Earth Educators Rendezvous 2019

Future of Undergraduate Geoscience Education & Geoscience Workforce

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Results from project sponsored by

National Science Foundation
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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

THE UNIVERSITY OF TEXAS AT AUSTIN

Make a Gift

Prospective Students JSG Community Alumni & Friends Recruiters & Companies

TEXAS Geosciences
The University of Texas at Austin
Jackson School of Geosciences

About Research Education People Outreach News Events Support

JSG Events

Home > JSG Events > 2016 Heads/Chairs on the Future...

DeFord Lecture Series
Master's Saturday
2016 Heads/Chairs on the Future of Undergraduate Geoscience Education Summit
Summit Materials, PowerPoints and Webcast Archive
Background Reading
Agenda
Graduation
Distinguished Lectures
Association Meetings
DGS Vehicle Reservation Calendar
Submit an Event

2016 HEADS/CHAIRS ON THE FUTURE OF UNDERGRADUATE GEOSCIENCE EDUCATION SUMMIT

Department Heads & Chairs Summit on the *Future of Geoscience Undergraduate Education*: January 2016

This NSF-sponsored summit brought together ~100 geoscience academic leaders from R1 research universities with undergraduate programs, four-year private and state colleges (4YC), and 2-year community colleges (2YC) from across the country. The summit participants discussed the developing community vision for undergraduate geoscience education and developed strategies for implementing this vision in departments across the country. Over the past two years, we have engaged a diverse spectrum of the geoscience academic and employer community in a comprehensive review of the skills, competencies, and conceptual understandings needed in geoscience undergraduate programs, the best methods of producing these learning outcomes, and how to best broaden, recruit and retain undergraduate geoscience students, especially underrepresented groups (see below). This summit was specifically designed for administrative leaders who have the ability to make and lead change.

Summit Materials, PowerPoints and Webcast Archive

Summit on the Future of Undergraduate Geoscience Education: January, 2014

This NSF sponsored summit brought together a broad spectrum of the undergraduate geoscience education community, ~200 educators from R1 research universities with undergraduate programs, four-year private and state colleges (4YC), and 2-year community colleges (2YC) from across the country, as well as representatives from industry and professional geoscience societies. The summit focused on three main topics:

- What content, competencies, and skills do undergraduates need to be successful in graduate school and the future workforce?
- What are the best ways of teaching and using technology to enhance student learning?
- How can we broaden participation and retention of underrepresented groups and prepare K-12 science teachers to build a robust, diverse and informed future geoscience workforce?

Mark Helper Leads GEO 660 Field Course

The Summit was the first step in developing a high-level community vision for undergraduate geoscience education and resulted in widespread collective agreement presented in a Summary Report. All parts of the Summit (Keynote presentations, panel discussions and entire group discussions) can be viewed at: Webcast Archive. A presentation of the Summit outcomes was presented for an AGU/AGI Webinar for Heads and Chairs in Fall, 2014: http://www.youtube.com/watch?v=QmCYgATD4po

Geoscience Community Survey: ongoing

Jackson School's Annual Lease Sale Student Competition

Please participate in our post-meeting Survey for participants and non-participants.

The online, ongoing survey of the geoscience community has had ~455 respondents so far with: 354 academics (78%), 76 industry (17%), 13 government agencies (3%), 7 other (1%), 5 professional society representatives (1%). Of these, 85% were not Summit participants, indicating that between the ~200 Summit participants and the ~390 non-participant survey respondent, we are receiving input from a large segment of the geoscience community. The gender distribution on the survey is 308 male and 147 female.

Survey Results are available that summarize the community's views on the skills, competencies, and conceptual understandings needed for graduate school and/or the future workforce and he status departments in terms of curriculum reform, use of various teaching methods, and constraints on their programs.

