Making a Broader Impact:

Geoscience Education, Public Outreach, and Criterion 2

Bridging Research and Education

Funded by the National Science Foundation
Making a Broader Impact:
Geoscience Education, Public Outreach, and Criterion 2

Report of a workshop held at the University of California Museum of Paleontology
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# Table of Contents

Executive Summary......................................................................................... 1

Introduction.................................................................................................. 3

Background: Looking at Criterion 2—Broader Impacts ......................... 4

Motivations, Opportunities, Challenges, Best Practices
  Motivations ............................................................................................... 6
  Opportunities ............................................................................................ 7
  Challenges ................................................................................................. 7
  Best Practices ............................................................................................. 9

Recommendations and Next Steps
  The Geoscience EPO Network................................................................. 10
  Characteristics of the Network ................................................................. 11
  Developing the Network ............................................................................ 11

Recommendations for the Geoscience Community
  Recommendations for the National Science Foundation....................... 13
  Recommendations for the Science Research Community....................... 16
  Recommendations for the EPO Community ............................................ 18
  Recommendations for DLESE ................................................................. 18

Conclusions ................................................................................................. 19

Participants .................................................................................................. 20

Related Web Resources ............................................................................... 23

References .................................................................................................. 24

Acknowledgements .................................................................................... 26
Executive Summary

Issues surrounding public scientific literacy have never been more critical. The need for understanding the ways in which dynamic Earth systems interact with personal decisions, public infrastructure, and public policies has escalated dramatically over the past decade. Today, our daily lives are so dependent on the products and scientific outcomes of geoscience research that we are rarely conscious of their continuing evolution and impact. We live in a world where real-time satellite imagery on daily weather programs is commonplace, new cars are equipped with global positioning technology, and large communities continue to grow and thrive, situated at tectonically active plate boundaries.

Far from having an anti-science public, we have a public that assumes that science and technology have the power to maintain their standard of living in the face of environmental change. The challenge facing the geosciences is to make explicit to the public the criticality of scientific research and the benefits derived from it, and to engage this public in actively understanding the world around them.

Although increasing numbers of scientists are engaging in education and public outreach (EPO) projects related to their research, historically EPO has not been widely viewed as a core responsibility of scientists. Traditionally, outreach activities have largely been the provenance of science education and communication professionals, such as museum educators and journalists. Today there is broad recognition in federal science organizations and funding agencies that more research scientists need to be directly involved in education and public outreach. Studies on teacher professional development projects designed to increase diversity in the sciences provide evidence that direct interaction of participants with research scientists is an important predictor of successful outcomes. Currently, however, professional reward systems of tenure and promotion work against research scientist engagement. Major shifts in perception, support, and reward systems need to take place before broad participation of geoscientists in EPO can be realized.

In 1997, the National Science Board took a critical step in fostering cultural change in the scientific community by requiring explicit consideration of the broader impacts of research in every research proposal. Termed the Broader Impacts Statement, Criterion 2 has catalyzed a dramatic shift in expectations within the geoscience community. All scientists who create proposals requesting National Science Foundation funding are aware of the necessity to address the broader impacts of their research, even if it is just to ensure that their proposals will meet with success in a review panel. Still, a significant proportion of scientists are frustrated with the Criterion 2 requirement, because as scientific specialists, they are unfamiliar with the best practices that can inform a successful broader impact effort, particularly in education and public outreach. Nor are the avenues to engage with specialists in EPO efforts always apparent.

In response to this evolving landscape, a workshop on geoscience outreach organized by the University of California Museum of Paleontology (UCMP) and the Digital Library for Earth System Education (DLESE) Program Center was held on the Berkeley campus May 11-13, 2005. Twenty-six scientists and educators who are actively engaged in outreach and education activities attended. The Geoscience EPO Workshop purposefully narrowed its focus to that of education and public outreach. In the broadest definition of EPO, we include any activities in which the scientific enterprise, research, and processes are shared with an audience beyond the research community. This workshop sought to
identify the proven models and best practices for effective outreach strategies that could be profitably shared with research scientists.

