Earth Educators Rendezvous 2019

*Future of Undergraduate Geoscience Education & Geoscience Workforce*

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*Results from project sponsored by*

[Image of National Science Foundation logo]
Heads/Chairs Workshop:  
Future of Undergraduate Geoscience Education

Goals

• Discuss outcomes of the Future of Undergraduate Geoscience Education initiative, how that maps to your undergraduate program & what changes should be made

• Learn the best practices have worked for your peers in implementing these changes into their departments, as well as what doesn't work

• Learn to navigate the common issues raised by faculty when faced with addressing these changes, and work in small groups to begin the process of preparing to address these issues
Summit on the Future of Undergraduate Geoscience Education

- National conversation on shape and content of future Bachelors-level geoscience curriculum & programs (supported by NSF-Geosciences)
  - Three meetings:
    - Summit: 1/14 - 180 educators (2YC to R1); ~20 employers
    - Geoscience Employers Workshop: 5/15 - 46 participants – Geology & Geophysics
    - Heads and Chairs Summit: 1/16; 109 Dept. leaders
  - Nationwide survey of geoscience faculty and professionals - 360 academics; 105 employers; 85% non-Summit participants
- Objectives:
  - identify consensus on essential skills & concepts
  - facilitate curricular transformation in geoscience programs nationwide

http://www.jsg.utexas.edu/events/future-of-geoscience-undergraduate-education/ (for reports and more information)
2014 Summit on the Future of Undergraduate Geoscience Education

Survey results:

What are the most important issues from your perspective in terms of undergraduate geoscience education?

- Improving competencies, skills & conceptual understanding
- Broadening participation/retention of more diverse student population
- Adopting research-validated pedagogies & technology in geoscience classes
- Preparing K-12 science or geoscience teachers

![Bar chart showing responses to survey questions.](chart.png)
Concepts, Skills, Competencies

• **Major conclusion of 2014 Summit**
  – Developing competencies, skills, and conceptual understanding
  – More important than taking specific courses

**Survey Results:**

- **Academics:**
  - Yes [80%]
  - No [20%]

- **Employers:**
  - Yes [80%]
  - No [20%]
2014 & 2016 Undergraduate Summit/Workshops, Survey, 2015 Employer Workshop

• Concepts:
  – Traditional Earth Science – most cover (deep time, earth materials, structure, surface processes, etc.)
  – Other geoscience – some cover, variable extent (climate, hazards, resources, hydrogeology)

Employers added granularity, plus emphasized
  – Systems Thinking
  – Understanding processes
  – Linkages, feedbacks, driving forces
  – Impacts

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Earth as a Complex System
• Non linear complex systems
• Energy, mass, fluid transport (movement and flow), residency, and cycles
• Work/changes that affect the Earth’s systems
• Solar system interaction

Deep Time
• Conventional concepts of geologic time
• Impact on processes
• Events and rates
• Temporal reasoning

Earth Materials
• What is a rock, mineral? Rock cycle
• Rocks: physical and chemical properties
• Processes that form rocks and minerals
• Resource applications, organic-inorganic materials

Earth Structure
• Structure of Earth
• Deformation
• Plate Tectonics, including
• Structural controls on resource accumulations
Surface Processes
- Sediment deposition & erosion
- Terrestrial and marine surface interactions
- Landscape alteration (geomorphology)
- Habitability, sustaining life

Hydrogeology
- Water cycle
- Groundwater/aquifers, confined vs unconfined aquifers
- Biogeochemistry and aqueous geochemistry
- Subsurface-surface water interactions
- Economics and public policy

Natural Resources
- Understanding of what is included in “natural resources”
- Solid vs. liquid resources, geographic distribution, uses
- Ecosystem services, analysis of renewable and non-renewable (finite) resources
- Resource dependency and limits

Climate Change
- What is climate change? Geologic scale vs. present change
- Driving forces and causal mechanisms
- Carbon cycle
- Difference between weather and climate & Impacts of climate change
Employer Workshop:
Systems Thinking & Understanding Processes

How systems work and interact
• Atmosphere, Hydrosphere, Lithosphere, Pedosphere/surface, Biosphere
• Solar/Earth Interactions
• Human/Societal Coupled to Earth

Processes
• Thermodynamics – energy, kinetics, diffusion, heat, mass transfer, fluid flow
• Geochemical Cycles – C, H₂O, N, P
• Geomechanics/Stress State/Rheology
• Geological Time/Earth Evolution
• Plate Tectonics/Geodynamics
• Tectonic Processes
• Depositional Processes
• Crystallization Processes