Geoscience Employers Workshop: May, 2015

The Geoscience Employers Workshop provided valuable input from geoscience employers on the skills, concepts and conceptual understandings needed by undergraduates for the current and future workforce and the role of employers in helping departments implement the developing community vision. Overall there was strong agreement with Summit and survey outcomes regardless of type of employer, and in addition to their own views, they provided more granularity on skills and concepts. The 46 participants included an even distribution of employers from the petroleum industries; hydrology, engineering and environmental consulting companies; and federal agencies that employ geoscientists, along with representatives from some of the geoscience professional societies. One participant represented the mining. Results are available in a Geoscience Employers Workshop Summary and a presentation given for a AGU/AGI Heads and Chairs webinar on October 9, 2015 and the Earth Educators Rendezvous in July, 2015.

- **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)

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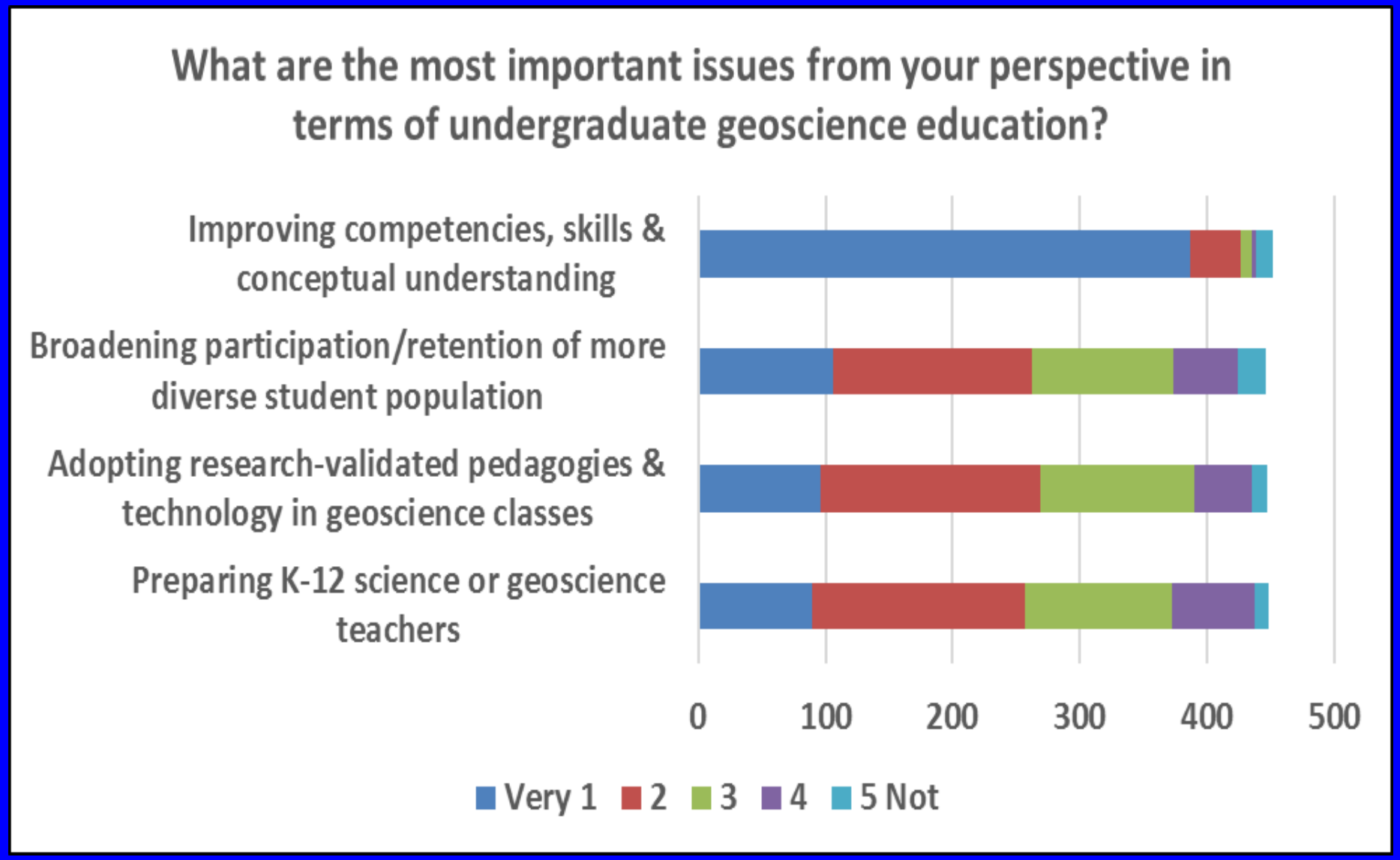
2014 Summit on the Future of Undergraduate Geoscience Education

