To download this presentation, please go to http://www.spacescience.org. Look for "Quick Links" at the bottom of the page, and select "Papers on EPO."

Scientist Involvement in Education and Public Outreach

Making the Case

PHOTO CAPTION: Dr. Robert Hoffman of NASA's Goddard Space Flight Center and educator Sheri Klug interact with students at Flatirons Elementary School in Boulder, Colorado. The visit was a part of the Space Science Institute's annual workshop for scientists on K-12 education, which is supported by NASA's Education Division.

[For more information see http://www.spacescience.org/Education/ResourcesForScientists/Workshops/1.html]

This draft presentation package was prepared by Dr. Cherilynn A. Morrow of the Space Science Institute in Boulder, Colorado, with support from the NASA Office of Space Science, the NASA Education Division, and the NSF Geosciences Directorate. Please send comments to camorrow@spacescience.org

We would greatly appreciate it if you would drop a line to let us know when and how you make use of this presentation or portions of it [camorrow@colorado.edu].

NASA/NSF Scientist Involvement in EPO

Research directorates of funding agencies like NASA and NSF are increasingly encouraging (and in some cases requiring) the integration of science and education and greater scientist involvement in Education and Public Outreach (EPO).

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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). In addition, smaller OSS research grant proposals have the *option* of including EPO segments up to $10K per year. [See *Implementing the Office of Space Science Education & Public Outreach Strategy* (1996) http://spacescience.nasa.gov/education/edprog.htm] Another component of the OSS EPO program is the Initiative to Develop Education through Astronomy and Space Science (IDEAS), which is a small grant program for scientists and educators who partner together on innovative EPO projects. [http://www.ideas.stsci.edu]

The NSF Geosciences Directorate has published an education strategy that includes a recommendation for the directorate to expand its educational agenda by promoting increased geoscience outreach to teachers, students, and the public. The strategy also recommends providing the information and training geoscientists need to become more effective contributors to such EPO. [See Geosciences Education: A Recommended Strategy. A report based on a workshop of the Geoscience Education Working Group to the Advisory Committee for Geosciences and the Directorate for Geosciences of the National Science Foundation (29-30 August 1996). NSF 97-171]

NASA/NSF Scientists Increase EPO Involvement

- NASA Office of Space Science (OSS) now *requires* every flight project (e.g., Hubble Space Telescope, Mars Pathfinder), to have a significant EPO program, totaling 1-2% of the overall mission budget.
- NASA's Earth Science Enterprise (ESE) is likely to enact a similar policy.
- NSF/GEO is now holding funding competitions for increased geoscience outreach to teachers, students, and the public.

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Goldin Advocates EPO Involvement

“The NASA Strategic Plan makes it the responsibility of each of our Strategic Enterprises to "embed" education into its program. No longer is it an acceptable practice to say, "we are too busy." Research, knowledge generation and education are all equal components of the NASA mission. We must combine our traditional methods of involving the education community with new and innovative ways so that the impact NASA has on education is greater.”

--Daniel S. Goldin, NASA Administrator, before the Committee on Science, United States House of Representatives, 28 April 1999

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Colwell Advocates EPO Involvement

"In science and math education, the links among inquiry, discovery and learning is omnipresent. All researchers - whether at a university, a national lab or circling the Earth in a space station - should link their inquiries with the education of the next generation."

--Dr. Rita Colwell, Director, National Science Foundation, before the House Science Committee, 28 April 1999

NASA & NSF Advocate EPO Training for Scientists

"OSS must provide focused opportunities (through workshops or other appropriate means) for training to allow members of the space science research community to become more useful partners in education and effective contributors to the public understanding of science." --NASA Office of Space Science Education/Public Outreach Strategy Implementation Plan, 1996

"GEO should help sponsor regular workshops for training geoscientists in educational issues that address a range of level of scientists involvement." --NSF Directorate for Geosciences, Geoscience Education Strategy, 1997

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The Need for Improvement - TIMSS

Third International Mathematics and Science Study (TIMSS)

Overall Comparative Findings
U.S. Performance Relative to the International Average

