Workshops for Scientists and Engineers on Education and Public Outreach

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ABSTRACT

Funding agencies like NASA and the National Science Foundation (NSF) are increasingly requiring the participation of their funded scientists and engineers in education and public outreach (EPO). The Space Science Institute (SSI) of Boulder, Colorado, designs and implements workshops to help scientists and engineers become better partners and supporters of professionals in formal and informal science education. This paper describes the background and motivation for these workshops, presents the elements of SSI's annual 4-day workshops, discusses lessons learned from our eight years of experience, and concludes with mention of other workshops being derived from our 4-day version. Evaluation data clearly indicate that our workshops are providing vital opportunities for scientists and engineers, especially those in space and earth science-related disciplines, to become more effective EPO partners and contributors.

BACKGROUND AND MOTIVATION

Space scientists and engineers offer much that is needed to contribute to the realms of primary/secondary education and public outreach, including: 1) respect and influence in their communities; 2) deep knowledge of science and the scientific process; 3) exciting connections to real world exploration and discovery; 4) educational access to data and facilities; and 4) role modeling for students and teachers. Research directorates of funding agencies like NASA and the National Science Foundation (NSF) are increasingly recognizing the essential contributions scientists and engineers can make. These agencies are encouraging (and in some cases requiring) the integration of research science and education and greater scientist involvement in Education and Public Outreach (EPO) at all levels.

For example, the NASA Office of Space Science (OSS) EPO strategy and implementation plan both call for EPO to become an integral part of the space science community's professional activities. Every OSS flight project (e.g., Hubble Space Telescope, Mars Pathfinder, etc.) is now *required* to have a significant EPO program (1-2% of the overall mission budget, including spacecraft, mission operations, and data analysis). NASA's Earth Science Enterprise (ESE) is enacting a similar policy for its space missions. NASA as a whole, recently elevated education to a core mission of the agency – with the intent of contributing to education at all levels "as only NASA can". The NSF Geosciences Directorate (GEO) has published an education strategy that promotes increased geoscience outreach to teachers, students, and the public. *Both NASA OSS and NSF GEO strategies articulate the need for conducting workshops that enhance scientists' and engineers' understanding of issues in education and contribute to their becoming more effective partners with education professionals.*

For the past eight years (1995 – 2002), the Space Science Institute (SSI) of Boulder, Colorado, has successfully conducted annual 4-day workshops for 40 scientists on K-12 education. NASA has supported these workshops for all eight years, and NSF GEO started to contribute funding in 2000. These workshops began as a spin-off of the work of Dr. Ramon Lopez, formerly the education director at the American Physical Society, who conducted leadership institutes involving physicists with educators and administrators to support science education reform in communities across the country. The goals of SSI's 4-day workshops are to:

- enhance and sustain a national cadre of well-informed scientists, engineers, and EPO managers who can act as leaders and advocates for effective science EPO, and as role models for colleagues;
- strengthen and increase the effectiveness of EPO activities involving earth and space scientists; and
- provide participants with opportunities for showcasing their work and networking with colleagues and experts in education.

SSI's nationally acclaimed 4-day workshops and their spin-off activities have now served over 400 scientists, engineers, and managers of education programs (who crossed over into education from career paths in science or engineering). More than 30 NASA missions and research programs have sent representatives, and we have alumni in over 40 states and Puerto Rico (see Figure 1). Participants come predominantly from universities (~70% from academic departments, research institutes, and space grant colleges). Another 25% or so come from NASA centers, NASA contractors, and space industry. The remaining 5% hail from state departments of education, school districts, and non-profit organizations.

ELEMENTS OF THE 4-DAY WORKSHOP AGENDA

All of the basic principles of exemplary professional development of teachers in science apply to scientists in education. Agenda elements of SSI's 4-day workshops include interactive presentations by education experts, small-group discussions, poster reception for participants, panel discussions, direct experience with hands-on activities, and orientation to resources that can be used at home institutions. A key highlight of the 4-day experience is a field trip to a local school where workshop participants observe and interact with students engaged in exemplary, inquiry-based curriculum. In general, we have designed the agenda to achieve the following outcomes for participants:

- Increased knowledge of educational issues from a national perspective
- Improved understanding of the characteristics of exemplary EPO products, activities, and programs that will strengthen existing EPO programs
- Generation of ideas to improve existing or envisioned EPO programs and/or planning efforts
- Creation of new opportunities or ideas for collaboration.

