Abstract

The goal of the project is …… The project is developing computer-based instructional modules for statics and mechanics of materials. The project uses 3D rendering and animation software, in which the user manipulates virtual 3D objects in much the same manner as they would physical objects. Tools being developed enable instructors to realistically include external forces and internal reactions on 3D objects as topics are being explained during lectures. Exercises are being developed for students to be able to communicate with peers and instructors through real-time voice and text interactions. The project is being evaluated by … The project is being disseminated through … The broader impacts of the project are …

Non engineers should substitute:
"Organic chemistry" for "statics and mechanics of materials"
"Interactions" for "external forces and internal reactions"

Merit Review Broader Impacts Criterion: Representative Activities
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Proposals submitted to the National Science Foundation are evaluated through use of two merit review criteria, which all proposals must address explicitly. Experience shows that while most proposers have little difficulty responding to the criterion relating to intellectual merit, many proposers have difficulty understanding how to frame the broader impacts of the activities they propose to undertake.

The *Broader Impacts* of a proposed activity are important considerations in advancing the NSF Mission: *"To promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes"* (NSF Act of 1950). The **NSF Strategic Plan** provides further background information for *Broader Impacts* through the NSF Vision, Core Values, Strategic Outcome Goals, and Investment Priorities (NSF Strategic Plan for FY 2006-2011: Investing in America's Future (NSF 06-48).

The examples provided below are organized by the set of potential considerations used in assessing the broader impacts of the proposed activity. They illustrate activities that, when successfully incorporated in a project description, will help reviewers and NSF program staff address the broader impacts criterion in the review and decision process. The list is not intended to be exhaustive, nor is any particular example relevant to all proposals. Proposers can draw from the examples but are urged to be creative in their approaches to demonstrating the broader impacts of their projects. Proposers already undertaking similar kinds of activities should carefully consider how to link these examples to the research and education projects they are proposing for funding. Proposers also should consider what types of activities best suit their interests, while enhancing the broader impacts of the project being proposed.

The components of the broader impacts criterion as defined by the National Science Board are listed below. The list is followed by short sections on each component that provide representative activities.

Broader Impacts Criterion: What are the broader impacts of the proposed activity?

- How well does the activity advance discovery and understanding while promoting teaching, training and learning?
- How well does the proposed activity broaden the participation of underrepresented groups (e.g., gender, ethnicity, disability, geographic, etc.)?
- To what extent will it enhance the infrastructure for research and education, such as facilities, instrumentation, networks and partnerships?
- Will the results be disseminated broadly to enhance scientific and technological understanding?
- What may be the benefits of the proposed activity to society?

Advance Discovery and Understanding While Promoting Teaching, Training and Learning

Examples of Activities:

- Integrate research activities into the teaching of science, math and engineering at all educational levels (e.g., K-12, undergraduate science majors, non-science majors, and graduate students).
- Include students (e.g., K-12, undergraduate science majors, non-science majors, and /or graduate students) as participants in the proposed activities as appropriate.
- Participate in the recruitment, training, and/or professional development of K-12 science and math teachers.
- Develop research-based educational materials or contribute to databases useful in

teaching (e.g., K-16 digital library).
• Partner with researchers and educators to develop effective means of incorporating research into learning and education.
• Encourage student participation at meetings and activities of professional societies.
• Establish special mentoring programs for high school students, undergraduates, graduate students, and technicians conducting research.
• Involve graduate and post-doctoral researchers in undergraduate teaching activities.
• Develop, adopt, adapt or disseminate effective models and pedagogic approaches to science, mathematics and engineering teaching.

Broaden Participation of Underrepresented Groups
Examples of Activities:
• Establish research and education collaborations with students and/or faculty who are members of underrepresented groups.
• Include students from underrepresented groups as participants in the proposed research and education activities.
• Establish research and education collaborations with students and faculty from non-Ph.D.-granting institutions and those serving underrepresented groups.
• Make campus visits and presentations at institutions that serve underrepresented groups.
• Establish research and education collaborations with faculty and students at community colleges, colleges for women, undergraduate institutions, and EPSCoR institutions.
• Mentor early-career scientists and engineers from underrepresented groups who are submitting NSF proposals.
• Participate in developing new approaches (e.g., use of information technology and connectivity) to engage underserved individuals, groups, and communities in science and engineering.
• Participate in conferences, workshops and field activities where diversity is a priority.