Workshop participants focused on the need for cultural change at many levels—a change that genuinely motivates and rewards research and education communities to work together. Such collaboration would contribute to a greater appreciation of the scientific enterprise, a broader understanding of the scientific process, and increased scientific understanding at all learning levels. To this end, workshop recommendations converged on the creation of a network as an important strategy to support effective EPO and engagement of the general public with the enterprise of science. The Geoscience Education and Public Outreach Network (GEPON) would:

- Provide an infrastructure to facilitate collaboration between scientists, educators, and EPO professionals
- Provide support systems for professional development and cross-disciplinary learning for all involved in EPO activities
- Recognize and give value to current EPO activities, thereby encouraging involvement by others
- Promote and help to institutionalize a cultural change that recognizes, values, and supports outreach as both a responsibility and an opportunity

Immediate next steps toward the development of this network would be the establishment of a GEPON web site. GEPON would serve to highlight current exemplars of EPO activities that provide qualitative and quantitative measures of successful outcomes, satisfying the Criterion 2 requirements. Initial steps toward this effort are already underway at http://www.gepon.org. A second major step is to identify within the geoscience community those who are willing to take leadership roles in designing and establishing GEPON. To this end, participants agreed that it would be necessary to convene an additional workshop to articulate the characteristics, strategies, and management models for a successful network effort.

Further recommendations included those to:

1. The National Science Foundation, to provide clarity and additional guidance with respect to Criterion 2 and the inclusion of EPO activities in reporting requirements; to advance the integration of science research and EPO by supporting meetings and workshops that promote continued dialogue; and to fund fellowships to researchers and graduate students supporting their engagement in EPO activities.
2. The science research community, to encourage, recognize, and reward scientist involvement in EPO and to document and disseminate institutional models.
3. The EPO community, to convene sessions at professional meetings in order to demonstrate the integration of research and the sharing of that research with a broader audience.
4. The Digital Library for Earth System Education (DLESE), to provide the technical infrastructure for the geoscience education community, to develop and disseminate EPO toolkits for researchers, and to serve as a community catalyst for moving forward with these initiatives.
Introduction

Surveys of public scientific understanding conducted by the National Science Foundation over the past 30 years evidence little, if any, increase in scientific knowledge or understanding, and a generally low level of scientific literacy among the general public (Gregory and Miller 1998). Surprisingly, the poor performance of the public on science knowledge surveys does not mean that the public is disinterested in science (National Science Board 2004). Far from having an anti-science public, we have a public that assumes that science and technology have the power to maintain their standard of living in the face of environmental change. However, as was brought into sharp focus during the natural disasters of summer 2005, the effectiveness of scientific and technological advances, such as those related to meteorological prediction and warning systems, can only be of use when the public has sufficient knowledge to understand the scientific meaning behind predictions and make informed decisions to guide behavior. Although extreme Earth events may be powered by forces beyond our control, public understanding of science gives us control over the way in which an event impacts our lives.

Over the past three decades, the gap in public science understanding has widened, indicating that we need to radically change the way in which we approach science education and public outreach if we are to take full advantage of the technological and scientific advances in the geosciences. Historically there has been a sharp demarcation between the scientists who conduct research and those responsible for communicating science to the public (Gregory and Miller 1998). These lines of separation are dissolving as scientists are being asked to participate actively in sharing their science with citizens, teachers, and students. Research reported by the National Research Council (1996) and Loucks-Horsley and others (2003) suggest that direct engagement of scientists in education and outreach is critical to positive and lasting outcomes.

In response to this mounting need, twenty-six scientists and educators actively engaged in outreach and education activities came together to share experiences and to discuss strategies for promoting the further involvement of the science research community in education and public outreach efforts. Participants examined motivations for involvement and identified successful strategies for meeting challenges involved in conducting a range of EPO activities. Important outcomes of the workshop included the articulation of the need for an established network to further these endeavors and a set of recommendations to promote the role of geoscience outreach and education as a complementary component to the scientific research endeavor. EPO activities serve as an essential strategy to address future workforce issues, increase the general scientific literacy of our nation, and ensure the ongoing public recognition and support of current and future scientific research.

