The Broader Impacts Toolbox Workshop: Helping Researchers Effectively Meet the National Science Foundation's Broader Impacts Criterion

Executive Summary

- Community attitudes and outcomes regarding the broader-impacts criterion could be improved significantly by emphasizing to researchers the motivation for implementing the broader-impacts criterion, and improving applicant, reviewer and program officer understanding of the criterion to produce more consistent application. (Section 3)

  1. **Action Item 1:** Develop a document in a Frequently-Asked-Questions format that clarifies the motivation behind broader impacts and what is expected from applicants. A survey of researchers (funded and unfunded) and reviewers would identify what issues should be addressed. The document could be disseminated via the web and through workshops run in collaboration with professional societies, research and education centers, and universities and colleges.

  2. **Action Item 2:** Encourage and facilitate community conversations about the broader-impacts criterion to encourage disciplines to explore how the broader-impacts criterion applies to their communities. This may take place through NSF-organized opportunities, such as PI meetings, or through gatherings at disciplinary meetings.

- An organized and easily accessible knowledge base for broader-impacts activities would help researchers develop and evaluate effective activities by leveraging existing knowledge and experience. (Section 4)

  3. **Action Item 3:** Develop a Broader Impacts Toolbox that addresses topics such as: what works and the evidence for it, questions that should be addressed before working with particular audiences, evaluation, and dissemination.

  4. **Action Item 4:** Develop a workshop template that can be adapted for different disciplines and used to disseminate the tools to different constituencies via workshops.

- Institution-centered (disciplinary societies, regional networks, colleges and universities, research centers, etc.) infrastructure can be an outstanding resource for assisting researchers in fulfilling the broader-impacts criterion in an effective manner. These organizations leverage existing programs and experience, and have important rolea as bridges between researchers and the results of education research. (Section 5)

  5. **Action Item 5:** Hold workshops to disseminate models of how institutions, disciplinary groups and regional networks can help researchers optimize the broader impacts of their research.

  6. **Action Item 6:** Support networking opportunities for those who have made involvement in broader-impacts activities part or all of their professional responsibilities. Facilitate sharing information such as evaluation data, management tools, and resources.

The Broader Impacts Toolbox Workshop: Helping Researchers Effectively Meet the National Science Foundation's Broader Impacts Criterion

1. INTRODUCTION

1.1. MOTIVATION

In 1997, The National Science Foundation revised its merit review criteria that separated "intellectual merit" from the "broader impacts" of the research. There was, and continues to be, concern in the Science, Technology, Engineering, and Mathematics (STEM) research community regarding the implementation of the broader-impacts criterion.

This white paper describes the outcomes of a workshop held on May 16-17, 2005, supported by the Office of Multidisciplinary Activities of the Mathematical and Physics Sciences Directorate of the National Science Foundation. Twenty-three people representing a range of STEM fields (see Appendix A) met in Arlington, VA, to discuss the issues surrounding the broader-impacts criterion, including how researchers and reviewers understand (or don't understand) the criterion, existing resources that could be more widely disseminated, and the need for new resources. Appendix B contains the questions used to guide the discussion. Prior to the meeting, participants were asked to provide information about their own experiences, resources that might be shared, and their perception of current needs. These answers are archived on the workshop website (http://physics.unl.edu/~diandra/DLP_Group_Website/BIT/BIT.php). Workshop participants included scientists, experts in facilitating broader-impacts activities and professional-society representatives.

This white paper begins by presenting the assumptions underlying the workshop and presents some background material on the origin and specifics of the broader-impacts criterion. Three primary categories of action items were suggested; the action items are listed and each is discussed in detail in subsequent sections.

1.2. ASSUMPTIONS

- Dissatisfaction with the implementation of the broader-impacts criterion among STEM researchers is well documented. There remain philosophical issues in the community as to whether researchers should be required to show anything more than intellectual merit; however, a significant facet of community dissatisfaction arises from a widely held belief that the broader-impacts criterion is unclear and inconsistently applied.
- Few STEM researchers receive preparation for fulfilling the broader-impacts criterion. The knowledge base regarding broader-impacts activities is small and not broadly accessible. Improved resources would improve the quality of the researchers' broader-impacts and make better use of researchers' time and resources.
- Different disciplinary communities are addressing the broader-impacts criterion in different ways. Cross-disciplinary communication will leverage existing resources.
- Most researchers are members of one or more professional societies. They read society publications, and attend and present their work at professional society meetings. Professional societies are an important component in the dissemination of broader-impacts information to STEM researchers.

1.3. GOALS OF THE WORKSHOP

a) **Identify existing efforts and issues across disciplines**. Prior to the meeting, participants were asked to identify efforts in their disciplines that involve researchers in broader-impacts activities, and to identify the needs of their communities. This information was compiled and distributed to participants via the workshop website prior to the meeting.

b) **Determine what types of materials (web, paper or other) are needed to help facilitate meaningful involvement of researchers in broader-impacts activities, the form of those materials and who should be involved in developing them**. Based on the expertise of the participants, we will identify what types of tools are most needed, and the form – hard copy, workshop, web, etc. – that these materials will take.

c) **Dissemination.** We will discuss how these materials could be adapted and disseminated to different audiences, and identify the most effective dissemination paths.

1.4. BACKGROUND

1.4.1. The National Science Foundation Merit Review Criteria

In 1997, the National Science Foundation (NSF) updated the merit review criteria used to evaluate research proposals for allocating funds. The criteria are:[1]

The intellectual merit criterion: ***What is the intellectual merit of the proposed activity?*** How important is the proposed activity to advancing knowledge and understanding within its own field or across different fields? How well qualified is the applicant (individual or team) to conduct the project? (If appropriate, the reviewer will comment on the quality of prior work.) To what extent does the proposed activity suggest and explore creative and original concepts? How well conceived and organized is the proposed activity? Is there sufficient access to resources?

The 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?

NSF staff will give careful consideration to the following in making funding decisions:

Integration of Research and Education

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.

Integrating Diversity into NSF Programs, Projects, and Activities

Broadening opportunities and enabling the participation of all citizens, women and men, underrepresented minorities, and persons with disabilities, are essential to the health and vitality of science and engineering. NSF is committed to this principle of diversity and deems it central to the programs, projects, and activities it considers and supports.

1.5. DEFINITIONS

Some clarification of terminology is appropriate, as some phrases have different meanings in different fields. We therefore refer to activities that fall under the broader-impacts criterion umbrella as *broader-impacts activities*. This is an unfortunately graceless term; however, a major misperception is that the broader-impacts criterion focuses only on education and public outreach. The purposeful use of the term "broader-impacts activities" emphasizes the breadth of the activities meant to be included in broader impacts. Some fields use the terms Education/Outreach (E/O) or Education and Public Outreach (EPO) to denote activities that deal with education and activities for the public. This term represents a subset of broader-impacts activities and should not be used as a synonym for broader-impacts activities.