Content Area	Fourth Grade	Eighth Grade	Final Year of Secondary School	Advanced Math & Science Students
Mathematics Overall	Above	Below	Below	____
Science Overall	Above	Above	Below	____
Advanced Mathematics	____	____	____	Below
Physics	____	____	____	Below

SOURCE: National Center for Education Statistics (1996-1998). For more information visit the TIMSS website: http://nces.ed.gov/timss

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Background Information on TIMMS:

With information on a half-million students worldwide, including more than 33,000 U.S. students in more than 500 U.S. public and private schools, the Third International Mathematics and Science Study (TIMSS) is the largest, most comprehensive, and most rigorous international study of schools and students ever conducted. During the 1995 school year, students from 41 nations including our country's major trading partners were assessed at three different grade levels (fourth, eighth, and in the final year of secondary school) to compare their mathematics and science achievement.

Key Findings from TIMMS:

At fourth grade, U.S. students were above the international average in both science and mathematics. In the eighth grade, U.S. students scored above the international average in science and below the international average in mathematics. At the end of secondary schooling (twelfth grade in the U.S.), U.S. performance was among the lowest in both science and mathematics, including among our most advanced students.

The Need for Improvement - Seasons

- According to NSF's *Science & Engineering Indicators -- 1996*, 53% of a sample population surveyed did not know that Earth orbits the Sun once per year.

- 21 out of 23 randomly selected students, faculty and alumni of Harvard University could not correctly explain Earth's seasons.

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• National Science Board, *Science & Engineering Indicators - 1996*, Washington DC, United States Government Printing Office, 1996.

• The Harvard students, faculty, and alumni were interviewed at a Harvard graduation and some of the interactions are documented in a video developed by Harvard-Smithsonian Center for Astrophysics called "A Private Universe". This videotape has proven very striking to scientists who report gaining valuable perspective and insight into common barriers to learning. This 21-minute video is available from the Astronomical Society of the Pacific [http://www.aspsky.org; Order # VT 129]

The Need for Improvement - Kansas

- In August 1999, the Kansas State Board of Education voted 6 to 4 to remove the teaching of evolution from the state standards.
- Scientists are needed to become advocates of sound policies and standards in science education.

Scientists Rise to the Occasion in Kansas

- "**Scientists** and school board candidates – even the governor – said Kansas would seem embarrassingly backward if the new science standards stayed in place."
- "**Steve Case, a biologist at the University of Kansas and a leader of the drive to restore evolution to the curriculum** said that he and others brought in speakers like Kenneth R. Miller, a Brown University microbiologist and author of "Finding Darwin's God: A Scientist's Search for Common Ground between God and Evolution."
- "In the election, voters defeated those candidates who last year supported removing the mention of evolution from the state science curriculum."

Source: "Science Expands, Religion Contracts" by Pam Belluck, *New York Times*, 13 August 2000

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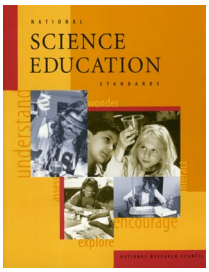
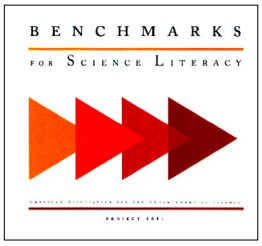
National Science Education Standards

- National Science Education Standards give a consensus of educators and scientists nationwide regarding what students should know and be able to do at different K-12 grade levels in science.
- Standards also address best teaching practices, professional development of teachers, and implementing systemic reform of education.





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Academic content standards describe what every student should know and be able to do in the academic content areas (e.g., mathematics, science, technology, geography). There are several standards-related documents and resources available at the McREL website (http://www.mcrel.org) including an integration of the NRC National Science Education Standards (http://www.nap.edu/readingroom/books/nses/), the AAAS Project 2061 Benchmarks (http://project2061.aaas.org/tools/), and other relevant education standards.

