

## **Broader Impact Area #1**

### **Advance Science While Promoting Teaching, Training, and Learning**

#### **1. Definition of Broader Impact Area: Teaching, Training, and Learning**

The broader impact area of Teaching, Training, and Learning encompasses activities that pursue effective strategies to transfer research methodologies and results, as well as its potential impact, to a broad community through teaching and training. Ideally, a “broad community” would extend beyond the PI’s research group, and possibly beyond the PI’s research area or institution. In the following section we provide examples of the many ways that PIs can accomplish this – for example, by integrating research activities into teaching or training, or by creating mentoring opportunities for training a broader community in research activities. Research results can be transferred to a broader community by developing research-based educational materials and training educators using research-based strategies for learning. Broader impact activities in teaching, training, and learning could target a variety of groups, including college graduate or undergraduate students (within the discipline or outside the discipline), K-12 students and/or teachers, colleagues, university administrators, educational councils, legislators, the press, professionals (IT, engineers, CS), and the general public.

#### **2. Current Exemplary Teaching, Training, and Learning Activities**

The following list provides concrete examples of BI activities in teaching, training, and learning that our discussion group identified as exemplary. The list is meant to provide *examples* of the breadth of possible BI activities, and is not meant to be exhaustive or proscriptive. Certainly, no PI is expected to be superwoman or superman by undertaking all, or even a significant number of these activities. The particular activity undertaken should be fit to the PI’s interests and talents, the proposal scale, and the proposed research project.

##### **K-12 Students, Teachers, Parents, and Administrators**

- Participate in National Lab Day to be matched with a K-12 teacher.
- Participate in or help develop a program in your department/institution to provide research experiences for high school teachers.
- Prepare and share a presentation/activity on your general research area at local K-12 schools.
- Help organize or participate in a middle/high school student/teacher day in your department with student posters and presentations and activities directed toward increasing awareness of computer science topics.
- Bring a high school student into your research lab for the summer.
- Hold group or individual lunches or dinners with local high school teachers to answer questions and provide information.
- Serve as a research mentor for high school senior projects.

### **College Students, Faculty, and other Researchers.**

- Serve as an effective research mentor for graduate and undergraduate students (see also the discussion in the following section).
- Write a textbook that is informed by one's research.
- Share course materials that are informed by one's research, such as class notes, project descriptions, and videos.
- Make research software and tools available to others.
- Organize a workshop or tutorial in your research area, at an international, national, or regional level.
- Participate in, or organize, a mentoring workshop for researchers, possibly targeted at under-represented groups.
- Organize a panel for a conference.
- Bring an undergraduate from a primarily teaching school into your lab for the summer.
- Support students attending research mentoring conferences and workshops.
- Establish special mentoring programs at your institution or region for under-represented groups in computing.
- Create a list of resources for faculty at your institution interested in participating in BI activities at the institution.
- Provide training for NSF Career proposal writing to fellow colleagues in your research area.
- Use resources available at a national level (like NCWIT, Anita Borg, CRAW, Tapia, and BPC alliances) to either tailor their programs and services to local needs or to become involved at a national or other level. (e.g., running a local/regional Grace Hopper Conference).

### **General Public.**

- Create videos, posters, or other materials targeted at increasing awareness of your research area among the general public.
- Serve as a panelist or speaker at events for the general public.
- Serve on government panels or other bodies, where your work is informed by your research.

## **3. Characteristics of a Good Broader Impact Activity**

Our group engaged in lively discussion not only about characteristics of good BI activity, but also what “counts” as a BI activity - whether activities that faculty undertake in the normal course of their job (e.g., mentoring graduate students, updating teaching materials informed by one's research) should “count” as a BI activity. One group of participants felt

passionately that BI activities should go beyond the normal scope of one's job. Others felt equally as passionately that even though graduate student mentoring and revision of teaching materials are indeed a part of a faculty member's job, they are also BI activities.