2. DISCUSSION OUTCOMES

Subsequent sections expand upon each of the following primary discussion outcomes.

- Community attitudes and outcomes regarding the broader-impacts criterion could be improved significantly by emphasizing to researchers the motivation for implementing the broader-impacts criterion, and improving applicant, reviewer and program officer understanding of the criterion to produce more consistent application. (Section 3)
    - **Action Item 1:** Develop a document in a Frequently-Asked-Questions format that clarifies the motivation behind broader impacts and what is expected from applicants. A survey of researchers (funded and unfunded) and reviewers would identify what issues should be addressed. The document could be disseminated via the web and through workshops run in collaboration with professional societies, research and education centers, and universities and colleges.
    - **Action Item 2:** Encourage and facilitate community conversations about the broader-impacts criterion to encourage disciplines to explore how the broader-impacts criterion applies to their communities. This may take place through NSF-organized opportunities, such as PI meetings, or through gatherings at disciplinary meetings.
- An organized and easily accessible knowledge base for broader-impacts activities would help researchers develop and evaluate effective activities by leveraging existing knowledge and experience. (Section 4)
    - **Action Item 3:** Develop a Broader Impacts Toolbox that addresses topics such as: what works and the evidence for it, questions that should be addressed before working with particular audiences, evaluation, and dissemination.
    - **Action Item 4:** Develop a workshop template that can be adapted for different disciplines and used to disseminate the tools to different constituencies via workshops.
- Institution-centered (disciplinary societies, regional networks, colleges and universities, research centers, etc.) infrastructure can be an outstanding resource for assisting researchers

in fulfilling the broader-impacts criterion in an effective manner. These organizations leverage existing programs and experience, and have important rolea as bridges between researchers and the results of education research. (Section 5)

- Action Item 5: Hold workshops to disseminate models of how institutions, disciplinary groups and regional networks can help researchers optimize the broader impacts of their research.
- Action Item 6: Support networking opportunities for those who have made involvement in broader-impacts activities part or all of their professional responsibilities. Facilitate sharing information such as evaluation data, management tools, and resources.

3. The Need for Clarifying the Broader-impacts Criterion

There is widespread confusion about the meaning, purpose, intent, and ways of satisfying the broader-impacts criterion despite the National Science Foundation's efforts to provide guidance to applicants, reviewers and program officers. A primary concern expressed by virtually all recent Committee of Visitors (COV) reports in Mathematics and Physical Sciences (MPS) is that there is a "real potential for inequity caused by a lack of clarity" regarding the broader-impacts criterion.[2] The term 'Criterion 2' has been interpreted by some to imply that broader-impacts are necessarily secondary, whereas the instructions to reviewers explicitly state that the relative weight given to the two criteria is variable. The application and interpretation of the broader-impacts criterion is an area of great concern to the STEM community.

3.1. Background

3.1.1. Changes in the Merit Review Criteria

The old (1981) and new (1997) criteria are summarized in Appendix C which is taken from a National Academy of Public Administration (NAPA) report on the implementation of the new merit review criteria.[3] The revised criteria retain the elements of the 1981 criteria, but add three areas: 1) the creativity and originality of concepts in a proposed activity (incorporated into the Intellectual Merit criterion); 2) the specific intention to promote teaching, training, and learning in addition to advancing discovery and understanding; and 3) broadening participation of underrepresented groups. The last two of these are incorporated into the broader-impacts criterion. It is important to emphasize that the need for societal benefit and contribution to STEM infrastructure were requirements prior to the implementation of the broader-impacts criterion *per se.*

3.1.2. Motivation for the Change

Some researchers view the broader-impacts criterion as an arbitrary dictum. Little in existing broader-impacts-related materials explicitly correlates broader impacts with the health of STEM research. For example:

1. Restructuring the criteria makes the broader impact and societal objectives more visible to the research communities *and* to Congress. The current budget situation emphasizes the need to provide policy makers with arguments they can use to justify funding increases for STEM research.
2. US demographics are undergoing a marked change as racial and ethnic minorities comprise a larger fraction of the total population. The US Census Bureau predicts that, by 2050,

Hispanics/Latinos are projected to comprise 24% of the total population and African-Americans will comprise 13%. Continuing the historical under-representation of members of these groups in STEM fields will decrease even further the talent pool from which STEM disciplines and industries can draw. This is critical to the establishment of a qualified STEM workforce, and to maintaining our leadership in STEM research.

3. A high percentage of those pursuing STEM graduate degrees are from outside the United States. Improving STEM infrastructure in other countries means that more of these students will return after receiving degrees, and fewer students will leave their home countries to pursue education in STEM disciplines. Difficulties in obtaining visas will add to the decrease in influx of foreign talent to US STEM programs and industries, as already indicated by a decrease in the number of non-US applications to some STEM graduate programs.[4, 5] Lack of talent will make it more difficult for the US to maintain its position as the global STEM leader.

4. One rationale for the involvement of STEM researchers with K-12 education is that U.S. superiority in STEM research has rested on the excellence of its higher education institutions; however, global comparisons show that the US lags behind other countries in STEM education at the K-12 level.[6] Continued excellence of STEM research and education will be unsustainable if the scientific research community does not engage in significant partnerships with K-12 schools to improve their capacity to implement consistent, high-quality STEM instruction. Few K-12 school systems have the expertise or experience to do this solely from internal resources, and the STEM research community is unlikely to be pleased with outcomes not developed in collaboration with STEM researchers.

5. A science-literate public is critical to increasing community support for science funding, and for making well-reasoned decisions about STEM issues such as low-level radioactive waste dumps, global climate change, stem-cell research, and a host of other topics that will be of increasing importance.

Emphasizing the rationale for the broader-impacts criterion will emphasize its importance to the sustainability of STEM research in the US.

3.1.3. Implications for the Review Process

A primary concern of researchers is that the lack of clarity regarding broader impacts leads to inconsistent application of the criteria in the merit review process.

NSF's Attempts to Clarify the Use of the Broader-Impacts Criterion. NSF has made several changes to encourage equitable usage of both criteria in the review process. In FY 2001, FastLane was modified to include two separate response boxes in which reviewers are required to address each criterion separately. Explicit instructions to reviewers request "detailed comments on the quality of this proposal with respect to **each** of the two NSF Merit Review Criteria". Effective October 1, 2002, NSF returns without review proposals that do not separately address both merit review criteria in the one-page Project Summary and reiterates that the broader impacts of the proposed project must be addressed in the Project Description and described as an integral part of the narrative.