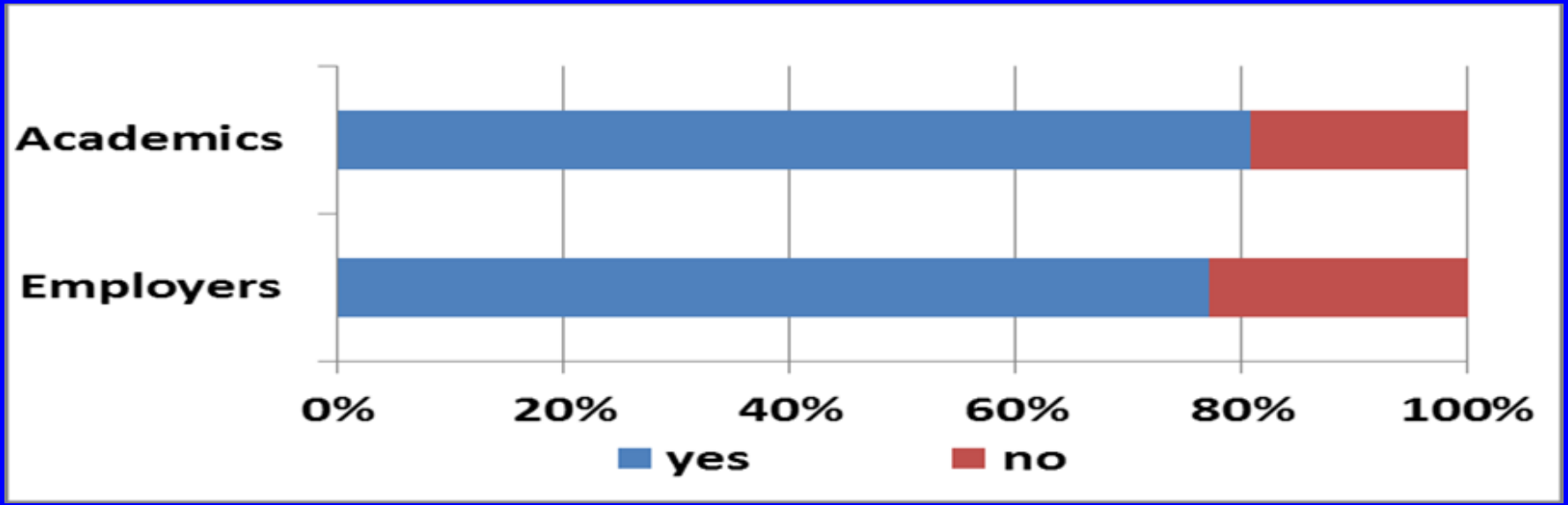
Survey results:



Concepts, Skills, Competencies

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

Survey Results:



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)