Browse the Standards in all core academic content areas starting at:

http://www.mcrel.org/standards-benchmarks/docs/contents.html

Science Standards – Earth and Space

http://www.mcrel.org/standards-benchmarks/standardslib/science-1.html

Note from Bullet #2 that

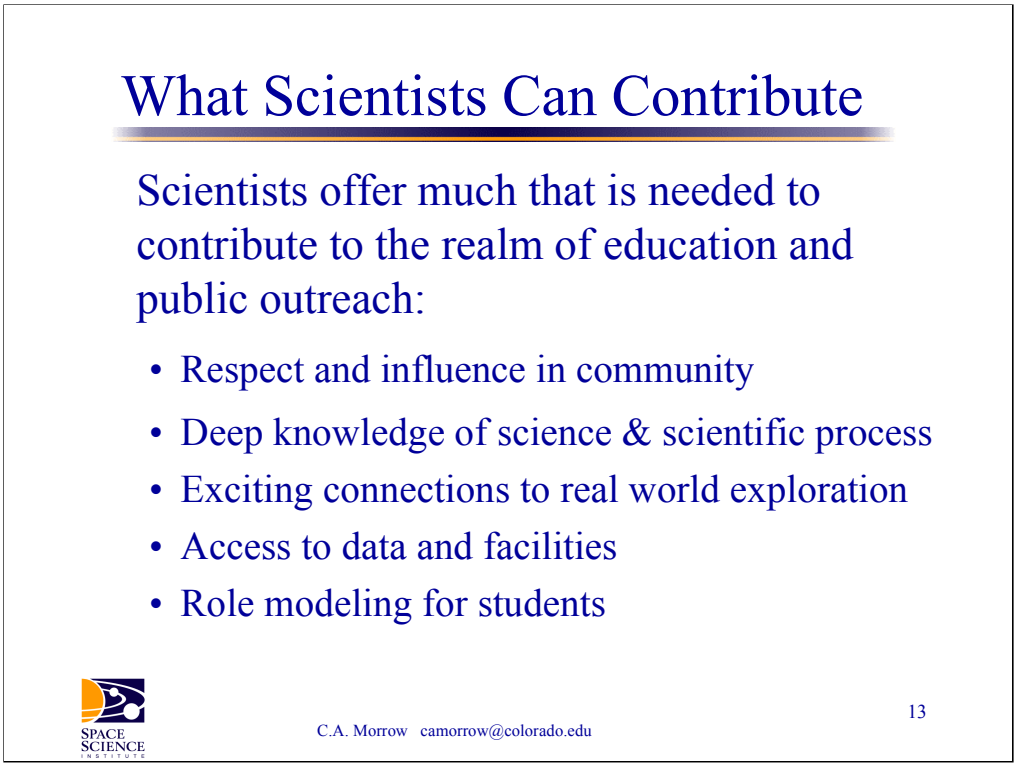
STANDARDS ARE MORE THAN CONTENT STANDARDS!

Importance of Partnerships - Alberts

"I now view effective science education partnerships between scientists and precollege education science teachers in a completely different light - as the only hope for lasting systemic change in precollege science education and, therefore, as an important national priority for the United States."

-Bruce Alberts,

President of the National Academy of Sciences, 1993



Examples of how these contributions may be of value:

Respect and influence in the community are valuable when it comes to advocating improvements to science and education, and in challenging politicians and school board members who promote science illiterate policies.