Use of Both Criteria by Reviewers. An internal NSF task force found that, from a sample of FY01 reviews, approximately 69% of reviews provided evaluative comments in response to the broader-impacts criterion.[7] In FY02, 84% of reviews contained information in both the intellectual merit and broader impacts text boxes, with this number rising to 90% in FY03.[8] Important, however, is that these numbers do not reflect the *quality* of information contained in the reviewer boxes or in the proposal. A number of Committee of Visitors (COV) reports find that, in addition to omitting entirely the broader-impacts criterion, some reviewers did not evaluate the broader impacts based on the stated program guidelines[9] and some reviewers identified broader impacts on behalf of applicants who did not explicitly address this criterion in their proposals,[2, 10] Additionally, they found inconsistency between panel and mail reviews (with panel reviews providing more consistent evaluation of broader impacts than mail reviews) and an overall lack of understanding of the review criteria by reviewers.[9, 11]

Use of Both Criteria by Program Officers. Similar inconsistencies are reported in the use of both merit criteria by program directors in justifying funding decisions. In FY02, approximately 78% of program officer review analyses commented on aspects of both merit review criteria.[12] A statistically determined sample of FY03 review analyses found that approximately 53% of review analyses contained comments on both merit review criteria.[13] (The FY03 review differed from the FY02 review in that it distinguished between substantive reviews that comment on specific material in the proposal and summaries that contain only reviewer and/or panel comments, or contain generic or boilerplate analysis not specific to the proposal).

Specific Issues. The NAPA report points out that the extensive list of activities that qualify for broader impacts suggests a check off list in which each item must be addressed.[3] COV reports also suggest that the breadth of possible activities makes it difficult for reviewers to consistently evaluate and compare the broader-impacts portions of proposals.[9] The metrics for performance in the broader-impacts area are ‘much less well defined than those for intellectual merit’.[9] Some criteria listed under ‘intellectual merit’ (such as qualifications of the applicant in executing the project and access to resources) apply equally to broader impacts.

3.2. Action Item 1: Develop and Disseminate a FAQ-Format Document to Directly Address Common Misconceptions Regarding Broader Impacts.

A short Frequently Asked Questions (FAQ) format guide should be developed to directly address common points of confusion regarding the broader-impacts criterion. Some items that need to be addressed are known from, for example, Committee of Visitor reports to NSF; however, a survey of researchers (funded and unfunded) and reviewers would pinpoint areas in need of clarification. Examples of issues to be addressed include:

- Broader impacts must be/must include/are limited to involvement with K-12 education.
- Broader-impacts activities must be new/original/innovative and should be judged by the same criteria as a research project.
- All proposals must have a separate broader-impacts activity that addresses education and outreach.

The STEM community opinion about the implementation of the broader-impacts criterion has not been checked since the 2001 NAPA report, which concluded in part that the criteria were too new at that time to make a judgment. Since almost ten years have passed since the introduction of the revised criteria, it may be time to re-assess community perceptions. The first step, therefore, is a survey of applicants (funded and declined) and reviewers to determine the most commonly held misconceptions. Since some NSF divisions include broader impacts as a significant part of their outreach to their constituencies, information could be obtained at these venues.

Format. We suggest a FAQ format, similar to that used in the *Guide to Engaging Scientists and Educators in Education and Outreach* (Draft) developed by the Centers for Ocean Science Education Excellence (COSEE), part of which is shown in Appendix D. The *Engager's Guide* is a much broader document that serves scientists and education/outreach facilitators, but the general format is ideal for the proposed purpose. NSF uses a similar format for FastLane questions. Since the broader-impacts FAQ is likely to be longer, it should be segmented into topical divisions.

The guide should include information on the motivation and rationale behind the broader-impacts criterion, as discussed in Section 3.1.2. (The National Academy's Diversity Builder's Toolbox includes statements on this issue.[14]) Each answer would be supported by NSF-generated materials, including the statement of the criterion and the examples provided. Not all points of confusion can be clarified on the basis of these resources, but a significant number of misconceptions can be dispelled. Some questions (e.g. "What is the correct weight of broader impacts vs. intellectual merit?"; "What part of the budget (if any) should be allocated to BI activities?") should be raised and discussed in the context of emphasizing that NSF-produced materials do not offer much guidance and interpretation may vary from program to program. The need to communicate with the NSF program officer for the program to which the proposal is submitted needs to be emphasized because of program-to-program variations.

Dissemination. The guide could be made available over the web and as a hardcopy publication. Professional societies, research journals, PI meetings, research/education centers, and universities could be valuable dissemination points, by directing members to the guide, and/or by incorporating it into proposal writing and broader-impacts criterion workshops.

3.3. ACTION ITEM 2: COMMUNITY DISCUSSION OF THE BROADER-IMPACTS CRITERION

Although the proposed FAQ should help reduce confusion about addressing broader impacts, deeper philosophical issues remain. The NAPA report makes the following recommendation:

> *"Address the intellectual and philosophical issues the objectives of the new criteria raise in appropriate public forums, both to clarify the meaning and application of the objectives, and to generate consensus about their use. …Appropriate public forums in which these underlying issues are debated will eventually accomplish more than attempting to improve understanding solely through one-way directives from NSF."*[3]

Some NSF divisions already sponsor these conversations, often in collaboration with professional societies. The Division of Mathematical Sciences (DMS) sponsored a meeting co-organized by four professional societies at which broadening participation was a major theme. A session at the January 2005 American Mathematical Society/Mathematical Association of America Joint Mathematics Meeting addressed broader impacts through a DMS re-enactment of a review panel.[2] The Division of Chemistry engaged Advisory Committee members to identify broader-impacts nuggets (which included issuing a 'Dear Colleague' letter (NSF 04-045) asking PIs to submit broader-impacts nuggets). PIs presented their work at a broader-impacts poster session at the 2005 Fall ACS National Meeting in Washington, DC.[15] A number of NSF divisions have worked with professional societies to place articles about BI in their news periodicals.[2, 11] The previously suggested FAQ would provide a starting point for such forums so they can focus on real issues within communities and not misinterpretations. These types of meetings are important and valuable ways of educating the community, and of getting feedback. Those units within NSF that are initiating and sustaining these types of outreach efforts should be commended for their initiative. NSF-sponsorship of these sessions may attract a group of participants that otherwise would not attend a meeting or workshop on broader impacts.

4. The Broader Impacts Toolbox

4.1. Background

Researchers undergo extensive training to become discovers of new knowledge; however, few receive training to help them identify and leverage the broader impacts of their research. The idea of a toolbox encompasses three parts: the tools *per se*, making sure people know where to find the tools, and teaching people how and when to use them. Taking the metaphor one step further, the toolbox can be filled with general information on what constitutes broader impact, examples of broader impact projects that have proven effective, options for leveraging existing programs, guidance on creating new programs or products, and resources to aid in assessing the effect of an effort. The toolbox materials will emphasize what already has been done so that researchers can build on the successful ideas and avoid those that have been shown to be less effective. Given the appropriate tools, easy access to the toolbox and adequate information for utilizing the tools, the net result should be demonstrable improvement in the overall quality of proposed and executed broader impact components.

