EXECUTIVE SUMMARY: EARTHCUBE EDUCATION WORKSHOP

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Earth Cube Workshop Title: EarthCube Education End-User Workshop

Introduction:

Forty-six geoscientists, geoscience educators, data providers, employers, technologists, and curriculum developers met on March 4–5, 2013, at Scripps Institution of Oceanography to advise EarthCube's leaders and builders on the needs of end-users who will use EarthCube for education. The learners targeted by our recommendations include traditional undergraduates, but also other motivated adult learners, especially scientists from other disciplines collaborating with geoscientists on interdisciplinary problems. The goals of the workshop were:

- to build EarthCube in such a way as to bring the power of learning through geoscience data and models within reach of novices
- to use EarthCube to educate future geoscientists, who will be unprecedentedly facile with data and models, and "native speakers" of interdisciplinary systems

GEOSCIENCE EDUCATION ISSUES AND CHALLENGES

1. **Important geoscience education drivers in the 21st century:** (list 3 to 6).
   - Few of the big claims of geoscience (e.g. plate tectonics, global climate change, age of the Earth) can be explored in traditional student laboratory activities in the way that physics students can experiment with forces and accelerations or biology students can experiment with growing plants. Thus, the availability of professional-caliber datasets on the Internet has been transformative, insofar as it has allowed geoscience students to engage, in many cases for the first time, with the data that form the evidentiary basis of the concepts that they are studying. Geoscience education is out ahead of the other sciences in its use of large professionally-collected datasets for undergraduate education, and thus is having to pioneer new pedagogy around teaching and learning with data and models.
   - We live in a data-infused society. In today's workforce, data isn't only for scientists. In an ever-increasing percentage of professions, from nurse to car mechanic to teacher, adults are expected to be able to make use of data in the daily demands of their work. In our current education system, science and math are the places where students encounter data, and so teaching basic data using skills ("data literacy") in these classes has become a basic workforce training imperative for all students.
   - Beyond the level of basic data literacy comes a degree of mastery that the workshop participants referred to as "data-savviness." The workshop wove an inspiring vision of the attributes of a data-savvy college graduate, skilled at using data and models to answer difficult questions and solve hard problems, facile with systems thinking and interdisciplinary problem solving, and able to make inferences about process and causality from Earth observations.
   - Our society faces many difficult decisions in the 21st century. The workshop conveners and participants think that better decisions would be made if a larger fraction of the populace used evidence, evidence grounded in data, in making decisions in their personal and professional lives. Undergraduate education is a prime time to establish the habit of mind of using data as an input to answering questions or solving problems. For the suite of decisions that revolve around approaching limits to growth on a finite planet (energy, water and mineral resource limits; environmental degradation; climate change), the relevant data will be of the sort served by

EarthCube.

- As computational models become a much more important part of the geoscientists' toolkit, geoscience education is endeavoring to convey this trend and prepare students to be a part of it. This is proving difficult, in part because students bring forward with them from K-12 the expectation that models are for demonstrating or explaining that which is already known rather than hypotheses to be tested by comparison with data. The epistemology of how scientists actually go about creating new knowledge using external runnable models is not widely understood by teachers or by the public.
- Pre-college education is on the cusp of change, driven by the advent of the Next Generation Science Standards (NGSS). The NGSS foreground "science and engineering practices," including "analyze and interpret data" and "develop and use models." If and when the NGSS are fully and widely implemented, students will arrive at college with much more knowledge of the Earth, of data and of models—and with an expectation that science education should involve activities in which students construct meaning through active exploration. In the meantime, the prominence of the practices the NGSS is spurring a flurry of education research on the practices, including the data-using and modeling practices.

2. **Current challenges to high-impact, interdisciplinary geoscience education using data and models:** (list 3 to 6).

- Tools and interfaces designed for geoscience experts pose a significant barrier to use by students and other novices, especially when working on interdisciplinary issues.
- Many students enter college with minimal knowledge or skills around data, models, or the Earth.
- For some topics and audiences, there is a shortage of high quality instructional materials (especially around models, but also around data), that involve students in active inquiry rather than cookbook direction-following.
- Many instructors lack pedagogical content knowledge (knowledge of how to teach a body of content rather than knowledge of the content itself) around teaching with data and models, and lack a community of practice within which to develop this knowledge.
- Relevant cognitive/learning science is sparse and insufficiently incorporated into instructional design.

TECHNICAL INFORMATION/ISSUES/CHALLENGES

1. **Desired tools, databases, etc., needed for geoscience education:**

- The undergraduate geoscience education community makes uses of a very wide variety of geoscience data types. To see the range and depth of data in current use in geoscience education, please browse the following collections: *Using Data in the Classroom: Data Sources and Tools:* *(*http://serc.carleton.edu/usingdata/resources.html) and *Earth Exploration Toolbook Chapters:* (http://serc.carleton.edu/eet/chapters.html).
- Cyberinfrasture desired by the education workshop (see further detail in full report):
    - Data germane to society's pressing problems
    - Field data
    - Ability to ingest and display student collected data
    - Tiered approach to data quality (allowing quality student data to be added, while keeping out inadequate data)
    - Near real-time data, and also historical archival data
    - Local informants' eye witness accounts
    - Novice-friendly interface options, scaling gradually up to the full professional interface
    - Support for data exploration and "making 'failure' cheap"
    - Collaboration tools
    - Supports for understanding uncertainty in data and model output

- Comprehensive and comprehensible metadata
- Simple and well-documented versions of geoscience models
- Support for student building of models

- Pedagogical & social infrastructure desired by the education workshop includes:
  - Support for citizen science
  - Mentoring for both teachers and students
  - Assessment techniques for student mastery of data and modeling practices.
  - Tutorials and training sessions
  - Venues in which to share and build a community of practice
  - Support for diverse populations, including learners with disabilities, urban youth with limited access to nature, and adult professionals crossing fields.
  - Support for entrepreneurial enterprizes

COMMUNITY NEXT STEPS

1. **List of what your community needs to do next to move forward and how it can use EarthCube to achieve those goals:**
   - Work with cyberinfrastructure designers to ensure that EarthCube's tools and interfaces have options to present themselves in ways that make sense to, and communicate effectively with, learners and novice users (see details in full report).
   - Work with in-service K-12 teachers and pre-service teacher educators to ensure that the EarthCube-relevant portions of the Next Generation Science Standards are implemented effectively: the Earth & Space Science Disciplinary Core Ideas, Practice 2 ("Developing & Using Models") and Practice 4 ("Analyzing and Interpreting Data".) EarthCube-based lesson plans, and EarthCube's social infrastructure (webinars, workshops, social media, etc.) will be useful in this effort.
   - Lay out a learning science research agenda covering key questions in how humans learn with data and models. Collaborate with cognitive scientists, learning scientists, and education researchers to implement the plan, using EarthCube data as a testbed for some studies. Disseminate the findings among curriculum developers and faculty.
   - Continue to develop and test teaching and learning materials that involve students in making meaning from data and models, using instructional sequences that go beyond cookbook step-by-step. EarthCube can help by providing virtual and face-to-face venues where such instructional materials can be shared, vetted, and improved.