We use a learning cycle model in devising the workshop agenda called OPERA, which is akin to (and derived from) many other successful learning cycles used in the development of curriculum and educator workshops. OPERA is an acronym:

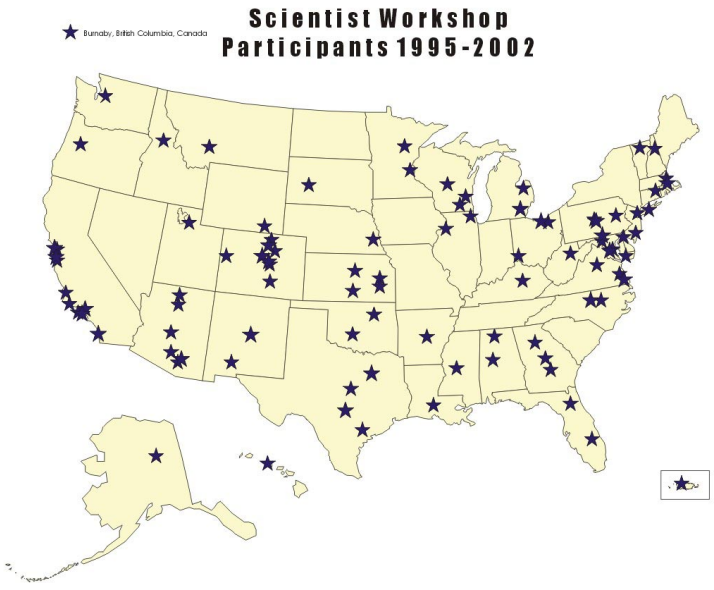

Fig. 1. Distribution of workshop participants by state from 1995 through 2002.

- OPENING a question of interest – engage inquiry
- PRIOR knowledge discussion or assessment
- EXPLORATION through experiments/ experiences
- REFLECTION on results; compare to prior knowledge
- APPLICATION of learned concepts to new situation

We endeavor to put this learning cycle to work on every scale, from the hours of an individual agenda element, to a complete day of workshop experiences, to the entire 4-day workshop agenda. Below, we present a day-by-day overview of current agenda elements to give a more complete picture of the intensive and comprehensive nature of the 4-day experience.

Day 1: Opening Prior Knowledge Discussions, Background on Key Issues, and Hands-on Experience with Exemplary Elementary Instructional Materials

- Opening, Overview, and Introductions
- What are the Goals for Science Education? – Small Group Discussions
- State of the Union in Science Education – keynote presentation from invited speaker
- Hands-on experience with exemplary elementary curricular materials [e.g. Electric Circuits]
- Exploration of the National Science Education Standards – Insights into Inquiry
- Presentation on Cognitive Science – How People Learn
- Time for reflection, evaluation, and action planning
- Reception: Poster presentations from participants

Day 2: Elementary School Explorations: Field Trip to a School District and Playing the Change Game

- Time to discuss learning and questions from the previous day
- Overview of the day at hand
- Field trip to elementary classroom and materials center of a school district implementing science education reform using the Full Option Science System (FOSS) kits
- Playing "The Change Game" which simulates the challenges of science education reform in the "Very Fine School District".
- Time for reflection, evaluation, and action planning
- Optional evening of videos on education (e.g. Private Universe, Minds of Our Own)

Day 3: Middle School and Informal Education Explorations, Roles for Scientists in Education

- Time to discuss learning and questions from the previous day
- "A Day in the Life of Middle School Teacher" – presentation with audience participation
- "Meet the Teachers" – Round robin of small group discussions between participants and a diverse selection of teachers from local school districts.
- Presentation on Multiple Intelligences: Kinesthetic Astronomy demonstration
- Perspectives on Engaging Scientists in Education and Public Outreach – panel
- The Very Fine Science Center – a hands-on experience with informal education
- Time for reflection, evaluation, and action planning
- Reception: Presenters' Showcase

Day 4: Explorations of Diversity and Educational Uses of Technology, Application of Workshop Learning to EPO Program/Proposal Planning OR Undergraduate Teaching

- Time to discuss learning and questions from the previous day
- Exploring Diversity in Education – presentation or round table discussions
- Educational Uses of Technology
- Application break-outs: Choose one: EPO planning or 2: Introductory Science Teaching
- Time for reflection, evaluation, and action planning

LESSONS LEARNED FROM OUR EXPERIENCE

We have evaluated and evolved our 4-day workshop every year of its existence. Based on feedback from the planning team, workshop presenters and participants, and other independent evaluation results we have made many adjustments to our recruiting of participants, our agenda, and our resource materials. We have discovered some significant cultural differences between "scientists" (meaning scientists and engineers) and educators and identified several misunderstandings that scientists commonly have about science education. We have also collected evidence of longer-term positive impact on our workshop participants.