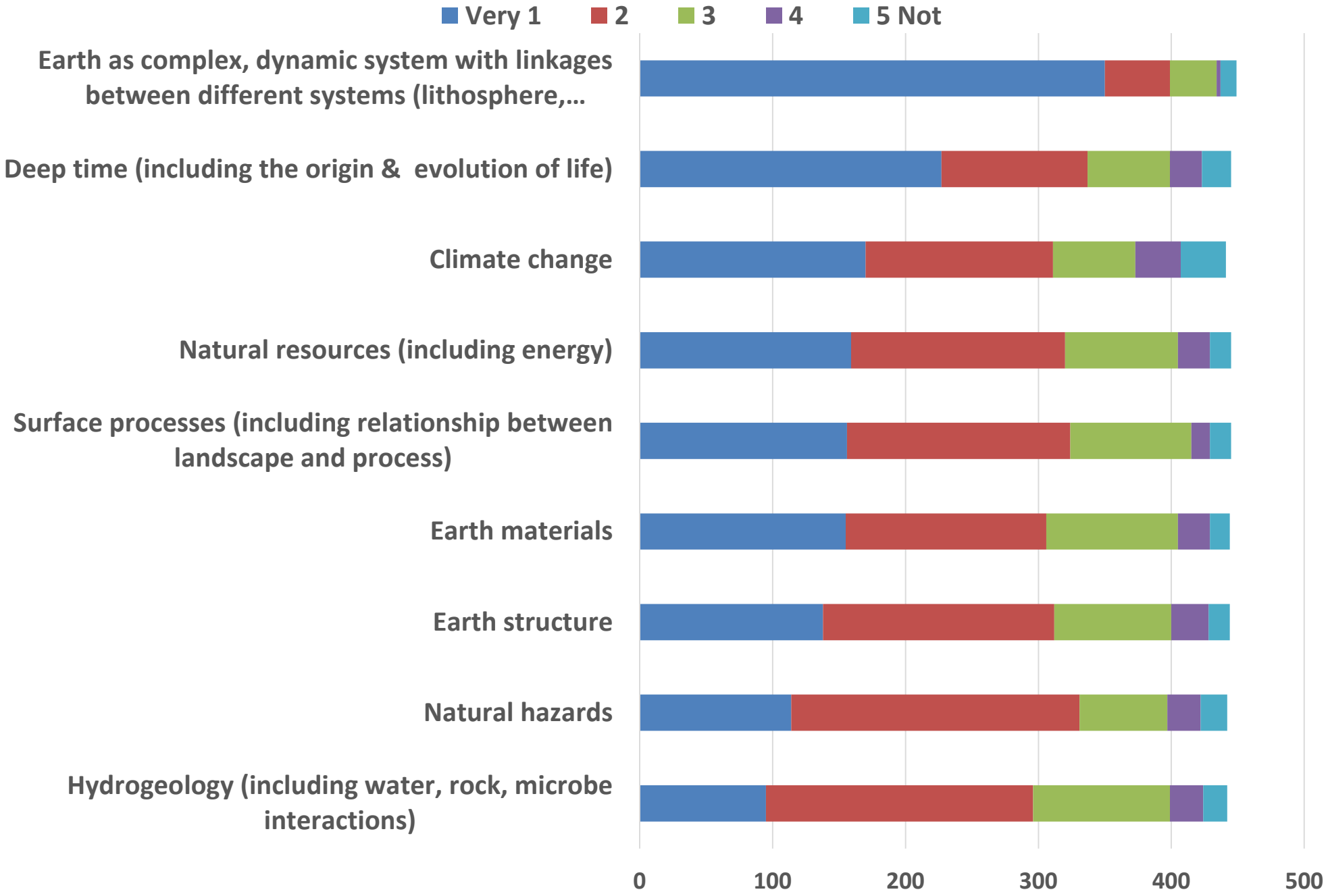
Employers added granularity, plus emphasized

- Systems Thinking
- Understanding processes
- Linkages, feedbacks, driving forces
- Impacts

eduweb

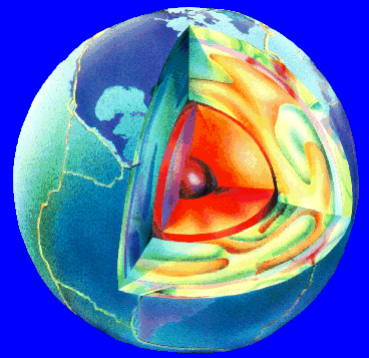
- http://www.jsg.utexas.edu/events/future-of-geoscience-undergraduate-education/ (for reports and more information)

