

Assessing the Current State of Informal Earth System Science Education

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Earth System Science is used to describe the study of the Earth as a multi-discipline, interconnected process, taking into account geology, biology, chemistry, physics, oceanography, and atmospheric science. Earth system science allows us to view the Earth—what is on, in, and around the Earth—for what it truly is: one dynamic system. And particularly now, as we further our understanding of the Earth as a system, we realize our impact as humans. When viewed in light of Earth system science, the public's responsibility as stewards of the Earth becomes clear. Because of this, it is imperative that Earth science literacy is achieved, particularly among the voting public.

A major change in the content of Earth science education is made necessary not only by our understandings of Earth systems and the way in which Earth science research is conducted, but also from new research on how people learn (Barstow, 2002). The National Science Education Standards for K-12 Education (NSES) (NRC, 1996) are key to the success of making these changes. The NSES promote new teaching practices, and for the first time at the national level, include standards of learning for Earth science together with those for biology, chemistry, and physics.

Informal education—i.e., those institutions outside K-12 (formal) education, such as museums, science centers, zoos, aquaria and the like—must be an integral component of Earth system science (ESS) education reform (Ross et al., 2001; Barstow, 2002). The facts that an estimated 150 million people visited the over 550 member museums of the Association of Science-Technology Center (www.astc.org) and that in total American museums average approximately 865 million visits per year (www.aamus.org) reflect incredible opportunities within these venues to educate the American public about Earth system science. Most Americans have never taken an Earth science course; yet in the informal setting of a museum, learning can occur among audiences of all ages and backgrounds. This can lead to enriched lives, Earth stewardship, and the public's understanding of Earth science research. Many scientists can trace their first motivation to pursue a career in science from such informal experiences as visits to a museum.

Museums and science centers are an effective starting point for improving informal ESS education. Informal education by definition can include any free-choice learning outside of formal education (e.g., Rogers, 2004). In addition to museums and science centers, free-choice learning takes place through media such as TV, radio, and Internet sites, printed materials for the lay public, boys and girls clubs such as Scouts and 4-H, as well as the wide range of natural history venues, parks, zoos, aquaria, and nature centers. Among informal education providers, museums (by virtue of their dedication to natural history collections) and science centers (which are dedicated especially to the illustration of physical principles) are most likely to have the staff and resources devoted to offering a wide array of learning opportunities in the Earth sciences. Some modern exhibitions and programming have become a blend of the best of these two worlds.

Personal interest in the Earth is the driving force behind informal ESS education. To increase public knowledge about the Earth, it is essential to foster "voluntary, self-directed" or "free choice" learning in Earth science. Some topics hold intrinsic appeal and can be used as a hook to introduce others. Interest in initial participation can be heightened through effective marketing. Unlike formal education, in which considerable

quantities of content are delivered through regular presentations and activities, informal education concentrates on a few key conceptual messages that can be delivered in limited amounts of time. Good informal science education aims to leave participants with overarching messages, such as that (for example) the Earth is dynamic, its processes are interconnected, it has an ancient history, and humans influence Earth processes. Such concepts become the framework from which other learning occurs.

Informal Earth science education is one of the primary ways the general public learns how and why Earth stewardship is necessary. Effective learning experiences in Earth science and history provide the additional perspectives that resources are finite, that the Earth does change, and that current global change is occurring relatively quickly. An informed citizenry is more likely to make lifestyle choices that positively influence environmental and natural resource issues.

Informal education is the primary means by which the public and government representatives can stay informed about interesting and societally significant Earth science research. People do not support what they do not understand. Without broad public support, Earth science research – and all that comes from this research – cannot flourish.

Informal education is a major way by which many young people consider careers in geology and related fields. The next generation of geoscientists is affected by the degree to which young people are encouraged to follow careers in Earth science. Many will have limited contact with Earth science in school and may be more open to learning science in free choice learning environments. In this way, museums that have substantial minority audiences could be especially significant for increasing diversity in the Earth sciences.