CHANGES TO RECRUITING OF PARTICIPANTS

The workshops started out by targeting funded NASA space scientists who were being asked to become more active in "pre-college" education (re-named "K-12" education in the following year). We soon observed that NASA engineers also found the workshops alluring, and we broadened our mission to "space scientists & engineers". We also noticed greater interest from young scientists (i.e., graduate students and post-docs) and so changed our policies to embrace their participation. We then noted that greater numbers of earth and life scientists started finding their way to the workshop and so we broadened our targeted participants to "scientists & engineers" in earth and space science, and then to just scientists and engineers in general. As the policies of NASA and NSF increasingly resulted in opportunities for scientists to become involved in the leadership of educational programs associated with scientific research projects and institutions, our workshop title evolved to: "A 4-Day Workshop for Scientists, Engineers, and Education Managers on K-14 Education." The shift from "K-12" to "K-14" derived from the recognition that greater awareness of inquiry-based methods in K-12 education was having a positive impact on the undergraduate (and even graduate) teaching of our workshop alumni.

ADJUSTMENTS TO THE AGENDA

Throughout the lifetime of these workshops, we have experimented with new agenda elements and improved existing ones. A few of the core experiences have been so well received that they have not been significantly modified. These include the classroom visit, playing the Change Game, and hands-on experience with exemplary curricular materials. In the past few years, we have added core experiences in diversity, educational uses of technology, and informal education. We have also vastly increased the time participants spend in dialogue with practicing teachers through an innovative round-robin technique that allows each table of six participants to have small group discussions with 4-5 different teachers. We have arranged for more time at the beginning and end of each day for reflection, evaluation, and action planning. We have also used breakout sessions to accommodate participants' diverse interests. In addition, we have increasingly used past workshop participants as workshop faculty and guest presenters. These include Dr. Tim Slater of the University of Arizona, Dr. Stephen Pompea of the National Optical Astronomy Observatories, and Dr. Susan Buhr of the Cooperative Institute for Research in the Environmental Studies at the University of Colorado.

IDENTIFICATION OF SCIENTISTS' COMMON MISUNDERSTANDINGS ABOUT EDUCATION

Our workshop experience has proven unequivocally that we must work both sides of the partnership, bringing knowledge and experience in education to scientists just as we bring knowledge and experience in science to educators. Just as educators and students have common misunderstandings about science, professionals who make a transition from science or engineering into careers in EPO management have common misunderstandings about education. There are misunderstandings about the roles for scientists in education, about education as inquiry, about teachers, and about educational products.

Evidence of failure to appreciate the diversity and nature of roles for scientists in education is marked by comments such as: "I don't have time to become an expert in education. Leave education to those who are experts." or "If I'm not good at public speaking or classroom presentation then I cannot contribute much to education, and I will leave it to those who can." Our workshops support scientists in becoming valuable partners with educational professionals, not replacements for them. Also, we stress that public and classroom speaking are important, but only a small sample of the broader spectrum of roles scientists can play behind the scenes, including writing, reviewing, and advising on high-leverage educational products and activities (e.g. science center exhibits, planetarium shows, and exemplary instructional materials).

Evidence of misunderstandings about the science education standards and the role of inquiry in science education reform are marked by comments like: "The standards are a list of facts kids are supposed to know, and I do not see my scientific discipline represented in the science education standards" or "I learned science in school via lecturing and textbooks, so if it was good enough for me, it's good enough for today's students" or "The new teaching techniques avoid hard work, lack rigor, and are responsible for the poor showing of students from the United States in international tests." Such remarks fail to appreciate the profound similarities between the way scientists inquire in order to learn new things and the way the science education standards are asking teachers to

guide student inquiry in their classrooms – "students as scientists." We have evolved agenda elements on standards, inquiry, and instructional materials that confront these possible attitudes directly.

Workshop participants often underestimate the challenges modern teachers face in their profession. The collegial discussions with teachers are usually successful in offering a clearer perspective. Scientists also tend to believe (or want to believe) that most teachers are comfortable with the fundamental concepts of science and familiar with the national science education standards. Such beliefs lead scientists astray in the process of product development, for example, by presuming that the abilities of a practicing teacher can substitute for the capabilities of a professional curriculum developer or evaluator.

IDENTIFICATION OF CULTURAL DIFFERENCES BETWEEN SCIENTISTS AND EDUCATORS

The quote and Table 1 below summarize some of the cultural differences we have observed in the context of our workshops.