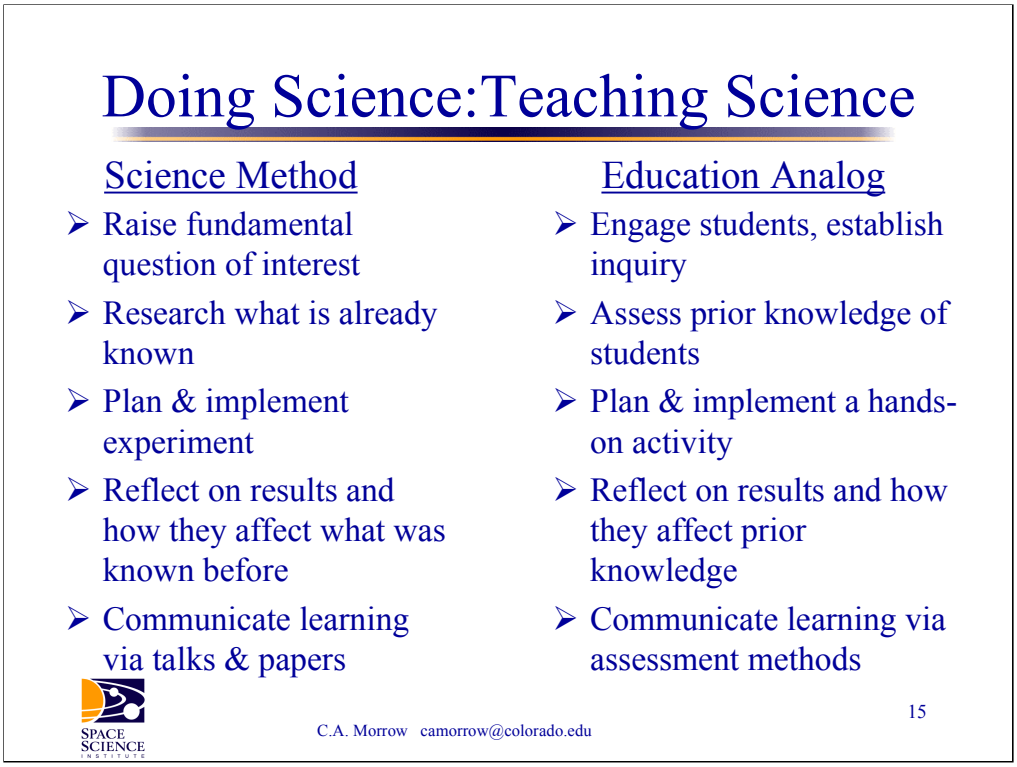
Deep knowledge of science and scientific process can be used in service to science teachers who are attempting to align their teaching with the idea of "students as scientists" rather than students as receptacles of facts and information (see next two slides on science education reform).

Connections to real-world exploration can enable exciting live educational programs linked to ongoing research that may be broadcast to classrooms and museums via the Internet.

Facilitating timely access to scientific data can be of great value to developers of curriculum, textbooks, museum exhibits, or other EPO products.

Modern Science Education Reform

- Students as "scientists" with teachers as facilitators of learning
  - Teacher as "a guide on the side" rather than a "sage on the stage".
- "Inquiry-based" process of learning
  - "The way scientists *do* science rather than the way they were *taught* science."



The slide shows the close analogy between how a scientist practices science and how modern science education reform advocates the teaching of science.

Note that hands-on activities alone do not constitute a complete lesson. Assessing students' prior knowledge without judgment and reflecting on how hands-on activities have extended or challenged that knowledge are essential components of learning cycle.

One effective 4-phase learning cycle used in lesson design is: Discuss, Explore, Reflect, and Apply.

1. Discuss: (assess students' prior knowledge and set up inquiry for activity/lesson)
2. Explore: (do activity)
3. Reflect: (look back at activity, analyze and discuss)
4. Apply: (apply learning in new contexts, communicate learning to others, identify questions that lead to next Discuss phase)

Comparing Approaches to Teaching

A Conventional Approach	A Hands-On Approach	An Inquiry-Based Approach
The teacher tells students that trees can be classified by examining their bark and their leaves. She shows pictures of trees in a textbook and asks students to memorize the names of the different types of trees according to the sort of bark and leaves they have.	The teacher tells students that trees can be classified by examining their bark and their leaves. She shows pictures of trees in a textbook and takes students to the park and asks them to match the pictures with the real trees.	The teacher tells students that scientists classify trees by the different features they have. She asks them to come up with ideas for what features would distinguish one tree from another. She takes them to the park to explore their ideas and to make observations and gather data that would help them create their own classification scheme for trees.

