physically disabled undergraduate or high school students as research assistants on their projects.

**Graduate Research Fellowships (GRF)** - program promotes the strength and diversity of the Nation's scientific and engineering base, and offers recognition and 3 years of support for advanced study to approximately 900 outstanding graduate students annually in all fields of science, mathematics, and engineering supported by NSF.

**Integrated Graduate Education and Research Training (IGERT)** - program supports multi-disciplinary training groups. These might include graduate students, undergraduate students, and post-doctoral students as well.

**Graduate Teaching Fellows in K-12 Education (GK-12)** - program supports fellowships and associated training that will enable graduate students and advanced undergraduates in the sciences, mathematics, engineering, and technology to serve as resources in K-12 schools. Academic institutions apply for awards to support fellowship activities, and are responsible for selecting fellows.

**Centers for Learning and Teaching (CLT)** - program addresses the need to enrich and diversify the national infrastructure for standards-based science, technology, engineering, and mathematics education. The goal is to increase the number of K-12 educators prepared in content, pedagogy, and assessment methodologies.

**Math and Science Partnership (MSP)** - program addresses a portion of the President's challenge enunciated in No Child Left Behind to strengthen K-12 science and mathematics education.

**Model Institutes for Excellence (MIE)** - program is a three-phase program. In the first two phases NSF funded four institutions to develop and refine models for increasing graduates from underrepresented groups in Science, Technology, Engineering, and Mathematics (STEM) disciplines. The third phase is to provide funding for the institutionalization of these models. This competition is restricted to the NSF-funded MIE institutions Metropolitana Universidad, Oglala Lakota College, University of Texas at El Paso, and Xavier University in New Orleans.

**Interagency Education Research Initiative (IERI)** - has the goal of improving preK-12 student learning and achievement in reading, mathematics, and science by supporting rigorous, interdisciplinary research on large-scale implementations of promising educational practices and technologies in complex and varied learning environments.

The following table lists additional NSF programs that have an impact on engineering education:

| Directorate/Division | Program |
|---|---|
| NSF-wide | Faculty Early Career Development (CAREER) |
| NSF-wide | Information Technology Research (ITR) |
| NSF-wide | Partnerships for Innovation (PFI) |
| NSF-wide | Research in Undergraduate Institutions (RUI) |
| BIO | Undergraduate Mentoring in Environmental Biology (UMEB) |
| CISE/EIA | CISE Educational Innovation (EI) |
| CISE/EIA | CISE Minority Institutions Infrastructure Program |
| CISE/EIA | Information Technology Workforce (ITWF) |
| EHR/HRD | Historically Black Colleges and Universities Undergraduate Program (HBCU-UP) |
| EHR/HRD | Louis Stokes Alliances for Minority Participation (LSAMP) |
| EHR/HRD | Research in Disabilities Education (RDE) |
| EHR/HRD | Research on Gender in Science and Engineering (GSE) |
| EHR/HRD | Tribal Colleges and Universities Program (TCUP) |
| EHR/REC | Evaluative Research and Evaluation Capacity Building (EREC) |
| EHR/REC | Research on Learning and Education (ROLE) |
| GEO | Geoscience Education |
| MPS/DMS | Enhancing the Mathematical Sciences Workforce in the 21st Century (EMSW21) |

**Summary**
This paper is intended to help engineering educators obtain a better understanding of the opportunities for engineering educational research at NSF. It is obvious from the wide-range of programs that NSF has become increasingly concerned with the need for changes in engineering education to meet the challenges of the changing workforce as well as with the need for fostering more diversity of the student body in the STEM disciplines and in the S&E workforce in the country. In all NSF programs emphasis is on better integration research and teaching, assessment of outcomes as well as the broader impact of the outcomes.

This paper is an overview and sets the stage for subsequent speakers in the session who will provide details as well as examples of programs that they have been part of.

**Biography:**
Krishna Vedula is a Program Officer at NSF with joint responsibility in the Division of Engineering Education & Centers (EEC/ENG) as well as the Division of Undergraduate Education (DUE/EHR). He is an IPA from the University of Massachusetts at Lowell, where was Dean of the Francis College of Engineering from 1995-2003. Prior to that Dr. Vedula has been in academics for 18 years in the field of materials science and engineering.