Summit Outcomes/Survey Results: Important Concepts



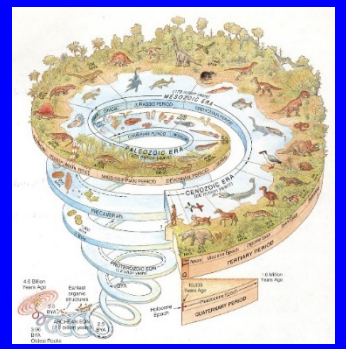
Earth as a Complex System

- 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



Concepts

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

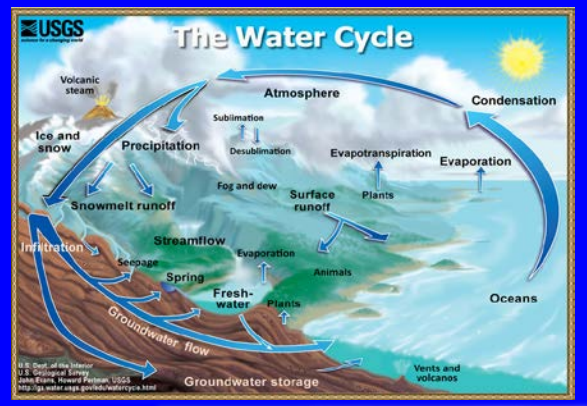
- Structure of Earth
- Deformation
- Plate Tectonics, including
- Structural controls on resource accumulations

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

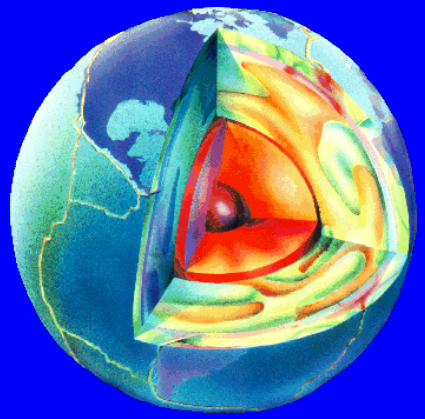
Employer Workshop:
Systems Thinking & Understanding Processes

How systems work and interact

- Atmosphere, Hydrosphere, Lithosphere, Pedosphere/surface, Biosphere
- Solar/Earth Interactions
- Human/Societal Coupled to Earth