Existing data suggests, however, that informal Earth system science needs more attention. A study of informal ESS education by NASA (NASA, 2000) revealed that 80% of 158 providers of informal education surveyed use 25% or less of their floor space for Earth science. More telling, few staff surveyed at the organizations were satisfied with the coverage of their Earth science topics. For example, only 21% of those that have exhibits on volcanoes and earthquakes were satisfied. We know of no literature that has broadly evaluated the quality of Earth science exhibits and programs in museums, but our personal experience is that most museums, especially small ones, are challenged by the lack of funds and staff to provide up-to-date exhibits and programming. Most documents on reform in science and Earth science education are explicitly focused on formal education (e.g., NRC, 1996; AAAS, 1993; Ireton et al., 1996), and other more general documents give informal science only a few paragraphs of attention (e.g., NSF Geoscience Education, 1997).

The Collaborative for Excellence in Geoscience Education. For the past two years, a group of four collaborating organizations—Paleontological Research Institution (PRI, lead organization), Denver Museum of Nature and Science (DMNS), Science Museum of Minnesota (SMM), and TERC, have been investigating the needs of the informal science education community to address current scientific understandings of Earth systems, in particular through the planning grant “Collaborative for Excellence in Informal Geoscience Education (CEIGE)” (NSF 0500002). The Collaborative has investigated a sample of the informal educator audience through a survey, documenting the amount and kind of ESS presented in informal venues that offer at least some ESS education and/or exhibits, the human resources available to carry out ESS education and exhibits, and educators’ interests in networking and shared resources.

Survey of the Informal ESS Community. Individuals from 75 organizations (from a mailing to about 350 organizations) filled out the survey. Other information was collected from available literature and from discussions coordinated as part of the CEIGE informal ESS education planning grant. These discussions occurred at, e.g., the Informal Geoscience Education open forum at the Geological Society of America (GSA) in fall 2004; a session at GSA in fall 2005; and an advisory panel meeting in Washington, D.C. in spring 2006. We believe that the museums that responded to our survey are fairly representative of the whole sample, and any bias would likely, if anything, overestimate the amount of ESS available in museums, as museums with substantial ESS exhibits may be more inclined to respond to the survey. Most museums in our sample are less than 100,000 sq ft (median of 20,000 sq ft). The median number of staff per organization involved with education and exhibits who have Earth science training is only one (1), and about 1/3 of institutions have no Earth science-trained staff.

To quantify the need for additional ESS programming, our survey asked whether institutions were planning to update ESS content within the next 5 years. Available answers ranged from 1 through 7 (1= “no way”, 7=“definitely”). Most (80%) respondents said they might be or would be changing content (choices 5-7), with over 20% indicating they would “definitely” be updating their ESS exhibit content. Though a small number of museums consider themselves to have extensive offerings in ESS, the median percentage of exhibits devoted to ESS is 20%; the median is similar for educational programming (20%) and for other educational resources, such as publications (16%). We might expect this number to be 25% if equal weight were given to biology, chemistry, and physics, and perhaps greater than 25% considering that the concerns of ESS overlap with other fields. From this perspective, more than half of museums devote a disproportionately small amount of effort to present ESS concepts.

We also asked the percentage of ESS exhibits and education dedicated to ten predefined categories. “Geological features and processes” and “paleontology and record of evolution” are relatively well-represented. However, the median effort in U.S. science museums devoted to “Earth systems,” “remote sensing and visualization,” “ocean processes,” and “glacial processes” – topics essential for adequately addressing issues of global change—*is zero*.

It is clear that the community of informal educators could benefit significantly from a network devoted to ESS issues specifically targeting average educators at smaller organizations, many without ESS training. These findings also indicate that there is a great need for quality professional development in informal ESS education.

ESSIEN: Earth System Science Informal Education Network

Based on our findings, and in recognition of the importance of Earth system literacy (ESL), we have begun to establish a collaborative national network among informal educators and exhibit developers. The Earth System Science Informal Education Network (ESSIEN) will promote ESL based on a core set of principles and will facilitate the sharing of knowledge, resources, and ideas among informal science education venues of all sizes.

One product of the NSF funded CEIGE informal ESS education planning project has been the development of a website now in its nascent stages, **InformalEarthScience.org** which is designed to provide a platform for informal ESS educators to share resources, ideas and news specific for the informal ESS community. The site is part of a proposed project to create a network of informal ESS providers, the Earth System Science Informal Education Network (ESSIEN), designed to promote Earth system literacy and facilitate the sharing of knowledge, resources, and ideas

among informal science education venues of all sizes. In our survey we assessed attractiveness of the idea of participating in such a network. The result was extremely positive, more so than any other suggestion in the survey. Over 85% of the respondents responded positively (the mode was 7, “definitely”) that they would participate in a network.