4.2. Action Item 3: Develop a Broader Impacts Toolbox

The lack of a centralized resource for sharing information on broader-impacts efforts leads to well-intentioned but misguided broader impacts activities that often re-invent materials that already exist, lack a meaningful evaluation component, and ignore the results of current research. The public discussions and survey proposed earlier will help guide the topics to be included. Regardless of topic, however, each tool must be specific and brief so that a researcher can find quickly the information by searching on topic, audience or content. Each tool must include sections on background materials, what has already been done, evaluation, dissemination, and the research base. These materials have implications beyond the broader-impacts requirements for research proposals: they may be very useful to those writing proposals in which education and/or outreach are the primary emphases. (CCLI, GK-12, IGERT, REU, etc.)

4.2.1. Building a Knowledge Base

Many researchers have expressed concern that the results of broader-impacts activities are not commensurate with the time required to implement them. Addressing this question head on has been an important factor in the success of curricular reform in various STEM disciplines. Discipline-based education research that develops standardized assessments and methodologies is convincing increasing numbers of researchers to adopt and adapt new teaching methods. Few broader-impacts activities have a comparable knowledge base, and many of those that do are not readily accessible to the average STEM researcher. In some cases, researchers' lack of familiarity with educational terminology makes it difficult for them to apply the information. Interpreting and incorporating these results in the toolbox will help researchers understand the likely impact of their involvement in an activity.

Examples of the type of materials that would be included are:

- A recent evaluation of NSF-sponsored undergraduate research opportunities shows specific data as to the effectiveness of these opportunities in broadening participation, the types of activities undergraduates are involved in, and the motivation of undergraduates and faculty sponsors for being involved with undergraduate research.[16]
- A research project to understand the impact of Research Experiences for Teachers (RET) programs is in progress and has released a preliminary report[17] addressing how the experience changes the teachers' classroom performance and ultimately impacts student performance.
- There is a benefit to researchers who participate in these types of activities. Positive effects such as improving researchers' communication skills and increasing the accuracy of scientific information communicated to others have been reported.[18, 19]

Few data are available regarding broader-impacts activities outside education and outreach projects. For example, information about broader impacts that involve technology transfer and intellectual properties is very hard to find.[11] Accumulating this type of data will improve the community's understanding of the value and nature of the broader-impacts criterion.

4.2.2. Case Studies

Many NSF divisions provide examples of broader-impacts activities. (See Appendix E) Developing case studies of a range of projects would be immensely helpful for researchers, as it shifts the emphasis from picking out of a list of options to asking why a project was chosen, how it was executed, and whether it 'worked'. Covering a range of different types of projects and why those projects make sense in particular situations shows researchers a broader range of possibilities, and provides information about the resources needed. Framing the case studies around these questions models the thought process that goes into writing such projects in a proposal.

4.2.3. Examples of Possible Toolbox Topics and Structure

Some main areas that emerged from the workshop that include:

1. Working with K-12;
2. Working with the public;
3. Industrial outreach;
4. Broadening participation;
5. Incorporating current topics in research into college-level classrooms (introductory courses, majors courses, graduate courses);
6. Using disciplinary education research to improve learning in college-level classrooms;
7. Running and evaluating REU programs;
8. Interacting with industry to enhance graduate student and/or undergraduate student education.

Some suggestions for format and overall philosophy include:

- Each tool should include a mechanism (such as a flowchart) that can help researchers decide whether that particular type of project best suits their needs, interests, and available resources. The National Academy of Sciences has sample questions along these lines on their RISE site.
- Each tool should present a list of questions to allow the researcher to determine whether he or she has the resources necessary to execute the project. (See Appendix F for a draft example.)
- Each section needs the equivalent of a literature review to document what has been done by others and what their results were. This information would improve the effectiveness and efficiency of broader-impacts efforts. A mechanism for keeping this information current must be developed.
- Each tool should discuss how to include the broader impacts in the proposal, how to assess what the broader impacts actually are, and suggestions for disseminating project results.
- Existing materials (such as the Diversity Toolbox in the Chemical Sciences[14]) should be leveraged and extended to other fields. Although not all projects are translatable between fields, sharing information can minimize duplication of effort.
- These materials must use the language of researchers. A dictionary of specialized terminology and acronyms relating to broader impacts would especially benefit new faculty members.
- Ways to broaden participation should be addressed in each of the tools, as well as being a topic in and of itself. This is a great opportunity to familiarize researchers with results from existing projects.

4.3. *Action Item 4: Teaching People to Use the Tools*

The second and third components of the toolbox are ensuring people know the tools are there, and showing them how to use the tools. A workshop highlighting how to find and use the toolbox must be developed. A standardized slide presentation that can be modified for particular audiences will ensure a consistent message. Dissemination could occur through professional society meetings, university proposal-writing workshops, content workshops, and new-faculty workshops.

5. Leveraging Infrastructure

5.1. *Background*

5.1.1. *Broader-impacts Professionals*

A growing number of people have as a significant fraction of their job coordinating, executing and/or evaluating activities that fall under the broader-impacts umbrella. This group includes education/industry/outreach coordinators at research centers and national laboratories, officers and volunteers of disciplinary societies, and faculty members with strong individual interests in broader-impacts issues. Regardless of whether these people come from STEM content or education backgrounds, they share the common philosophy of approaching these activities as intellectual endeavors.

This group has an extremely high potential to facilitate creative and effective broader-impacts activities that include researchers in a meaningful way, especially if they can leverage researcher participation in existing activities such as IGERTs, Math-Science Partnerships, GK-12 projects and digital libraries. The scope of the involvement may range from assisting individual investigators with designing and executing broader-impacts activities or involving them in existing appropriate activities, to managing the broader-impacts activities for an entire center.

There are a number of challenges in enabling this group to make a significant contribution: not only lack of a knowledge base regarding broader-impacts activities, but also evaluation of these activities, lack of professional outlets (journals, conferences, etc.) for sharing information and lack of a career path and reward structure.

5.2. ACTION ITEM 5: DISSEMINATE MODELS FOR INFRASTRUCTURE SUPPORT

There are many models for centers that can facilitate the involvement of researchers in the types of activities that satisfy broader impacts. These centers may be located at an institution (such as a university), or be discipline based (perhaps run by a professional society). Discipline- or regionally based infrastructure is critical for access to those at institutions that cannot support such infrastructure on their own. A conference bringing together people who have established such centers and those interested in establishing similar infrastructure (or taking advantage of that infrastructure) would facilitate sharing experiences and resources. A broad range of models should be presented and a monograph produced for the benefit of those who cannot attend. The idea of a partnership (and not transferring of responsibility) must be emphasized.

5.3. ACTION ITEM 6: FACILITATE NETWORKING OPPORTUNITIES

There currently are few mechanisms for exchanging information and resources about broader-impacts activities, especially across disciplines. Traditional structures reward activities such as publishing in journals and presenting papers at conferences: establishment and recognition of such forums for broader-impacts activities would leverage the existing knowledge base, form links between disciplines, and generate new material for the knowledge base. NRCEN (the National Science Foundation Research Center Educators Network) is an example of one such group, which involves people working in NSF science and engineering research centers.(http://www.outreach.caltech.edu/NRCEN/). Possibilities that could be explored include meetings (virtual or face-to-face), websites, dissemination outlets, integration with the research community, and generation/updating of the knowledge base.