Tools – used to measure & gather data
Summit Outcomes/Survey Results: Science Skills

- Critical thinking/problem solving skills
- Communicate effectively to scientists & non-scientists
- Ability to access and integrate information from different sources and to continue to learn
- Understand and use scientific research methods
- Have strong quantitative skills and ability to apply
- Work in interdisciplinary teams and across cultures

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Be technologically versatile (i.e. Google Earth, tablets, smartphones, apps)

Have strong computational skills and the ability to manage and analyze large datasets

Have strong field skills and a working knowledge of GIS

Integrate data from different disciplines and apply systems thinking

Work with uncertainty, non-uniqueness, incompleteness, ambiguity and indirect observations

Readily solve problems, especially those requiring spatial and temporal (i.e. 3D and 4D) interpretations

Make inferences about Earth system from observations of natural world combined with experimentation and modeling

Summit Outcomes/Survey Results: Geoscience Skills

- Very 1
- 2
- 3
- 4
- 5 Not
Employer Workshop: Geoscience Thinking

Earth Science habits of mind/geoscientific thinking
• Temporal and spatial thinking – 3D & 4D
• Systems thinking – Earth as system of interacting parts & processes
• Geologic reasoning and synthesis

Problem solving
• Open and dynamic system
• Real data, non-unique answers
• Work by analogy, inference and the limits of certainty

Intellectually flexible - applying skills in new scenarios
Critically evaluate literature, critical thinking
Experience with authentic research, collection of new information

Preparation for life-long learning
• How to learn and use new technology and software
• Ability to learn and apply new concepts, ideas and data
Higher level math & computer programming skills
• Probability, statistics, uncertainty analysis & risk assessment
• Differential equations/linear algebra
• Computer programming, modeling

Data Analysis Skills: BIG DATA
• Integrate multiple large datasets

Field Camp and Field Experiences & GIS
• Improves spatial cognition, creative problem solving, teamwork, geoscience synthesis

Cross-disciplinary Teamwork on Interdisciplinary Projects/ Project management
• Working in teams with different backgrounds, specialties, experience, personalities
• Goal setting
• Time management
• Conflict resolution

Communication skills
• Written & verbal scientific communication & Listening

Non-technical Skills
• Ethics
• Interpersonal skills - ability to work with different types of people
• Professionalism
• Global perspective
• Understanding societal relevance & implications
Effective Ways of Developing Skills/Competencies/Concepts

Experiential learning

Constant engagement/opportunities to practice skills/use concepts

- Problem solving; using and analyzing real data in classes
  - ASBOG test as a source of problem-oriented activity
- Integrate written/oral intensive courses in programs
- Collaborative, integrative, interdisciplinary team projects
- Integration and interactive use of technology
  - Visualization, simulation, modeling, use of real data

• Substantial experiences
  - Fieldwork and field experiences
  - Capstone, problem/project oriented courses
  - Independent research experiences/projects, Senior Theses
  - Internships or REUs

Active collaboration between academia and the outside employers
Universal skills for Geoscience Graduate Student Success in the Workforce

National conversation on skills/competencies needed by Ph.D. & M.S. students in Ocean, Atmosphere & Earth Sciences for current and future workforce

- **Geoscience Employers Workshop – Oct. 2018**
  ~52 participants representing broad spectrum of geoscience employers of PhD & MS students in Earth, Ocean & Atmospheric Sciences
  - Industries, Non-profits, other organizations: Weather/climate, Energy/natural resources, Oceans/fisheries, Environment, Reinsurance/hazards
  - Government agencies – NASA, NOAA
  - Research labs & universities
  - Professional societies

- **Summit for Heads/Chairs - May 2019**
  ~80 Departmental leaders

http://www.jsg.utexas.edu/events/summit-on-improving-geoscience-graduate-student-preparedness-for-the-future-workforce/ (for more information)
What skills and competencies make PhD and MS graduates successful in the workplace today (and future)?

Geoscience Employers Workshop
• Need Expertise/Depth in core area → leads to judgment and confidence
  – Knowledge in their field of geosciences
  – Research skills; field skills
• Problem solving & critical thinking
• Teamwork, Collaboration
• Leadership
• Communication - Expressing technical work effectively to appropriate audiences; Listening Skills
• Data Management & Data Analytics - Currently need and increasingly important in the future – across employer spectrum
• Computational skills – Basic programing, coding, etc.
• Basics of statistics and math – from undergrad
• Systems Thinking – not just Earth
• Project & Program Management
• Business Skills
• Ethics & Professionalism
• People skills