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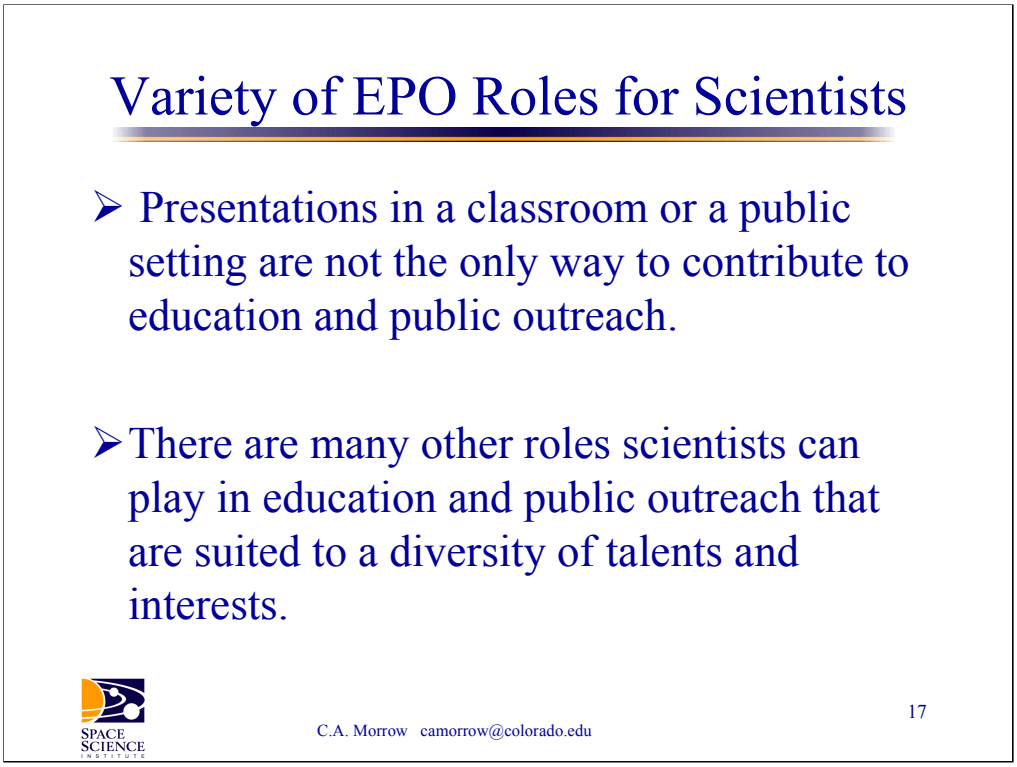

It is a common misconception among scientists that they should leave EPO to those who are exceptionally good at public presentation. There are many other ways to contribute that take advantage of a diversity of talents and interests in the science community (leads to presentation of Roles Matrix on next slide)

A Sampling of Roles for Scientists in Education

Entry Point		Nature of EPO Involvement		
		ADVOCATE	RESOURCE	PARTNER
	K-12 STUDENTS	• Participate in PTA	• Judge a science fair • Answer student email • Give tour of research facility	• Mentor a student • Tutor a student
	IN-SERVICE K-12 TEACHERS	• Speak out in support of appropriate professional development opportunities for teachers.	• Answer teacher email • Present in teacher workshop	• Work with a teacher to implement curriculum. • Hire a teacher intern.
	INTRO UNDERGRADUATE SCIENCE TEACHING	• Speak out in a faculty meeting in favor of attention to educational research that supports the reform of undergraduate science teaching. • Support the teaching profession in your science classroom.	• Teach a segment of a science or science methods course for pre-service teachers.	• Teach an intro science course that applies innovative inquiry-based methods • Develop a science course or curriculum in your department for teachers-to-be.
	SCHOOLS OF EDUCATION (Science Courses for Pre-Service Teachers, Graduate Students, Faculty Members)	• Speak out in your department or organization in favor of closer ties with Colleges of Education • Support the teaching profession in your classroom	• Teach a segment of a science course or science methods course for pre-service teachers. • Collaborate with education faculty to improve courses on teaching science	• Hire a graduate in education as evaluator of an education project • Work with an Education professor to develop a new "science methods" course for teachers-to-be.
	SYSTEMIC CHANGE (District, State, National)	• Speak out at professional meetings about the importance and value of scientist involvement in systemic change.	• Review science standards for science accuracy.	• Collaborate on writing or adapting science standards.
	EDUCATION MATERIALS DEV. (NSRC, EDC, Lawrence Hall)	• Speak out at a school board meeting for adopting exemplary educational materials.	• Review science educational materials for science accuracy.	• Collaborate to create exemplary science education materials.
	INFORMAL EDUCATION (e.g., Science Centers, Scouts, Planetaria, Elderhostels, Amateur Astronomy Groups)	• Participate on the board of a science center or planetarium.	• Review scripts for science exhibit or planetarium show. •Serve as a science advisor for an exhibit	• Create content for a museum science exhibit or planetarium show. • Serve as science coordinator for a scout troop
	PUBLIC OUTREACH (e.g., NPR, PBS, popular magazines/books/encyclopedias, lecture circuits, public websites)	• Advocate that quality science news be covered by your local newspapers and television stations	• Give a public lecture • Review an article or web site on science for accuracy and currency	• Collaborate in the production of a PBS television show • Write an article for a popular science magazine
	EPO PROGRAM MANAGEMENT	• Advocate the involvement of scientists in education and public outreach	• Assist a scientist with matching their talents and interests to an EPO project	• Design EPO programs with effective partnerships between scientists and educators.