> Listening to teachers talk it made me aware of the different personality traits that scientists have that really put off other people – like being confrontational, questioning each other constantly. We're used to that because we do it every day. But I realized I need to be more careful when I'm around non-scientists. If scientists and teachers are working together, you need to be aware of that.
> — scientist and SSI workshop participant

Table 1. Cultural differences observed in the context of SSI workshops

Cultural Tendencies in Scientists	Cultural Tendencies in K-12 Teachers
Intellectually confident/arrogant	Less intellectually confident
Competitive	Collaborative
Critical	Appreciative
Less socially adept	Good social skills
Confronts problems	Works around problems
Assigns credit carefully for others' ideas	Borrows good ideas freely from others

IMPROVEMENTS TO RESOURCE MATERIALS

One of the authors (Morrow) has written a PowerPoint presentation and a series of white papers to address common cultural differences and misunderstandings that scientists have in education. These papers have been made available on a CD called "Resources for Scientists in Education", in hard copy via the workshop's Source Book, and via the web (Click "Papers on EPO" on the Quick Links menu at the bottom of http://www.spacescience.org). Participants report using these resources in communicating with colleagues at home institutions. Some of the titles include:

- Scientists' Involvement in Education and Public Outreach: Making the Case (ppt)
- A Framework for Planning EPO Programs Associated with Scientific Research Program
- The Diversity of Roles for Scientists in K-14 Education and Public Outreach
- What are the Similarities Between Scientific Research and Science Education Reform?
- Misconceptions Scientists Often Have about the K-12 National Science Education Standards (recently published in *Astronomy Education Review:* http://www.aer.noao.edu)

EVIDENCE OF IMPACT

Occasionally, we have conducted follow-up surveys of past participants to collect reflections and testimonials about the effect of our workshops. The quote below comes from one of those surveys and is representative of the kind of shift in perspective often reported by our alumni:

> From the moment I walked out of the SSI workshop, I knew that I had to step back and completely re-think our outreach efforts. In the two years since then, we have revamped our program from one that promoted content that our scientists thought the world should learn to a program driven by what the national standards (and education experts) prescribe. We now look to the standards and the needs of the teachers first and then to where our content fits, rather than creating programs and products and then retro-fitting them to standards. — Manager of Education for a major NASA research program

In 1998 we hired an independent evaluator, Dr. Timothy Weston of the University of Colorado, to conduct more substantive follow-up interviews with that year's workshop participants several months after their attendance. Weston's report provided evidence that the SSI 4-day workshop had changed the behavior of participants in substantial ways including:

- Greater involvement with outreach efforts research institutions – trying to change institutional policies to promote education.
- More confident overtures to teachers
- Writing or revising existing grant proposals in response to new insights on education
- Changing teaching philosophy and practice of teaching
- Greater communication and advocacy with colleagues
- Lasting connections between workshop participants

SPIN-OFF WORKSHOPS AND THE FUTURE

The success of our workshops has resulted in spin-off workshops and sessions for scientists at meetings of scientific professional societies. Such programs are custom-designed to fit the needs of a particular scientific or engineering audience. Table 2 below provides a list of the major workshops that have thus far been derived from our 4-day workshop experience:

Table 2. Major workshops derived from SSI 4-day workshop experience

Calendar Years	**Type of Workshop**	**Sponsors**
Nov 2001	2-day for 75 NASA engineers	NASA Glenn Research Center
Nov 2002	1-day for 20 NASA Earth Science Senior Executives	NASA Earth Science
Jan 2003	3-day for 30 scientists and education mgrs. Special Topic: Designing Exemplary Professional Development Experiences for Educators	NASA Space Science, NSF Geosciences [in collaboration with Biological Sciences Curriculum Study – BSCS]

We plan to continue our annual 4-day workshops and to spin off new workshops in response to community needs. The response to our special topic workshop on the professional development of educators was very high, and we plan to continue to offer this option to graduates of our 4-day workshops. We are also interested to explore other special topic workshops on informal education and educational uses of technology. We also envision offering a workshop experience designed to empower others to offer successful workshops on education to scientists.

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Filename: COSPAR paper - Workshops 4.doc
Directory: C:\program files\qualcomm\eudora\attach
Template: C:\Documents and Settings\brawley\Application Data\Microsoft\Templates\Normal.dot
Title: K-14 Education Workshops for
Subject:
Author: Cheri Morrow
Keywords:
Comments:
Creation Date: 4/7/2003 10:37 AM
Change Number: 15
Last Saved On: 5/6/2003 4:55 PM
Last Saved By: brawley
Total Editing Time: 141 Minutes
Last Printed On: 5/6/2003 4:55 PM
As of Last Complete Printing
Number of Pages: 8
Number of Words: 3,980 (approx.)
Number of Characters: 22,691 (approx.)