This report summarizes the discussion and outcomes of this workshop, focusing on how geoscience education and outreach activities can support the science research community in their efforts to fulfill NSF Criterion 2 requirements. The workshop was organized by the University of California Museum of Paleontology (UCMP) and the Digital Library for Earth System Education (DLESE) Program Center, and was conducted on the UC Berkeley campus May 11-13, 2005. In keeping with its long-standing commitment to EPO activities, the workshop was sponsored by the National Science Foundation’s Geosciences Directorate.
Background: Looking at Criterion 2—Broader Impacts

The National Science Board approved Criterion 1 and Criterion 2 in March 1997, requiring that both intellectual merit and broader impacts resulting from projects proposed to the National Science Foundation be addressed in the Project Description of all proposals (National Science Foundation 1997). Subsequent versions of the Grant Proposal Guide (GPG) increasingly emphasized the importance of addressing both criteria in the preparation and review of proposals submitted to NSF (National Science Foundation 2004). The GPG also makes clear that Principal Investigators (PIs) must address these merit review criteria within the one page Project Summary. Criterion 2 reflects NSF’s commitment to the development of a scientifically literate citizenry as well as world-class scientists, mathematicians, and engineers. NSF recognizes that education and research are always in the public service, inextricably bound at all levels. To emphasize the importance of Criterion 2, in fall 2002 NSF announced that it would not review proposals that did not separately address both merit review criteria. Although some PIs view the additional requirement as burdensome, many acknowledge that the potential societal benefits of integrating research and education are substantial. However, there is an emerging sense that scientists feel caught between the conflicting emphasis on core research for tenure and promotion and the increasing emphasis on broader impacts in order to qualify for grants that enable them to do their research (Franks, Peach et al. 2005; Brown, Propst et al. 2004).

Criterion 2 offers the researcher a variety of venues and strategies through which to satisfy the broader impacts requirement, including formal science education, informal science education, public outreach, marketing, and news media support (Figure 1). This workshop, however, purposefully narrowed its focus to that of education and public outreach (Mayhew 2005). In the broadest definition of EPO, we include any activities in which science research and processes are shared with an audience beyond the research community. These activities may be designed to enhance broader scientific literacy, expand the pipeline for future geoscientists, or provide innovative ways of conveying scientific concepts to students at multiple learning levels.

**Criterion 2: 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 1997)
The workshop provided the opportunity for researchers, science educators, and institutional or organizational representatives to contribute their ideas on strategies to balance science research and broader impact requirements as they relate to EPO activities. A key outcome was consensus on the need to promote a cultural change among all stakeholders—NSF, the research community, academic institutions, and professional scientific organizations—to one that recognizes, values, and supports outreach as both a responsibility and an opportunity. Such a cultural shift would foster the engagement of scientists in science education, public communication, and public discourse. Participants discussed the nature of their personal involvement in EPO, identified strategies for optimizing success and overcoming challenges, and initiated dialogue on the design of a network that would support geoscience outreach efforts.

Figure 1: This 3-circle Venn diagram offers a conceptual framework to distinguish among the realms of Formal Science Education, Informal Science Education, Public Outreach, Marketing, and News Media Support (Morrow, 2000)
Motivations, Opportunities, Challenges, Best Practices

Participants began their discussions in groups that reflected three education and public outreach perspectives from the geoscience community—those of the researcher, the "bridge builder," and the institution or large organization. Researchers are primarily scientists—they may be faculty at universities, or scientists at government agencies or laboratories. Bridge builders introduce or connect individual researchers to education and outreach opportunities and provide support services for EPO projects as they develop. Moreover, bridge builders facilitate interactions between three cultures: scientists, professional educators, and the general public. Institutional representatives coordinate outreach activities for large agencies or universities on an institutional or national scale. The motivations, opportunities, challenges, and successes identified in group discussions served as key elements pointing the way to identification of best practices for outreach and education for target audiences.

Science enjoys broad public support based on a general perception that it has helped bring about improved quality of life. That support, however, is as shallow as it is broad, and cannot be relied upon when science must compete with many other worthy programs for scarce dollars when federal budgets are tight. If public support is to continue and hopefully grow, scientists must work with partners...to put forward focused and convincing rationales for why their research improves people’s lives. (Applegate 1999)

Motivations
Participants identified the following motivating factors as critical drivers for involvement of scientists in EPO activities:

- A scientifically literate citizenry capable of making informed decisions is essential to the welfare of the population and stewardship of the Earth
- Scientists have an obligation to share results with the public that funds their research
- Funding from most government agencies is now contingent on public dissemination of research outcomes; EPO is an effective means to meet this requirement

Secondary benefits to EPO involvement are not inconsequential. K-12 education, particularly science education, is recognized as a high-need area. Teachers need professional pathways to increase their content knowledge and understanding in order to keep pace with scientific and technological developments, and require science education resources that support their classroom instruction. Supporting excellent science education at the K-12 level is a strategy that eventually has direct impact on the scientific community, through better academic preparation of incoming college students.