It is to NSF's benefit to support and publicize the activities of groups such as NRCEN and their equivalents in other disciplines. One organization may not be the best approach because of disciplinary differences; however, an interdisciplinary approach to dissemination via an on-line journal or national meeting would be a good linking mechanism. Support of a national coordinator who could devote some reasonable fraction of his or her time toward organizing such a framework would be a valuable start.

6. NEXT STEPS

This white paper identifies six action items. The breadth items proposed indicates the varied interests and expertise of the workshop participants and the communities they represent. The logistics of managing a project this ambitious are likely to be complex. They include relatively simple matters, such as geographical limitations, but also more serious issues such as the culture differences between different disciplines, culture differences between STEM researchers and those whose primary focus is broader impacts activities, how to collect and organize widely dispersed information, how to best communicate the information, and ensuring the quality of the resulting materials.

While enthusiastic and capable people believe that the steps produced here will produce higher-quality broader-impacts components that make more effective use of researchers' time and talents, history shows that there are serious issues regarding the implementation (and sometimes lack of implementation) of the broader-impacts criterion. The efforts proposed here will be for naught if reviewers and NSF program officers do not apply the broader-impacts criterion in a consistent manner. Applicants have a vested interest in fulfilling the BI criterion; however, some reviewers still do not understand the criterion or apply the criterion inconsistently. If applicants feel that their efforts to satisfy the 'spirit of the law' in addressing the BI criterion are being ignored by reviewers and/or program officers, they will have no reason to continue to attempt to satisfy the BI requirements. Ultimately, the primary responsibility for ensuring that the broader-impacts criterion is addressed and executed meaningfully lies with NSF Division Directors and Program Officers.

7. APPENDICES

APPENDIX A: PARTICIPANT LIST

Bell, Jerry, Senior Scientist, American Chemical Society

Buhr, Susan, Director, Cooperative Institute for Research in Environmental Sciences (CIRES) Outreach and Education Program, University of Colorado Boulder

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Fortenberry, Norman, Director, Center for the Advancement of Scholarship on Engineering Education, National Academy of Engineering

Hall, Michelle, President, Science Education Solutions

Hehn, Jack, Director, Education American Institute of Physics

Holtz, Mark, Professor Department of Physics Texas Tech University

Karsten, Jill, Education and Career Services Manager, American Geophysical Union

Leslie-Pelecky, Diandra, Associate Professor, Department of Physics & Astronomy Center for Materials Research & Analysis University of Nebraska

Lichter, Robert L., Merrimack Consultants, LLC

Manduca, Cathy, Research Associate, Geology Department, Carleton College

Massey, Christine, Director of Precollege Research and Education, Institute for Research in Cognitive Science, University of Pennsylvania

Mogk, David, Professor Department of Earth Sciences Montana State University

Morrow, Cherilynn, Education and Outreach Broker/Facilitator for **NASA's** Office of Space Science, Space Science Institute

Pak, Dotti, Education/Outreach Coordinator, Materials Research Laboratory, University of California, Santa Barbara

Peach, Cheryl, Academic Coordinator , The California Center for Ocean Sciences Education Excellence, Scripps Institution of Oceanography, Birch Aquarium

Pearson, J. Michael, Associate Executive Director, Director of Programs & Services, Mathematical Association of America

Pearson, Jr., Willie, Professor and Chair, School of History, Technology, and Society, Georgia Institute of Technology

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APPENDIX B: DISCUSSION QUESTIONS AND INSTRUCTIONS

Introduction

The NSF broader-impacts (BI) criterion have resulted in science, math, engineering and technology (STEM) researchers paying greater attention to how their research projects have a broader effect on the world in general. BI covers a wide range of projects: one way to classify them might be according to the familiarity of the STEM researchers with the target audiences and/or the delivery mode: high comfort level (sharing data and programs; mentoring graduate students) to medium comfort level (working with undergraduates in research; translating research results to an undergraduate majors classroom) to low comfort level (translating research results for use in a middle-school classroom). The preparation of researchers for dealing with different audiences and types of projects varies and they value projects differently according to their own interests. Excluding the high-comfort-level projects that tend to be very specific to each sub-discipline, we can group the remainder of the projects under the term Education/Outreach (E/O).

Although some of the discussion questions focus specifically on NSF-BI-related issues, keep in mind that, if NSF decided tomorrow that the broader-impacts criterion should be eliminated, there still would be STEM researchers who want to communicate their results to the public, work with K-12 students and teachers, and/or improve how they teaching undergraduates. STEM researchers interested in writing proposals for informal science activities or curriculum development also could benefit from the same set of tools as those who are trying to meet the BI criterion.

Although we will visit explicitly issues surrounding broadening participation in science, please keep the questions of increasing diversity in mind throughout your conversations.

Most of the workshop will consist of breakout sessions by table. About 45 minutes will be spent working in the table-level group. We suggest that the first 30 minutes should be brainstorming and the last 10 minutes be devoted to making two lists on the paper provided at your table. The 'A' list should have your table's primary conclusions. The 'B' list should have any questions that were raised during the discussion that you feel need to be addressed. The last 15 minutes will consist of reports from the tables and discussion. We intend for the lists to form the outline of the white paper that is to result from this workshop. The questions for the tables follow. Table assignments will be made at the workshop.

BREAKOUT 1: GOAL SETTING:

Please answer these questions on the index cards provided, and then discuss as a table.

1. Why did you, personally, agree to come to this meeting?
2. What do you hope to take away from the meeting?
3. What would you like to see accomplished by the time we finish tomorrow?
4. What do you think are the long-term indicators that this meeting was worthwhile?

BREAKOUT 2: COMMUNITY ATTITUDES TOWARD BI AND REWARD STRUCTURE

Table 1: Do researchers understand NSF's broader-impacts requirements? If not, what aspects do you think need clarification or expansion? If you were to write a FAQ targeting STEM researchers seeking to satisfy the NSF broader-impacts criterion, what questions would you include?

Table 2: What makes a BI project 'successful' and how can STEM researchers be held accountable for their BI projects? What metrics might reviewers use to judge whether a applicant satisfied the BI criterion of their last proposal?

Table 3: What makes a BI project 'successful'? What type of information could help reviewers (most of whom are experts in research and not in E/O) determine whether BI projects proposed are likely to be 'successful'? Are there particular types of projects that should be discouraged (and why)?

Table 4: What can be done to recognize and reward STEM researchers who successfully address broader-impacts issues? Are there organizations prepared to take the lead? What leverage can be brought to bear on institutions, professional societies, etc. to value E/O work done by their STEM researchers?