A viewpoint that reconciles these two contrasting views is to explicitly recognize that there is a *spectrum* of BI activity, ranging from the minimal BI activity that faculty do in the normal everyday course of their job, to additional BI activities that often reach beyond the PI's lab and institution. A proposal's BI activity – just as a proposal's intellectual merit – is not simply a “check box”. Instead, proposed BI activities will differ in both scale and impact. A review panel (see following section) will likely see a spectrum of proposed BI activities, and those proposed activities should be evaluated by the review panel in much the same way that a proposals' intellectual merit is reviewed and evaluated.

Some key characteristics of a good BI activity in teaching, training and learning are:

- **Positively impacts people beyond the PIs research lab.** As noted above, training researchers within the research group is an expected responsibility of research mentors. A broader BI activity can reach beyond the PIs research group to teach, train, or mentor a broader audience, such as other undergraduate or graduate students within the department, institution, or nation; or beyond college students to K-12 teachers or students, adult learners, or the general public.
- **Relates to the PIs funded research project.** The BI activity should integrate with the intellectual merit of the research project. For example, the BI activity may be informed or enabled by the research or involve educating others about some aspect of that research area, possibly to increase awareness of the problems. For example, the participatory sensing research performed by the Center for Embedded Networked Sensing (CENS) enables society to assist in the collection of ecologically important data pertaining to climate change. The broader impacts of the participatory sensing work by CENS not only provides tools for use by society, but also enables education about climate change. Sometimes, creating concrete links between the BI and the intellectual merit, or informing BI activities with one's research may be difficult. In cases where the research is seemingly removed from society, good BI activities align with the skills and passion of the PI and the general research area.
- **Can be sustained beyond the grant period.** Many universities and national or regional organizations have existing infrastructure to assist in performing outreach activities. PIs can leverage the existing infrastructure at their institution or nationally to make their broader impact activities sustainable for the long term. The PIs proposed BI activities could be sustained through integration into another program, not necessarily led by the PI in the future. Creating a program or participating in a program that outlives the grant's lifetime will ultimately reach a larger audience over time.
- **Promotes broader impacts awareness and participation among students.** A particularly desirable goal is to infuse students who are mentored by a PI with an expectation of, and desire for, lifelong involvement in broader impacts activities as they graduate and begin to lead their own research labs. Involving students in one's

broader impacts activities can support this perspective and behavior. However, PIs should be careful to balance the students' primary objectives of research training with that student's involvement in the PI's BI activities.

- **A good broader impact activity does not need to be innovative; but it must be effective.** While a PI should strive to propose BI activities that integrate well with her/his own skills, passions, and circumstances, a BI activity need not be unique or novel. Indeed, all of the exemplar activities discussed in section 2 have already been undertaken by PIs in the past; that lack of novelty, however, does not diminish their importance or impact.

## 4 Suggestions to NSF

The committee identified several major challenges in evaluating proposed broader impacts activities in research grant proposals. Our committee offers several suggestions regarding reviewing guidelines.

### 4.1 Challenges in Broader Impact Activities

The following challenges were enumerated:

- The appropriateness of a given BI activity in teaching, training, and learning varies depending on a number of factors, including the PI's career stage, resources (existing infrastructure at the institution), and prior experience with BI activities, as well as the proposed grant project size and duration. Some of the participants felt that as the career level of the research team increases, the BI effort should increase as well; others disagreed with this viewpoint. As discussed below, there was uniform agreement that the level of BI activity for untenured faculty deserves special consideration, since a large BI effort would necessarily mean significantly less time for research. Our group agreed that as the funding level of the research effort increases, the scale of the BI should be expected to increase as well.
- University tenure decisions typically emphasize research accomplishments with some weight on teaching and even less weight on BI activities. However, impact of one's research is important and some BI activities can translate into impact. Junior faculty should choose BI activities carefully so that they have a positive impact on the individual's tenure case. In addition, tenure and promotion committees should understand the value that BI can play in funding and in an overall successful research career.
- Closely related to the previous challenge is the fact that most new faculty have not been exposed to or involved in any BI activities as part of their graduate student training. Thus, they do not know what constitutes a BI activity, nor have an appreciation for BI activities and their importance.
- The appropriateness of the BI activity needs to take into account the strengths and weaknesses of the PIs. For example, PIs not comfortable or not effective as a public speaker may not pursue such BI opportunities. Instead, they may collaborate with a person well trained in communicating with the public to assist in diffusing technology

and knowledge to society. Thus, explicitly judging the appropriateness of a given BI activity outside of the context of a given research proposal is unrealistic in many cases. Examples of good BI activities are not necessarily good for all contexts.