ADAPTED FROM: "Improving Science Education: The Role of Scientists," Bybee, Rodger W., and Cherilynn A. Morrow, Fall 1998 Newsletter of the Forum on Education of the American Physical Society

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The far left column constitutes various entry points into the EPO realm. In general, as you move down the left column, the potential for reaching greater numbers is increased. There is sometimes a trade-off between numbers reached and the impact on those affected. The subsequent columns labeled, "ADVOCATE", "RESOURCE", and "PARTNER" represent a graduation in the time and energy spent on EPO, as discussed in the next slide.

The activities listed in the chart are representative of the ways scientists can be involved. This is by no means a comprehensive selection, but it is hoped that scientists of a diversity of talents and interests can see themselves making substantive contributions to EPO.

For a more detailed discussion of the roles scientists can play in Education and Public Outreach, please request the complete paper "The Diversity of Roles for Scientists in Education and Public Outreach" from camorrow@colorado.edu.

This chart is an updated version of one first published in"Improving Science Education: The Role of Scientists," Bybee, Rodger W., and Cherilynn A. Morrow, Fall 1998 Newsletter of the Forum on Education of the American Physical Society.

Nature of EPO Roles for Scientists

- **Advocate:** inspires, encourages, gives permission, empowers
- **Resource:** helps when called upon; makes resources available
- **Partner:** works shoulder-to-shoulder, "in the trenches," with education specialists to create new products or opportunities

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Classifying Scientists in EPO

- **A Tither** - a practicing research scientist who volunteers some of his/her time to EPO -- generally less than 10%
- **A Part-timer** - a scientist who is paid to do part time research and part time EPO
- **A Cross-over** - a full time EPO professional who was trained to do scientific research, and now has "crossed over" to the EPO field