Table 5: How can institutions or professional societies provide infrastructure to help STEM researchers run effective E/O projects? What arguments can be made to institutions as to why they should make such an investment? Are there examples of organizations successfully providing this infrastructure?

BREAKOUT 3: ESSENTIAL QUESTIONS TO BE ASKED BEFORE PLANNING A PROJECT.

Table 1: Compile a list of questions that a researcher considering a project that involves graduate education (for example, planning internships for graduate students in industry or government, or increasing the diversity of graduate students at their institution by developing a summer bridge program for undergrads from minority-serving institutions) should ask prior to deciding to go ahead with the project. Are any of these questions discipline specific? Are there resources readily available to help the researcher answer the important questions?

Table 2: Compile a list of questions that a researcher who is considering a project that involves teaching or mentoring undergraduates (for example, developing a course for majors that focuses on nanotechnology or starting an REU program) should ask prior to deciding to go ahead with the project. Are any of these questions discipline specific? Are there resources readily available to help the researcher answer the important questions?

Table 3: Compile a list of questions that a researcher who is considering a project that involves working with teachers (for example, offering a professional development workshop or developing a course for future teachers) should ask prior to deciding to go ahead with the project. Are any of these questions discipline specific? Are there resources readily available to help the researcher answer the important questions?

Table 4: Compile a list of questions that a researcher who is considering a project that involves working with K-12 students (for example, starting an after-school science club or developing a curricular unit) should ask prior to deciding to go ahead with the project. Are any of these questions discipline specific? Are there resources readily available to help the researcher answer the important questions?

Table 5: Compile a list of questions that a researcher who is considering a project that involves working with the public (for example, developing an exhibit for a local science museum or starting a newspaper column to answer science questions) should ask prior to deciding to go ahead with the project. Are any of these questions discipline specific? Are there resources readily available to help the researcher answer the important questions?

Breakout 4: Preparing Researchers for Participation in EO

Table 1: What do faculty, graduate students and/or postdocs gain from participating in E/O projects? Do any of the skills or knowledge transfer into better research? Are there other, perhaps less altruistic, benefits to participation?

Table 2: What projects/resources exist to prepare researchers for participation in EO? Are there projects that could serve as models? How transferable are the materials across disciplines and/or institutions?

Table 3: In the broker model, an E/O professional directs the E/O aspects of the grant and coordinates with the STEM researcher. What are the advantages and disadvantages of this type of model compared to a STEM researcher running his or her own project? Does a broker model circumvent the intent of the BI criterion?

Table 4: How do E/O professionals communicate? What mechanisms exist for sharing information and resources? Do E/O professionals and STEM researchers involved in E/O projects have different enough needs that separate networks would be beneficial?

Table 5: How E/O professionals help educate researchers regarding possible ways to increase diversity and the reasons for the lack of diversity? Is there discipline-to-discipline variation in terms of the needs and approaches to increasing participation?

Breakout 5. Collecting Resources

Table 1: A lot of resources that might be helpful to STEM researchers already exist. If you were designing a database to hold these resources, what type of information would you include? How would you vet the quality of the projects? Would inclusion be a sign of quality that STEM researchers can cite as recognition of the quality of their BI project in their next grant?

Tables 2: One type of resource that has been made available to STEM researchers is examples of BI projects from successful grants. How can these resources be most useful to STEM researchers? How would you vet the quality of the projects?

Table 3: A number of resources cite ‘best practices’ for enhancing diversity. Is it sufficient to compile a list of these websites/resources? If additional information is necessary for these ‘best practices’ to be useful to the researcher, what type of information would have to be provided?

Table 4: Many websites have lists of materials such as applets, problems for cooperative problems solving, etc. that can be used in improving teaching undergraduates. Is pointing to those resources sufficient? If not, what additional information should be provided to make them useful to the STEM researcher?

Table 5: Many larger centers (such as Science and Technology Centers (STCs), Engineering Research Centers (ERCs) and Materials Research Science and Engineering Centers (MSRECS) have significant E/O efforts. Can results from these centers be leveraged to benefit individual STEM researchers?

Breakout 6. Educational Research and Evaluation

Table 1: Are there specific instruments that could be used by individual STEM researchers for evaluating ‘stock’ activities (such as undergraduate research)? How can the researcher determine whether his or her project is ‘working’ without spending an inordinate amount of time?

Table 2: Develop a checklist of questions that a researcher could use *post facto* to evaluate whether their project ‘worked’.

Table 3: Have there been studies that could inform STEM researchers as to the potential impacts of a specific type of project? Is there a need for overarching research programs to determine the efficacy of specific types of E/O projects? Is it feasible for an educational researcher to work with a group of

individual STEM researchers engaged in a specific type of project (for example, professional development for graduate students)?

Table 4: How do you make (and support) connections between educational evaluators/researchers and STEM researchers?

Table 5: Proposals rarely have money to fund meaningful research or evaluation of projects. Are there ways to make collaborations between SMET researchers and education researchers beneficial for both parties?

BREAKOUT 7. DISSEMINATION.

Table 1**:** Will STEM researchers attend free-standing (i.e. not attached to an existing professional meeting) workshops focused on improving their participation in education and outreach? Would single-topic workshops that focus on one particular topic (for example, communicating research to a general audience) be more helpful than broader workshops that try to give a broad overview of all variations? What incentives are needed (financial or otherwise)? If incentives are needed, where do you get them and how do you sustain them? Who could organize and execute such workshops?

Table 2: Are there existing mechanisms to support activities directly intended to produce documentation and publication of E/O efforts? What mechanisms would be most effective? If such mechanisms don't exist, what institutions might be most appropriate to support such projects?

Table 3: NSF encourages submission of BI projects to Digital Libraries. How can STEM researchers learn about Digital Libraries for which their BI projects would be appropriate for submission? Would acceptance of the project be a way for the researcher to show success? Are these projects held to different standards than projects such as a CCLI or ISE grant?

Table 4: How can professional societies help with dissemination? How discipline specific are the basic principles of doing good E/O?

Table 5: Are websites sufficient mechanisms to communicate the information STEM researchers need regarding E/O? What type of supplementary materials might be necessary to make the website more effective?