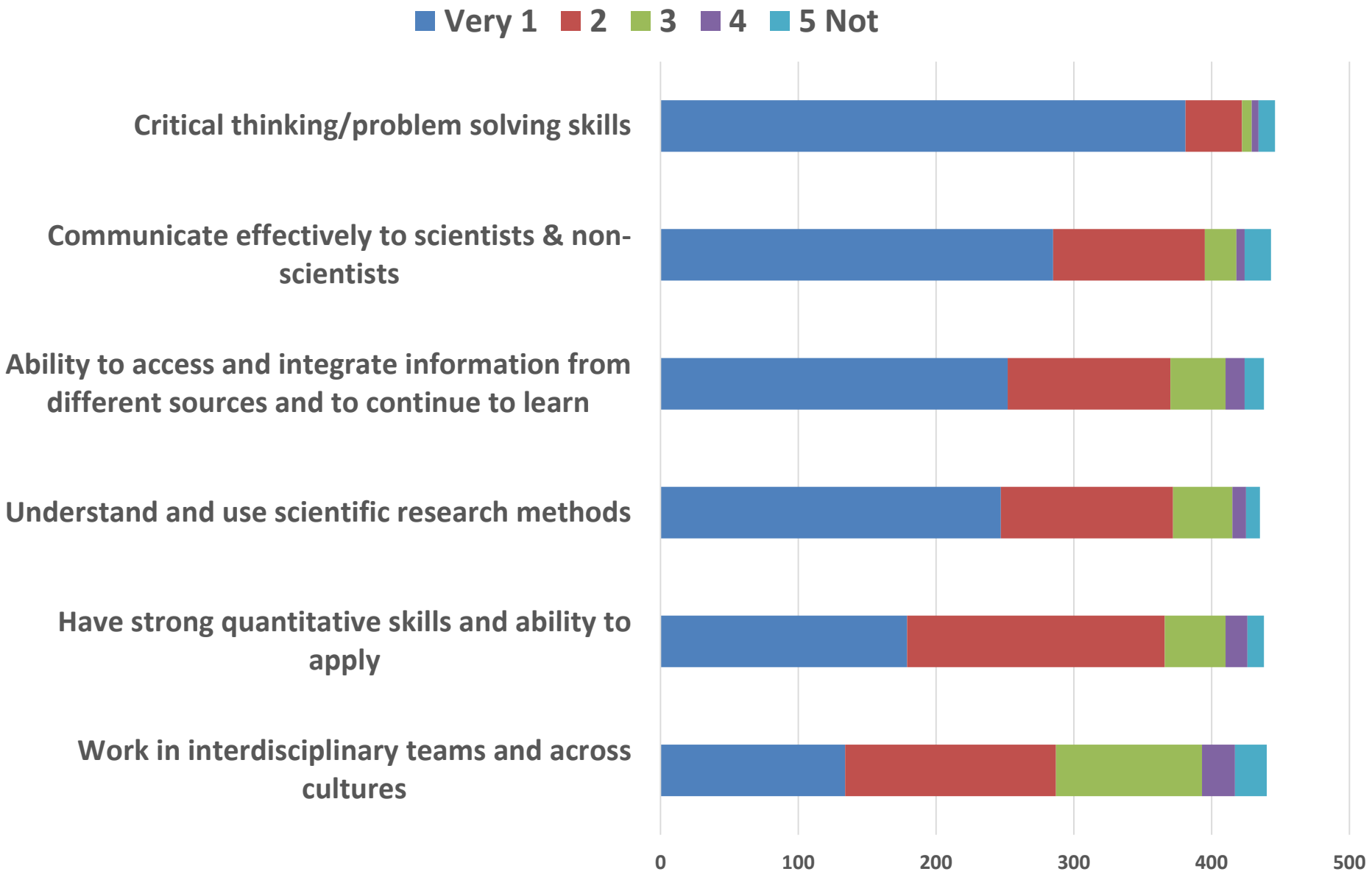
Processes

- Thermodynamics – energy, kinetics, diffusion, heat, mass transfer, fluid flow
- Geochemical Cycles – C, H_2O, N, P
- Geomechanics/Stress State/Rheology
- Geological Time/Earth Evolution
- Plate Tectonics/Geodynamics
- Tectonic Processes
- Depositional Processes
- Crystallization Processes