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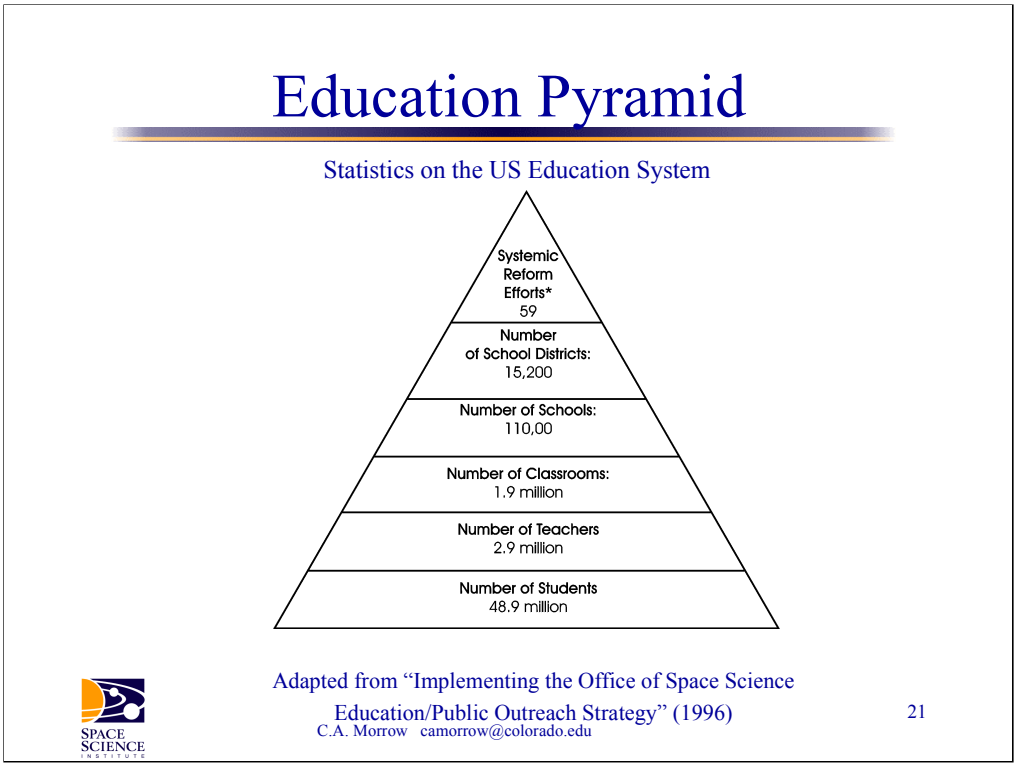
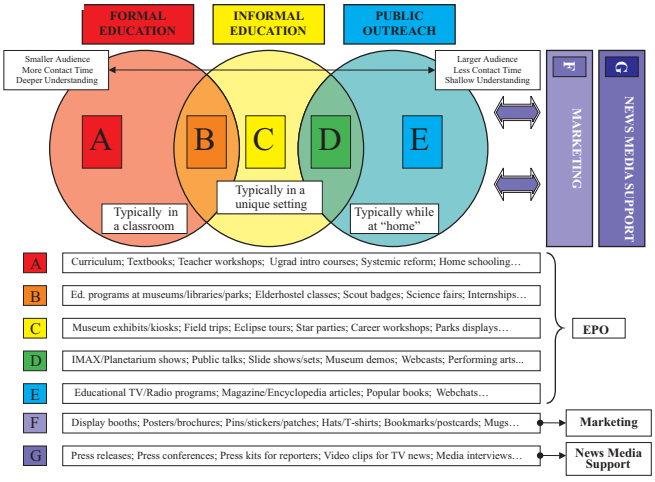


There are a few ten thousands of space and earth scientists and millions of students, teachers, and other citizens. It is important to amplify the efforts of individual scientists as much as possible by choosing an appropriate entry point into the education system.

For a more specific breakdown of statistics in the pyramid (e.g. private vs. public schools) visit the center for Education Reform's "Education Statistics At-a-Glance" website at http://edreform.com/pubs/edstats.htm.

*Systemic Reform Efforts consist of NSF's Systemic Initiatives including 18 Statewide Systemic Initiatives, 20 Urban Systemic Initiatives, 2 Rural Systemic Initiatives and 17 Comprehensive Partnerships for Mathematics and Science Achievement.

A Conceptual Framework for EPO Planning



This 3-circle Venn diagram offers a conceptual framework for planning education and public outreach programs associated with scientific research programs.

Cherilynn Morrow, Space Science Institute, May, 2000. Email camorrow@colorado.edu.

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This 3-circle Venn diagram offers a conceptual framework to distinguish among the realms known as Formal Science Education, Informal Science Education, Public Outreach, Marketing, and News Media Support.

In principle, these realms are all part of a continuum of activity that may be more broadly called "Science Communications" whose larger purpose is to increase science attentiveness, appreciation, and understanding. In practice, however, space and earth scientists are now being called upon to contribute to Education and Public Outreach (EPO), as distinct from Marketing or News Media Support (NMS).

The framework offered here is based on actual EPO planning. It makes no claim to being unique, but hopes to earn the claim of being useful, both in helping to identify and organize suitable elements of Education and Public Outreach (EPO) plans associated with scientific research programs, and in helping to develop mutually beneficial connections with Marketing and NMS activities. Note that while the framework is intended to provide ideas and terms of reference in support of actual EPO planning, it is not intended to represent any particular institution's organizational approach to science communications.

For more information and papers that more explictly define the regions (A-G), please contact Cheri Morrow at camorrow@colorado.edu.

Defining Formal Education

Provides a sustained opportunity to deepen knowledge and understanding of fundamental ideas and concepts that are useful in contributing to and interpreting the world around us.