Scientist involvement in fully integrated research and education programs also has the potential to provide additional professional opportunities and funding for graduate students, who are now entering the profession. Finally, EPO activity provides researchers with a larger constituency with whom to share their science.
Opportunities
Although EPO activities may at first seem to be an added burden on the time and energies of the researcher, workshop participants believe that there are key indications that EPO benefits the researcher as well.

*Greater access to resources:* Workshop participants recognized that there is a tension between research and education dollars. However, there was strong consensus that outreach activities have the potential to both increase the visibility of a particular research area to the broader citizenry and increase funding for the researcher. Once public awareness is elevated and support is established, additional research funds may be easier to obtain.

*Broader graduate student training:* Involving graduate students in EPO activities provides them the opportunity to improve communication skills, to examine ways to adapt their own teaching approaches to the needs of specialized audiences, to incorporate the sharing of science into their professional goals, and to hone interpersonal skills that strengthen their career prospects. Perhaps most importantly, the required cultural change to one that recognizes and values EPO activities will become institutionalized as this next generation of graduate students moves into research positions and continues to conduct these types of activities based on prior experience and knowledge.

*Multiple venues for increasing public awareness:* The K-12 education sector is often the focus of education and outreach activities designed to respond to Criterion 2, but the critical audience for science communication and awareness extends far beyond formal education settings. Scientists have the opportunity to contribute to exhibits and instructional outreach efforts of museums, participate in public and corporate broadcast programs, and assist with the educational efforts of professional societies, all of which provide venues for sharing science with wide audiences and raising public awareness of the importance of scientific research.

Challenges: Building Partnerships
Establishing strong partnerships between our research and education communities is critical to successful education and outreach programs. Creating and maintaining such partnerships requires bridging the differences between these two communities, building on individual strengths, and developing a bilateral recognition of the expertise and energies of each.

Bridge builders are professionals who have experience and expertise in the cultivation of mutually beneficial partnerships between scientists and educators. From their perspective, the greatest challenges to developing successful EPO programs include:

- Recruiting and retaining scientists
- Developing adequate resources to support, evaluate, sustain, and scale their activities
- Coordinating the efforts of each party involved
There is an emerging sense that scientists feel caught between the conflicting emphasis on core research for tenure and promotion and the increasing emphasis on broader impacts in order to qualify for grants that enable them to do their research.
Best Practices

The participants identified effective strategies and structural components for optimizing success across a broad range of EPO activities.

Effective strategies include:

- Using a team approach that provides direct involvement in the planning and implementation of the EPO activity by all constituents: the researcher, the educator, and members of the intended audience
- Aligning EPO activities with the needs of the audience, e.g., if the target audience is formal K-12 education, activities should reference relevant science standards
- Involving graduate students and young scientists to promote an awareness of the importance of EPO efforts by scientists and the need for culture change
- Providing a menu of opportunities for researcher involvement, recognizing that not all scientists or research programs can or should be engaged in EPO at the same level or in the same role

Important structural components include:

- A venue and opportunity for dialogue between scientists and educators to focus on the benefits of bridging the two cultures of science research and education
- Professional development opportunities for both scientists and educators to gain fluency and confidence in areas of mutual interest and professional intersection
- Appropriate personnel and financial support to complete the proposed activities, including strong project management
- Institutional commitment and incentives, including the development of a system of rewards for advancement and tenure of science faculty that recognizes the importance of public communication of science
- Realistic consideration of sustainability and continuity in activities
- Ongoing evaluation coupled with feedback to all partners in a timely fashion

EPO activities serve as an essential strategy to address future workforce issues, increase the general scientific literacy of our nation, and ensure the ongoing public recognition and support of current and future scientific research.
Recommendations and Next Steps

Workshop participants focused on the need for cultural change at many levels—a change that genuinely motivates and rewards research and education communities to work together. Such collaboration would contribute to a greater appreciation of the scientific enterprise, a broader understanding of the scientific process, and increased scientific understanding at all learning levels. To this end, workshop recommendations converged on the creation of a Geoscience EPO Network (GEPON) as an important strategy to support effective EPO and engagement of the general public with the enterprise of science.