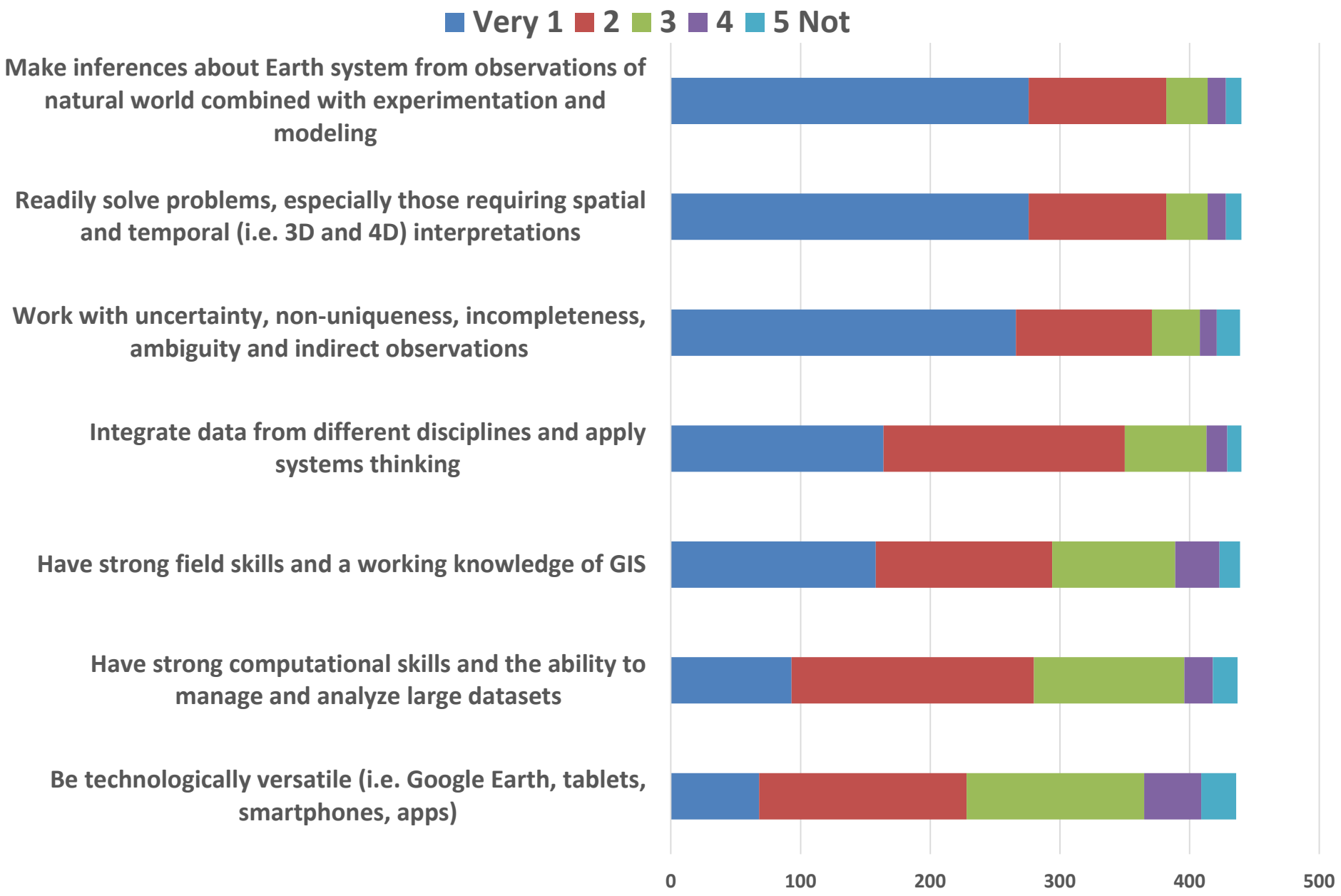


Tools – used to measure & gather data

Summit Outcomes/Survey Results: Science Skills



Summit Outcomes/Survey Results: Geoscience Skills



Employer Workshop: Geoscience Thinking

earthday.jpg

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

Skills

Higher level math & computer programing 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

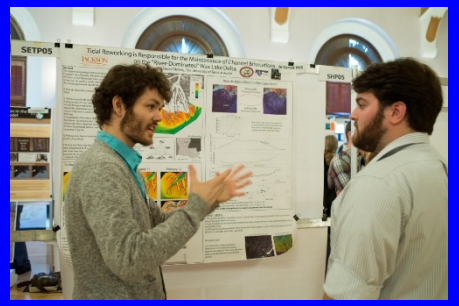
- Ethics
- Interpersonal skills - ability to work with different types of people
- Professionalism
- Global perspective
- Understanding societal relevance & implications

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

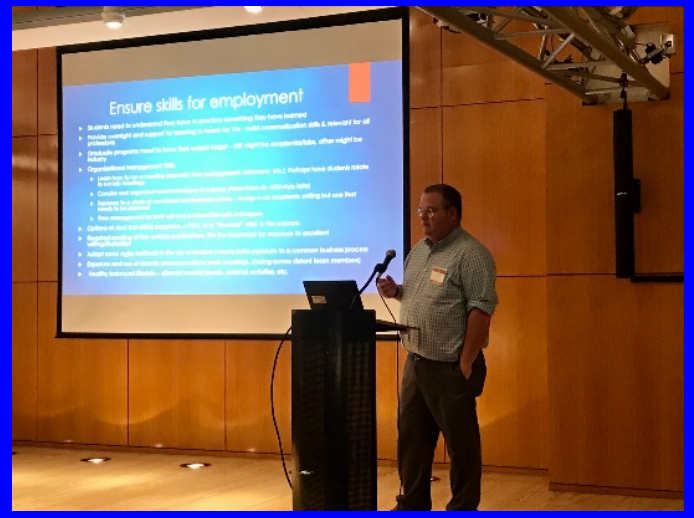


- **Substantial experiences**
  - Fieldwork and field experiences
  - Capstone, problem/project oriented courses
  - Independent research experiences/projects, Senior Theses
  - Internships or REUs

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)

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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