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PHOTO CAPTION:

Eda Davis-Butts, director of the SMILE program for minority outreach at Oregon State University, interacts with students during a field trip to Flatirons Elementary School (1999) as a part of the Space Science Institute's annual workshop for scientists on K-12 education. For more information on these workshops, please see http://spacescience.org/Education/ResourcesForScientists/Workshops/1.html (Photo by Susan Solari)

Defining Informal Education

Offers engaging learning opportunities in unique environments (e.g. museums, planetariums, nature centers) that motivate further learning and life long interest.

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PHOTO CAPTION:

School girls interact with a prototype rover that will become a part of the Space Science Institute's MarsQuest traveling science exhibit. For more information on this exhibition, please see http://spacescience.org/Outreach/TravSciExhibits/MarsQuest/1.html.

(Photo is courtesy of Kennedy & Associates)

More than 100 million Americans visit science centers each year. This is more than all major sports events combined.

Defining Public Outreach

Reaches out to where people may conveniently tune in to hear or see in their everyday lives with information that excites, interest and arouses curiosity (e.g. TV, radio, home computer, magazines).

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PHOTO CAPTION:
Mother and daughter enjoy images of Mars and Venus in a popular astronomy magazine.

Defining Marketing

Primarily intended to market the worth of programs and products to targeted customers or special interest groups.

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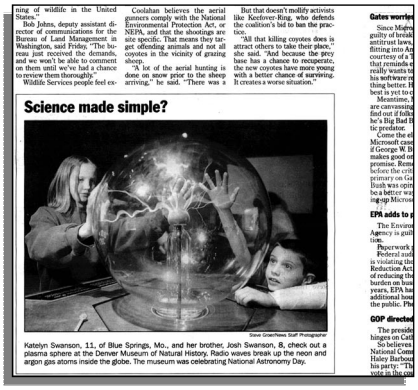
PHOTO CAPTION:
Carol Jo Crannel of Goddard Space Flight Center staffs the NASA Office of Space Science booth at a conference for science teachers.

Defining News Media Support



ning of wildlife in the United States."
Bob Johns, deputy assistant director of communications for the Bureau of Land Management in Washington, said Friday, "The bureau just received the demands, and we won't be able to comment on them until we've had a chance to review them thoroughly."
Wildlife Services people feel ex-

Coolahan believes the aerial gunners comply with the National Environmental Protection Act, or NEPA, and that the shootings are site specific. That means they target offending animals and not all coyotes in the vicinity of grazing sheep.
"A lot of the aerial hunting is done on snow prior to the sheep arriving," he said. "There was a

But that doesn't mollify activists like Keefover-Ring, who defends the coalition's bid to ban the practice.
"All that killing coyotes does is attract others to take their place," she said. "And because the prey base has a chance to recuperate, the new coyotes have more young with a better chance of surviving. It creates a worse situation."

Science made simple?

Steve Groenhows Staff Photographer

Katelyn Swanson, 11, of Blue Springs, Mo., and her brother, Josh Swanson, 8, check out a plasma sphere at the Denver Museum of Natural History. Radio waves break up the neon and argon gas atoms inside the globe. The museum was celebrating National Astronomy Day.

Provides new information for the print, radio, and television media via reporters. Reaches large audiences, and content can sometimes be adapted for more substantive educational purposes.

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PHOTO CAPTION:
The children are interacting with a plasmasphere that is a part of the Space Weather Center exhibit, a 1000 square foot traveling mini-exhibit developed in partnership between the Space Science Institute and Goddard Space Flight Center, with funding from NASA and the National Science Foundation. The news article illustrates an important connection between EPO efforts and the News Media.

Three C's for Partnerships with Educators

- COLLEGIALITY
  (find mutual respect with educators; acknowledge their expertise in education and the way it can complement your expertise in science)
- COMMUNICATION
  (do not condescend or try to take over; be very conscious of scientific jargon)
- COLLABORATIVE SPIRIT
  (collaborate rather than compete with educators)

Conclusions

- There is a strong need to improve science education and science literacy in the US.
- The participation of scientists in collegial partnership with educators and outreach specialists is vital to meeting this need.
- There are a wide variety of valuable EPO roles for a scientist depending on his or her particular talents and interests.