The Geoscience EPO Network

The proposed network would:

- Provide an infrastructure to facilitate collaboration between scientists, educators, and EPO professionals
- Provide support systems for professional development and cross-disciplinary learning for all involved in EPO activities
- Recognize and give value to current EPO activities, thereby encouraging involvement by others
- Promote and help to institutionalize a cultural change that recognizes, values, and supports outreach as both a responsibility and an opportunity

There was strong recognition that there are currently many successful outreach activities conducted at various scales by independent PIs, institutions, and organizations. However, these efforts remain largely disconnected from one another. What is missing is the ability to leverage these efforts so that EPO activities can move beyond isolated, individual success stories to a coordinated national effort that has the potential for much greater impact. GEPON should heighten the visibility of successful EPO programs that can serve as models, and function as a resource for new efforts. GEPON would not
supplant or oversee existing programs; instead, it would showcase successful efforts, amplify their success, and promote the scaling and sharing of proven strategies so that larger and more diverse audiences can be reached.

**Characteristics of the Network**

GEPON would also serve to foster support and provide recognition for science researchers’ involvement in EPO. It should propose and promote standards of quality in EPO that are grounded in the research on learning and address real and substantial problems, and it should engage existing and highly respectable leaders in our field. It should be structured to support diverse audiences, be inclusive of government agencies, societies, universities, and individuals, foster collaborations across the disciplines of geoscience, and engage with formal and informal science education communities. GEPON should promote interaction and exchange within the scientific and educational communities and take advantage of existing tools, services, and organizations, such as digital libraries, clearinghouses, and other forms of sharable and high quality resources and expertise, including the concentrated expertise within the professional societies.

Participants recognized that there are already several important networks that serve a subset of these purposes, including DLESE, the Centers for Ocean Science Education Excellence (COSEE 2005), and professional geoscience societies. Hence, the proposed network should be built on established efforts. GEPON must be characterized by a broad range of services and sensitivity to diverse audiences and opportunities. It is often overlooked that the culture of science is itself non-homogenous, and that there are in fact many cultures within the broad geoscience community. Atmospheric scientists, oceanographers, geologists, and geophysicists, for example, currently operate within their own networks and may be resistant to combining efforts unless there is a perceived personal benefit associated with participation in a broad-based, integrated EPO network.

The proposed network would ideally provide both an intellectual space for dialogue as well as practical services to its members. Workshop participants examined current networks as potential models, such as IRIS—the Incorporated Research Institutions for Seismology—and specific funded programs within NASA. Though several aspects of these operational models do not apply to a geoscience EPO network, it is worth examining these and others in considering the potential scope and activities of the network.

**Developing the Network**

There are many ways to interpret the network concept. Although it is premature to detail the specific structure of such a network without additional community discussion, it is possible to identify steps towards its growth and development. During the workshop, participants identified two foci for initial phases of network development: the documentation of best practice exemplars and the creation of a user-friendly guide for geoscience EPO. Possible models for network leadership and organization were also discussed.

**Document EPO exemplars.** The GEPON would provide ready access to exemplars of successful projects, including those that were developed specifically to satisfy Criterion 2. Since Criterion 2 has been part of the review process for several years, it should be possible to identify those completed NSF projects demonstrating quantifiable measures of success and pass them on to the geoscience community in the form of exemplars.
THE ROLE OF GEPON: Members of the network can develop standards for what is meant by successful to facilitate the choice of projects to be highlighted. The selected exemplars can be documented and disseminated through a network web site, hosted by DLESE or other NSF geoscience facility.