APPENDIX C: THE CHANGE IN REVIEW CRITERIA

1981 Criteria		1997 Criteria
Criterion 1 **Research Performance Competence**		**Criterion 1** **Intrinsic Intellectual Merit**
Capability of proposer	→	Qualifications of proposer
Technical soundness of approach	→	Well-conceived and organized activity
Adequacy of institutional resources	→	Sufficient access to resources
Recent research performance	→	Quality of prior work
Criterion 2 **Intrinsic Merit of the Research**		
Leads to new discoveries or advances within own field or impacts other fields	→	Advances knowledge and understanding within own field or across different fields
	New	Explores creative and original concepts
Criterion 3 **Utility or Relevance of the Research**		**Criterion 2** **Broader or Societal Impact**
Contributes goals extrinsic to research field, basis for new technology	→	Disseminates results broadly to enhance scientific and technological understanding
Assists in solution of societal problems	→	Proposed activity benefits society
Criterion 4 **Effect on Infrastructure of S & E**		
Contributes to S&E infrastructure: research, education, human resource base	→	Enhances infrastructure for research and education: facilities, instrumentation, networks, partnerships
	New	Promotes teaching, training, and learning
	New	Broadens participation of underrepresented groups (gender, ethnicity, disability, geographic)

Comparison of the 'old' and 'new' merit review criteria.[3]

APPENDIX D: COSEE FAQ

III. FAQ for Scientists

General Questions:

1. What is COSEE?
The Centers for Ocean Sciences Education Excellence (COSEE) is a network of seven regional centers that act locally and regionally, as well as dream, think and act nationally. The goals of COSEE are to: promote the development of effective partnerships between research scientists and educators; to disseminate effective ocean sciences programs and the best practices that do not duplicate but rather build on existing resources; and to promote a vision of ocean education as a charismatic, interdisciplinary vehicle for creating a more scientifically literate workforce and citizenry.

2. What is Education and Outreach (E&O)?
Involving scientists in education and outreach is a topic receiving considerable attention as the National Science Foundation and other funding agencies focus on the broader societal impacts of the research that they sponsor. In order to understand how to get involved in education and outreach (E&O), it may be helpful to define what we mean by these terms.

The goal of education is to increase one's *understanding* of a topic. Science education is usually equated with the learning that takes place in a formal (K-16 classroom) or informal setting (aquarium, museum, science center, etc.).

Outreach, on the other hand, focuses on raising *awareness* of a particular topic or issue. Outreach can take many forms (from contributing to a fact sheet to speaking to a rotaryclub) and may be targeted to many different audiences (from homeowners to policy makers).

Together these areas are referred to as Education and Outreach (sometimes written as E&O, E/O, or just EO).

3. What is in it (E&O) for me?
In 1997, the National Science Board approved the use of two merit review criteria for NSF proposals including 1) the intellectual merit of the proposed activity, and 2) the broader impacts resulting from the proposed activity. In October 2002, the National Science Foundation (NSF) began the policy of returning proposals that did not include the required Broader Impact Statements (BIS). This shift in policy by the agency has now made it profitable for research scientists to participate in E&O projects as a way to satisfy Criterion #2. Many federal funding agencies have adopted similar policies.

Most scientists are passionate about the process of scientific inquiry and learning and have an innate desire to share their expertise with others. Participating in E&O activities can be both personally and professionally rewarding.

4. Do you (COSEE) do the E&O?
Yes and no. COSEE supports and strives to disseminate programs that are examples of best practices within the ocean science education community. Many COSEE PIs and staff are ready and willing to work with you to craft and implement new E&O programs. However, a primary mission of the COSEE network is to *catalyze* relationships between scientists and educators so as to capitalize on infrastructure and programs that already exist, and that would benefit from the participation of a scientist. COSEEs throughout the nation have an impressive and growing network of education partners and associates that are poised to work with the research community. By connecting researchers with exemplary E&O partners, scientists gain access to professionals who have expertise in translating research topics into concept-centered programs, exhibits and online resources, and to a diverse student, teacher and public audience.

5. Do you really think that including E&O will give me any advantage in the review process?
The answer is......it depends! There are lots of variables in the proposal review process. There is no question that in large multi-million dollar awards, a good E&O section will enhance your chances of getting funded. Although the validity and importance of the research are still paramount (as it should be!), NSF and other funding agencies are starting to place more emphasis on the broader impact of your proposed research. The level of attention paid to E&O is still very much in the hands of the agency panels and program managers.

6. My science is extremely complex. How can I hope to base an E&O project on my work when it is difficult for some of my colleagues to understand?
One of the major benefits of working with professional science educators is that they are experts at translating complex scientific concepts into materials appropriate for a variety of audiences. Also realize that the goal for most E&O projects is not to teach the details of your work, rather it is to convey the excitement of your science. Often the projects that will evolve out of your partnership with a top-notch educator are based on the general concepts that underlie your research, not the detailed research itself. You will find that good educators are extremely facile with extracting the most exciting and relevant (to the lay audience!) components of your work for inclusion in quality E&O.

7. I don't like interacting with people. Are there E&O opportunities that will work for me?
There are a wide variety of opportunities to disseminate the results of your research and your contributions to science. For example, you might want to contribute to publications. Publications can take many forms from print to web-based materials. Options abound:

- You could write the piece, or you could be interviewed.
- It could be short like a fact sheet, or longer as in a magazine feature story.
- Potential audiences range from K–12 students to policymakers to the general public.

You can also explore contributing your data or research findings to educational products or museum exhibits. A COSEE facilitator can help you find the right fit for you.

Time commitment, funding and other proposal writing logistics:

8. Does COSEE have money to support my E&O efforts?
COSEE does not have money to support individual researchers E&O efforts, but we are glad to provide you with information on how you can contribute to existing efforts at little to no cost to yourself. A better approach is to budget for high quality E&O in your research proposal. ➡

FAQ for Scientists (continued from previous page)

9. Do the funding agencies support inclusion of $$$ for E&O in research proposals?
Although policies on this vary among agencies and even among divisions and programs within a single agency, the short answer is, "Yes". We all acknowledge that conducting research requires money for salaries, equipment, travel, etc. Reviewers, panelists and program officers are increasingly recognizing that designing, executing, evaluating and disseminating quality E&O programs also require funding. In fact, the sincerity of PIs who promise results with respect to E&O but fail to include sufficiently detailed plans and budgetary requests may be in question. We encourage scientists and their education-focused partners to allocate sufficient funds to carry out their E&O plans. Doing so helps ensure success of the E&O program, and also sends a clear message to the funding agencies and the scientific community that there are real costs associated with quality E&O.

10. How much does NSF expect us to contribute in time and/or funding for broader impact?
First, remember that Criterion #2 is very broad in scope and can be satisfied in many ways, one of which is E&O. The allocation of time and money should fit the work proposed. While successful NSF proposals have allocated as much as 50 percent of the total budget to E&O (including the PIs time), a more reasonable ballpark figure is 2-10 percent.

11. Are there minimum requirements in terms of budgeting for E&O for COSEE to work with us?
The policy on this may vary among the regional Centers that make up the national network. California COSEE does not have such a requirement at this time.

12. With space limited to 15 pages, is there any way to more fully describe the E&O component without using up space in the project description?
We appreciate that space is often at a premium in a proposal. In addition to writing succinctly, we can be creative in providing details about the proposed E&O plan in support letters and facilities description forms as well as hypertext links to relevant websites. Please be aware however, that many reviewers focus exclusively on the Project Description. Hence it's best to include fundamental information in the body of the proposal.