- Sustainability of BI activities is a challenge to many researchers. This could be aided by enhancing infrastructure for BI activities at the institution level, and ensuring that faculty are aware of the available programs and resources. A number of CS departments have recently begun to provide this support.
- Some BI activities require explicit funding in the grant proposal budget, which takes away from the research project budget components.

## 4.2 Reviewing Guidelines

Our principal recommendation is to revise the review guidelines such that the guidelines clarify and guide reviewers in their evaluation to consider the challenge stated earlier: the appropriateness of a given BI activity in teaching, training, and learning varies depending on a number of factors, including the PIs career stage, resources (existing infrastructure at the institution), prior experience with BI activities, as well as the proposed grant project size and duration. It would also be useful for reviewers to be provided with concrete examples of evaluation of proposed BI activities. It should also be stressed that just as BI activity (similar to intellectual merit) should be more than simply “checking off a box”, so too should the *evaluation* of BI activity.

We also recommend that reviewers should explicitly rate the BI activity separate from the intellectual merit evaluation of each proposal, i.e., that there be two separate scores. The separate rankings could be used in the panel discussions and relative rankings of proposals.

## 4.3 Other Recommendations

The committee had several additional overall recommendations for improvement of BI activity participation beyond NSF review guidelines.

- Recommend that the NSF require researchers to include a summary of the existing BI infrastructure available at the university in the Facilities section of the grant proposal. This will assist panelists in assessing the proposed BI activity.
- Recommend that the NSF annual report explicitly require a report of BI activities funded by the proposal as well as other unfunded BI activities that the PIs participated in.
- Recommend that NSF proposals require description of explicit deliverables and expected outcomes of proposed BI activity.
- Recommend that the “Results from Prior NSF Grants” section of grant proposals or a separate section such as “Prior BI Activities” include a description of PI’s previous BI activities as well, in particular BI activities funded by NSF grants.
- Recommend that universities establish a centralized information source for faculty researchers to learn about institution-level resources and programs that they could participate in that involve BI activities.

- Recommend that researchers expose their graduate students to BI activities, through involvement in their own BI activities or others as part of their graduate student training.
- Recommend that NSF programs consider a separate budget portion required for each grant budget that can not be used for research project itself, to put money behind the BI activity requirements focus.
- Recommend that high quality BI activities and efforts be better publicized, e.g., highlighted and shared at major conferences as posters to provide visibility and educate researchers of effective ongoing efforts.

## **5. Broader Impact Area #1 Participants**

Susanne Hambrusch (Moderator), Purdue University  
 Jim Kurose (Moderator), University of Massachusetts, Amherst  
 Kinnis Gosha (Documenter), Clemson University  
 Alan Marchiori (Documenter), Colorado School of Mines  
 Lori Pollock (Writer), University of Delaware  
 Kerri Stone (Writer), Colorado School of Mines  
 Valerie Barr, Union College  
 Deborah Estrin, UCLA - CENS  
 Rajiv Gandhi, Rutgers University-Camden  
 Judy Goldsmith, University of Kentucky  
 Joshua Guerin, University of Kentucky  
 Gregory Hislop, Drexel University  
 Bo Hong, Georgia Institute of Technology  
 Richard Hughey, University of California, Santa Cruz  
 Cynthia Irvine, Naval Postgraduate School  
 Zachary Ives, University of Pennsylvania  
 Anura Jayasumana, Colorado State University  
 Steven Levitan, University of Pittsburgh  
 Yaohang Li, North Carolina A&T State University  
 Joan Peckham, National Science Foundation  
 Mary Beth Rosson, Pennsylvania State University  
 Aviral Shrivastava, Arizona State University  
 Harriet Taylor, National Science Foundation