**Develop a user-friendly guide.** The proposed guidebook would serve as a primer on outreach strategies and opportunities for the scientist, and include goals, objectives, guidelines, a summary of best practices, concrete examples, and an extensive bibliography. The guide can be modeled along the lines of NSF’s *2002 User-Friendly Handbook for Project Evaluation* (Westat 2002). Most universities have a sponsored projects office, and these offices would be important partners in the dissemination of the guide to their scientists. The ReSciPE project—Resources for Scientists in Partnership with Education—at the University of Colorado has already begun to develop such a resource, the online ReSciPE Book (CIRES 2005).

THE ROLE OF GEPON: Some members of the workshop expressed willingness to produce a document that helps scientists envision ways in which Criterion 2 can be most effectively implemented. This guide could be hosted on the network web site and referenced by NSF and sponsored projects offices. In addition to the guide, a Frequently Asked Questions site, with contributions from the network members, could also be constructed.

*There was strong recognition that there are currently many successful outreach activities conducted at various scales by independent PIs, institutions, and organizations. However, these efforts remain largely disconnected from one another. What is missing is the ability to leverage these efforts so that EPO activities can move beyond isolated, individual success stories to a coordinated national effort that has the potential for much greater impact.*
Recommendations for the Geoscience Community

Workshop participants drafted a set of recommendations directed toward several audiences: the National Science Foundation, as a major funder for education and outreach efforts; the science research and the EPO communities, as major stakeholders; and DLESE, as an already established network able and willing to provide technological and community support to the emerging geoscience EPO Network. These recommendations also identify the potential role of GEPON where appropriate.

Recommendations for the National Science Foundation

*Provide clarity and additional guidance.* Researchers have requested guidance on how to best meet Criterion 2 requirements, and have expressed their frustration about the lack of clarity with respect to the role of Criterion 2 in the grant proposal review and award process. Many feel that they need to be as innovative in their EPO activities as they are in their research, discouraging them from taking advantage of reproducible successful programs or strategies. Workshop participants recognized that the guidelines have been purposefully left open-ended to encourage creative thinking and to accommodate a broad range of activities. However, they indicated that the lack of guidance in a realm for which they have no expertise makes them vulnerable and compromises the chances of success for their proposal.

The lack of consistency in interpreting the requirements across NSF programs and Directorates fosters frustration and shared misinformation among research scientists. Scientists want to know the relative weight of Criterion 1 versus Criterion 2 requirements with respect to granting awards through the proposal review process. Mervis (2001) reported in *Science* that NSF review panels were inconsistent in application of Criterion 2, generating a mixed message to the scientific community about its importance. There is a strong desire for assurance that Criterion 2 evaluation is applied
systematically, not capriciously, in the review process. At the very least, there is a sense that Criterion 2 outcomes should be specified and incorporated in a meaningful manner into annual and final project reports to the NSF.

**NSF should provide both more guidance with respect to Criterion 2 activities and also ensure that there is more uniformity regarding the weight of these activities in award decisions across all the Directorates. NSF should encourage researchers to partner with programs and organizations that have EPO experience.**

**Recommendations**

- NSF should provide both more guidance with respect to Criterion 2 activities and also ensure that there is more uniformity regarding the weight of these activities in award decisions across all the Directorates.
- NSF should encourage researchers to partner with programs and organizations that have EPO experience.
- NSF should be proactive in educating reviewers of proposals and ensuring that EPO components receive as equally knowledgeable a review as do the science components of a proposal. EPO efforts should be held to the same high scholarly standards as those applicable to research. At the same time expectations should be scaled realistically to the size of the effort—for example, pilot projects by individual PIs on small grants should not be expected to disseminate nationally.
- NSF should include EPO activities in reporting requirements. Standardizing the format of EPO reports can facilitate the establishment of a set of exemplars and innovations.

**The role of GEPON:** Network members can provide input to help establish reporting procedures.

**Support the integration of research and EPO.** A number of EPO bridge builders indicate that they are sometimes pressured by collaborating scientists to take over full responsibility for outreach, rather than functioning in the preferred role as an educational specialist in partnership with scientists. The question emerges whether the NSF can take proactive steps to stem this trend by encouraging both direct and indirect involvement by scientists in EPO and by supporting the integration of research, education, and outreach projects and products as a valued response to Criterion 2.
**RECOMMENDATION:**

- NSF should host a series of workshops designed to bring together teams of scientists and educators in collaborative projects with practical, real-time outcomes, integrally linking research and education. There are several models on which such a program could be based (e.g., the Earth Exploration Toolkit workshops held by DLESE Data Services; or the Cutting Edge Workshop for Early Geoscience Faculty) (Ledley, Manduca et al. 2003; Macdonald, Manduca et al. 2003)

**THE ROLE OF GEPON:** Many of these workshops could be organized and/or facilitated by the network or by network members.