13. I am a faculty member with a full teaching load and very little time. Can my graduate student fulfill my broader impact requirement by participating in an E&O activity?
Absolutely! In fact, NSF encourages the participation of graduate students in E&O activities. NSF has a document that provides examples of how this can be done effectively: www.nsf.gov/pubs/2003/nsf032/bicexamples.pdf.

14. I am submitting my proposal to Division/Directorate X/Y in NSF. What are their particular requirements with respect to Broader Impact?
All NSF proposals are required to address merit review Criterion #2 – Broader Impact. Having said that, you should know that the extent to which Criterion #2 is scrutinized within the review process varies throughout the Foundation – variation that to some degree reflects the community of scientists within that discipline. Speaking with a Program Director is advisable when you need information on how Criterion #2 is treated for individual programs. Also remember that Criterion #2 is very broad in scope and can be satisfied in many ways, one of which E&O.

15. Do you assist with E&O components for funding agencies other than NSF?
Yes, we would be pleased to assist in the preparation of proposals to other funding agencies and private foundations. We are as happy to help you spend funds from NASA, NOAA, ONR, NIH, EPA, corporations, and philanthropic endowments on quality E&O as we are to spend NSF's money.

16. My proposal is due tomorrow. I need a broader impact component and the budget is already done – can you help me?
Don't panic. We'll do our best to help you out. But you must promise to allow us more time to assist you, preferably a few weeks, next time you submit a proposal. We'll be frank that the E&O options of PIs who do not allocate sufficient funds to this important element of their proposals are limited. That said, there are a number of no-cost possibilities you may consider. Many of these involve proposing to direct some of your time, or that of your graduate students, technicians, or post docs, to some type of service. The service could be giving a presentation about your work to pre-college students, teachers, or the public. You could lend your expertise to the design of an exhibit, educational program, or online resource. You couldhost a student or teacher intern in your lab, lead a student field trip, or mentor a student science fair project. You can volunteer to serve on the advisory board of an educational organization, or serve on the education committee of a professional society. All of these options involve commitments of time and intellectual or physical energy, all of which have value. We may be able to help you, even on very short notice, pursue a partnership with an individual or organization to achieve your E&O goals.

17. I am collaborating with someone on the East/Gulf/West coast. Is there another COSEE there that we can collaborate with?
Currently, there are seven COSEE Centers located across the country. These centers have formed a network that is connected by a Central Coordinating Office (CCO). If you would like to find out more information about these centers, the CCO maintains a web site that provides links to each of the centers www.cosee.net. There you will also find a simple request form that initiates contact with real people at COSEE centers across the country. A response to your initial inquiry will come from people at the appropriate COSEE center(s) who can help you. Also, feel free to ask the regional COSEE nearest you to initiate the contact.

Other:

18. What do I do if I have a problem with the E&O partner that you find for me? Can I call you?
Our interest in the success of your E&O plan doesn't end when the proposal is submitted – and hopefully funded! By all means, we will help you resolve issues that may arise during the course of your collaboration with E&O partners. Recognizing that cultural differences between academics and educators can occasionally lead to misunderstandings, we are ready to assist in helping those involved come up with constructive solutions to problems. All of us can learn from each other in addressing these sorts of challenges.

APPENDIX E: EXAMPLES OF BROADER IMPACTS ACTIVITIES PROVIDED BY NSF

Integration of Research and Education

Background:
Integration of research and education is one of "three core strategies that guide [NSF] in establishing priorities, identifying opportunities, and designing new programs and activities.... 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" (NSF GPRA Strategic Plan 2001 - 2006)

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

Background:
One of NSF's five-year strategies is to "broaden participation and enhance diversity in NSF programs. At present, several groups, including underrepresented minorities, women, certain types of academic institutions, and some geographic areas are less than full participants in the science and engineering enterprise. NSF is committed to leading the way to an enterprise that fully captures the strength of America's diversity." (NSF GPRA Strategic Plan 2001-2006)

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

Background:

The NSF Act of 1950 authorizes and directs the Foundation "to foster and support the development and use of computer and other scientific and engineering methods and technologies, primarily for research and education in the sciences and engineering;..." "NSF investments provide state-of-the-art tools for research and education, such as instrumentation and equipment, multi-user facilities, ... telescopes, research vessels and aircraft, ... Internet-based and distributed user facilities, ... research networks, digital libraries and large databases." (NSF GPRA Strategic Plan 2001-2006)

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

Background:

"NSF advocates and encourages open scientific communication. NSF expects significant findings from supported research and educational activities to be promptly submitted for publication.... It expects PIs to share with other researchers, at no more than incremental cost and within a reasonable time, the data, samples, physical collections and other supporting materials created or gathered in the course of the work. It also encourages grantees to share software and inventions . . . and otherwise to make the innovations ... widely useful and usable." (GPG; NSF 01-2a)

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

Background:
NSF is committed to fostering connections between discoveries and their use in service to society. The knowledge provided by NSF-funded projects offers a rich foundation for its broad and useful application. For example, projects may contribute to understanding the environment, commercial technology, public policy, health or safety and other aspects of the public welfare. (NSF GPRA Strategic Plan 2001-2006)

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.

Appendix F: Draft of Questions for working in K-12

A sample of the types of questions that a scientist interested in working in K-12 should ask himself or herself prior to starting on the project.

Questions if you are planning on working with teachers

1) What do the teachers need?
2) What do I have to offer that would meet the needs of the teachers
3) What skills/resources are necessary to carry out my idea?
4) Do I have the needed skills/resources? If not, who can I involve to help me? What do I need to provide those people (funding? information?) so that the experience is rewarding for them as well?
5) How does my content area relate to national and state standards?
6) Do I understand the constraints facing the teacher (time, topic, high-stakes testing, etc.)
7) Am I considering the teachers as equal partners in this enterprise? Are they professional colleagues/collaborators?
8) What do I expect to gain from doing this project? (Knowledge? Building relationships for future students? Sense of satisfaction?)
9) Do I have a good understanding of the impact this project is likely to make? For example, one-shot visits to a classroom don't have particularly lasting impact. Is there an existing program that might utilize my experience in a more effective manner?
10) Am I aware of other projects similar to what I'm thinking about doing? What have they learned that I might take advantage of?

Questions for working with K-12 students:

1) How does this fit in with state standards, curriculum, testing schedules, time available?
2) What do students already know?
3) What are the teachers' and students' needs?
4) What else is being done by others (locally and nationally). Are there opportunities to collaborate?
5) Who are the pertinent contacts? Teachers? Principals? Are there local requirements that must be satisfied before sending anyone into the schools (i.e. background checks, informing them of proper dress codes?)
6) Do you understand the environment of the school(s) with which you want to work? (Cultural differences)
7) What are your own goals? How will you accomplish the goals? How will you evaluate whether you've met your goals?
8) Do you understand school policies and procedures?
9) Do you know what the 'touchy' subjects are in your district? What are the policies on teaching evolution?
10) How do teachers in your target school teach? The lecturing or demonstration you are used to doing may not be appropriate for some classrooms.

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