The results of our survey suggest that there is a great need for a coordinated effort to build a more cohesive network to share resources and best practices among providers of informal ESS education. Though many examples of informal ESS education exist, there is no resource allowing an organization to find a comprehensive, evaluated, and reviewed set of plans for building exhibits and creating programs. There are no journals or books, websites, digital libraries, mailing lists, or society meetings, which act as a centralized source for communicating the latest innovations in informal Earth science exhibits and education. ESSIEN will help to provide a forum for uniting the community nation wide, and give informal ESS providers access to resources such as traveling exhibits, programming, and best practices as well as forums for discussion of pertinent topics. ESSIEN would therefore not only benefit larger institutions with resources to disseminate, but most importantly, provide those venues with few resources access to those members who may have no- or low-cost exhibits plans, programming and the like to share within the informal ESS community. ESSIEN may also provide a ‘home base’ for providers to connect at professional meetings and conferences, helping to organize/host workshops, roundtables, etc. on topics specific to the community.

Professional Development for Informal ESS Providers. Our survey also showed that, unfortunately, many informal Earth science venues lack staff degreed in some area of Earth science. Professional development (PD) in ESS for the informal education community is greatly needed. Such PD will better inform the informal ESS education staff on Earth system science principles, as well as knowledge on effective inquiry-based teaching methods applied to ESS. Creating this professional development would provide the pedagogical content knowledge necessary for offering effective Earth system science programming at the venue.

PR1 is working through the Earth System Science Education Alliance (ESSEA) to produce professional development for informal ESS providers. ESSEA is an NSF and NASA funded organization that supports educational institutions across the country in offering a series of online Earth system science courses for *formal* (K-12) educators. Working in collaborative groups, teachers earn graduate or continuing education credit while solving problems, building models, and designing classroom activities. We intend to work through ESSEA, using their model for professional development and apply that model to designing PD for informal Earth science educators. Part of the ESSEA grant will also provide for mini-grants to participants’ home institutions for contextualizing their learning through upgrading exhibit signage and/or programming.

Using informal ESS venues as a conduit to provide local formal educators with ESS professional development. The ESSIEN website will be a contact point for disseminating the ESSEA professional development for both the informal education community, and in the next phase of the project, for disseminating ESSEA K-12 teacher ESS PD. There are thousands of informal venues across the U.S., and their potential to provide quality teacher professional development is largely untapped. Most museums and science centers have established relationships with their local formal educators. A study by CILS (Phillips, 2006) showed that over 50% of these venues—many in rural areas and serving groups underrepresented in the sciences—serve local teachers and

students with programming, and also provide some form of teacher professional development. Our survey of informal Earth science venues also showed that although venues may deliver some teacher PD the majority of venues don't possess the resources in-house to foster high quality, inquiry-based teacher professional development in Earth science. Informal ESS educators need an effective, evaluated, program for K-12 professional development in Earth system science to provide the pedagogy K-12 teachers require to successfully teach Earth system science in the classroom. ESSEA has that product, and given the thousands of informal education venues who are in touch with their local teachers across the U.S., using these venues as conduits for teacher professional development and better education in Earth system science has the potential for immense impact. Existing members of the Network will make excellent candidates for piloting the ESS PD, as there are approximately fifty "Founder" members of the Network, geographically and demographically diverse, who have shown an interest in being at the forefront of providing and evaluating resources for the informal community.

The professional educators and exhibit developers that the products of the CEIGE planning grant will serve are based at museums, science centers, and related informal education venues that offer informal ESS education. This professional audience is increasingly called upon to provide information about 21st century issues, including sustainability and global climate change; Earth hazards such as earthquakes, tsunamis, and hurricanes; and the conservation of energy and mineral resources. Informal ESS educators are also called upon to present topics of public fascination that are among the most accessible entries into science, such as new ideas on the biology and ecology of dinosaurs, new discoveries in hominid evolution, the significance of asteroid impacts, and the remarkable new views of Earth from satellite imagery. Through collaborative efforts such as ESSIEN and *InformalEarthScience.org*, and offering quality professional development in informal ESS education, the informal ESS community can better serve the public *and* their formal education partners in the dissemination and understanding of Earth system science.

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