**Actively continue the dialogue.** The fact that many of the workshop participants had not met before emphasizes the need for NSF investment in an infrastructure to support meetings, workshops, and forums to facilitate collaborations among EPO specialists and the general geoscientist community.

**RECOMMENDATION:**

- NSF should support meetings and workshops that promote continued dialogue.

**THE ROLE OF GEPON:** Many of these meetings can be organized and/or facilitated by the network or by network members.

**Develop new funding opportunities that emphasize involvement in EPO.** Many researchers and graduate students would welcome the opportunity to be more involved in EPO activities if appropriate means were available for them to do so.
RECOMMENDATION:
- NSF should consider funding semester-long and year-long sabbatical fellowships that would free scientists from teaching responsibilities, enabling them to work with educators or educational organizations to initiate an EPO program based on their research.
- NSF should consider funding graduate student fellowships that explicitly address EPO activities and encourage graduate students to integrate research and education throughout their careers.

THE ROLE OF GEPON: The network can recommend projects for researchers to use as models, giving them the opportunity to analyze a successful program prior to initiating one of their own.

Recommendations for the Science Research Community

Document and disseminate institutional models. University administrators and department heads must adjust performance expectations to match those required by the NSF and Criterion 2. Until then, the concern of EPO specialists about the long-term impact of delegating and isolating Criterion 2-related EPO responsibilities exclusively to EPO specialists will continue. More optimistically, several workshop participants noted that there are successful models that integrate EPO activities within academic departments and are thus stimulating a change in cultural values in those institutions.

Workshop participants focused on the need for cultural change at many levels—a change that genuinely motivates and rewards research and education communities to work together. Such collaboration would contribute to a greater appreciation of the scientific enterprise, a broader understanding of the scientific process, and increased scientific understanding at all learning levels.

RECOMMENDATION:
- Institutions should endorse and embed EPO staff within academic departments to work with research scientists as a team, in order to support an institutional or departmental plan for sharing science with a broader audience.

THE ROLE OF GEPON: The network can document and disseminate institutional models such as those of the University of Alaska, Fairbanks, the University of Minnesota, Scripps Institution of Oceanography, and Stanford University Department of Earth Sciences. These institutions have created offices to support the development of education and outreach projects in conjunction with research conducted at the university. Programs such as these provide clear examples of changes in values and orientation that should be encouraged in other institutions around the country.

Encourage, recognize and reward involvement in EPO. Under consideration at some institutions is the notion that outreach activities can serve as a measure of professional achievement for scientists seeking career advancement. Such a change in institutional values must be strongly encouraged for EPO to be universally perceived as an important component of an academic career.
RECOMMENDATIONS:

- Institutions should establish academic committees to plan, coordinate, and advocate for recognition of researchers involved in EPO, and include EPO engagement as a merit activity in the tenure process. In the interim, departmental, college, or university-based awards for accomplishments by a researcher in outreach could provide another set of incentives.
- Professional societies that offer graduate student research grants (such as the Geological Society of America) should include opportunities for graduate students to submit proposals to conduct EPO activities.
- Scientific societies and journals have the opportunity to catalyze a shift in the definition of the research scientist by featuring articles reporting on successful projects integrating EPO with research.

THE ROLE OF GEPON: As key members of the network, professional societies can play a significant role in fostering EPO related to research. For instance, high profile plenary addresses at conferences such as AGU that signify the importance of public engagement with science could be featured annually. Influential and highly respected scientists should be encouraged to be involved in such efforts. Professional societies can provide a venue where network meetings can take place; professional societies can also highlight collections of high quality EPO products and programs involving their researchers on their web sites.
Recommendations for the EPO Community

Because EPO professionals are often seen as bridge builders, they need to continue to coordinate current efforts and work to document processes, challenges, and benefits.