Enhance Infrastructure for Research and Education
Examples of Activities:
• Identify and establish collaborations between disciplines and institutions, among the U.S. academic institutions, industry and government and with international partners.
• Stimulate and support the development and dissemination of next-generation instrumentation, multi-user facilities, and other shared research and education platforms.
• Maintain, operate and modernize shared research and education infrastructure, including facilities and science and technology centers and engineering research centers.
• Upgrade the computation and computing infrastructure, including advanced computing resources and new types of information tools (e.g., large databases, networks and associated systems, and digital libraries).
• Develop activities that ensure that multi-user facilities are sites of research and mentoring for large numbers of science and engineering students.

Broad Dissemination to Enhance Scientific and Technological Understanding
Examples of Activities:

• Partner with museums, nature centers, science centers, and similar institutions to develop exhibits in science, math, and engineering.
• Involve the public or industry, where possible, in research and education activities.
• Give science and engineering presentations to the broader community (e.g., at museums and libraries, on radio shows, and in other such venues.).
• Make data available in a timely manner by means of databases, digital libraries, or other venues such as CD-ROMs.
• Publish in diverse media (e.g., non-technical literature, and websites, CD-ROMs, press kits) to reach broad audiences.
• Present research and education results in formats useful to policy-makers, members of Congress, industry, and broad audiences.
• Participate in multi- and interdisciplinary conferences, workshops, and research activities.
• Integrate research with education activities in order to communicate in a broader context.

Benefits to Society
Examples of Activities:
• Demonstrate the linkage between discovery and societal benefit by providing specific examples and explanations regarding the potential application of research and education results.
• Partner with academic scientists, staff at federal agencies and with the private sector on both technological and scientific projects to integrate research into broader programs and activities of national interest.
• Analyze, interpret, and synthesize research and education results in formats understandable and useful for non-scientists.
• Provide information for policy formulation by Federal, State or local agencies.

NSF Broader Impact Criterion Workshop
Excerpts from the Project Description of a Sample Proposal

"The project will involve the collaboration of six institutions, two of which are community colleges. The PIs will work with an advisory board made up of materials engineers from different industry sectors. The industry board will contribute ideas for examples, demonstrations, design problems, and laboratory projects. A community college partnership with the lead university and community colleges in the area will be used to solicit input on the modules from the community colleges."

"The modular format of the curriculum will allow the material to be easily adapted to other institutions and even other courses. Curriculum will be developed at one institution and beta tested at another institution. The testing allows verification of the utility and adaptability of the curriculum to multiple universities. The institutions involved in the development and beta testing represent a diverse set of engineering schools, including primarily teaching universities, research universities, and community colleges. They also represent diverse student populations and different campus cultures. For example, the lead university has very large minority and transfer student populations. One of the collaborating institutions has a large population of non-traditional freshman (average age 5-6 years older than the traditional freshmen)."

"Each of the two sets of modules will involve demonstrations that show how materials science and engineering relates to modern technologies. These demonstrations would be ideal for use in recruiting at the high school level. The goal of all of these outreach activities is to excite students about engineering and increase the number and diversity of students entering the field. The modules developed for the Introduction to Materials class have the potential to address this problem. For each module, the PIs will develop a small packet that includes handouts on the relevant materials science and engineering concepts and instructions for a classroom demonstration. These will be distributed to local high schools with a letter encouraging teachers to distribute them to interested students."

"Surveys of freshmen and sophomores who left engineering found that the most important reason cited for women and second most important for men was that the reason for choosing the major was found inappropriate. In other words, a significant number of students were not retained because they no longer felt engineering offered interesting work or many job opportunities. Thus, retention of engineering students may be improved by placing the freshman and sophomore curriculum more in the context of true engineering where they can see these opportunities. Efforts across the nation to enhance the experience in freshmen engineering courses by adding design and/or project-based components are a reflection of this effort."

"Relevant conferences and journals where this work will be presented include American Society for Engineering Education Annual Conference, ASEE/IEEE Frontiers in Education Annual Conference, Materials Research Society Education Symposium, Journal of Engineering Education, and the Journal of Materials Education. The full content of the modules will be placed on CD-ROM. A major engineering publisher will publish the modules."