RECOMMENDATION:
EPO community members should be proactive in jointly convening sessions with members of the scientific research community at professional meetings to demonstrate the integration of research and education, and to share that research with a broader audience.

THE ROLE OF GEPON: Working together within the network, EPO experts can contribute to a national directory of specific EPO activities that cut across science disciplines. They can help to define standards for success of EPO programs and how to assess their impact. Such a set of standards would serve to guide the review process for Criterion 2 projects and also to identify those projects to be highlighted and disseminated as success stories.

Recommendations for DLESE

Provide the infrastructure for the Geoscience Education community. There was a strong consensus that DLESE has already established a viable technical and social infrastructure for the geoscience education community. However, that infrastructure is largely untapped and unknown to the scientific research community.

RECOMMENDATIONS:
- DLESE should work to become the dissemination arm of high quality EPO products and programs for the new network. Scientists and others who are interested in developing EPO programs can locate partners within the DLESE community and examine DLESE holdings to identify opportunities, learn from others, and expand on existing efforts.
- DLESE should work with members of the network to develop and disseminate EPO toolkits for researchers, a best practices guide, and a catalog of Criterion 2 strategies and projects.

Serve as a community catalyst. The group expressed a strong desire to keep the momentum generated at the meeting alive, and requested that DLESE play a role in supporting a variety of emerging efforts related to community coalescence and support.

RECOMMENDATIONS:
- DLESE should facilitate opportunities for formal and informal networking at professional meetings.
- DLESE, in conjunction with other established groups, should request funding from NSF to support an additional workshop that would organize a core group of leaders from this meeting to further develop a network plan that would act on the recommendations from this workshop and meet the needs of the geoscience community.
Conclusions

Participants felt that this workshop was a first step in a much larger effort. There is a need for continued dialogue and the opportunity to better articulate the characteristics, benefits, and administrative structures that would be involved in establishing and managing a network. These must be incorporated into a working model that will reflect the best practices and support the strategies for success expressed in the meeting. There was strong agreement that the network must facilitate and not impede current efforts while encouraging the initiation of new efforts.

A next step toward this expanded effort is the development of a GEPON web site that would serve to highlight current exemplars of EPO activities that provide indicators of successful outcomes and satisfy the Criterion 2 requirements. This web site would also host the recommended guidebook to serve as a primer on outreach strategies and opportunities for the scientist. A prototype site is under development at http://www.gepon.org. A second major step is to identify those within the geoscience community who are willing to take leadership roles in designing and establishing GEPON. Finally to this end, participants agreed that it would be necessary to convene an additional workshop to articulate the characteristics, strategies, and management models for a successful network effort.

The most notable outcome of the workshop was the clear message that there is a great deal of energy and enthusiasm among those EPO professionals and scientific researchers who are actively and creatively supporting a wide range of Criterion 2-related efforts in the geosciences. The participants in this workshop serve as a nucleus upon which a broader effort can be built. Through the coordinated efforts of research scientists, EPO professionals, and institutions, the necessary cultural change toward broad scientific participation in education and public outreach can be catalyzed. With this vision, the geosciences can look forward to a future of integrated geoscience research, education, and public outreach that is accessible, meaningful, effective, and relevant.
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Related Web Resources

Bigelow Laboratory for Ocean Sciences, Integrating Ocean Research & Education
http://www.dpc.ucar.edu/projects/geosciOutreach/blos_edu_flyer.pdf

COSEE-California Engaging Scientists
http://www.cacosee.ucsd.edu/home.html

COSEE-Mid-Atlantic Scientist Connections
http://www.macosee.net/res_ed/guide_intro.htm

NSF Merit Review Broader Impacts Criterion Representative Activities
http://www.dpc.ucar.edu/projects/geosciOutreach/broaderimpacts.pdf

NSF Division of Chemistry (2002). "Dear Colleague" letter from Arthur B. Ellis, NSF publication #02-161


http://www.nsf.gov/od/opp/opp_advisory/oaccrit2.jsp

Space Science Institute. Resources for Scientists in Education and Public Outreach (E/PO)
http://www.spacescience.org/education/extra/resources_scientists_cd/

Scripps Center for Educational Outreach Connection. SciOpps: A Compilation of Education and Outreach Opportunities for Scientists
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Geoscience Education, Public Outreach, and Criterion 2

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