Universal Skills needed for Undergraduate Student Success in Diverse Geoscience Professions

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Summit on the Future of Undergraduate Geoscience Education


THE UNIVERSITY OF TEXAS AT AUSTIN

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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=QmCYpATD4po

Jackson School's Annual Lease Sale Student Competition

Geoscience Community Survey: ongoing

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.

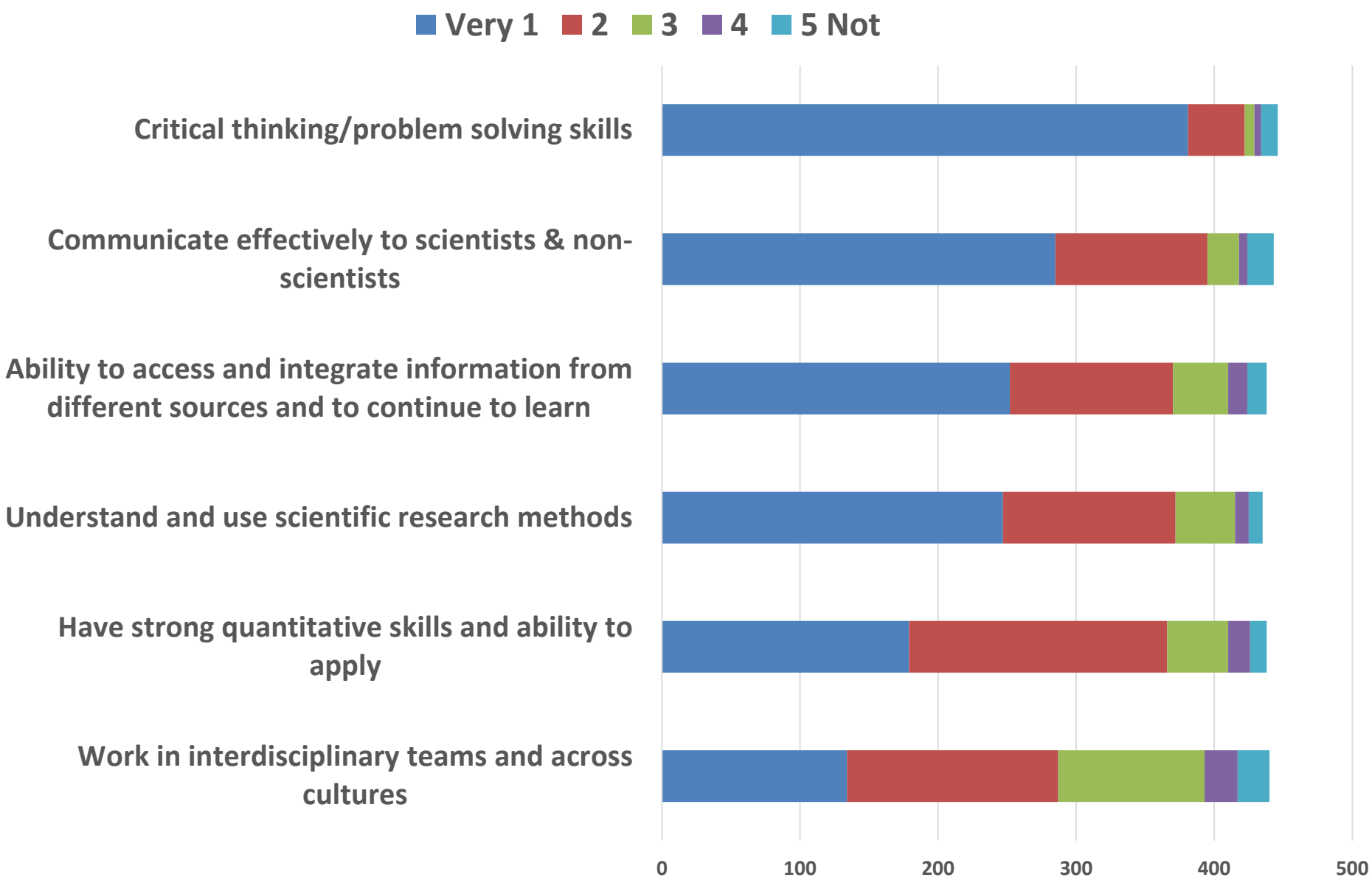
Geoscience Employers Workshop: May, 2015

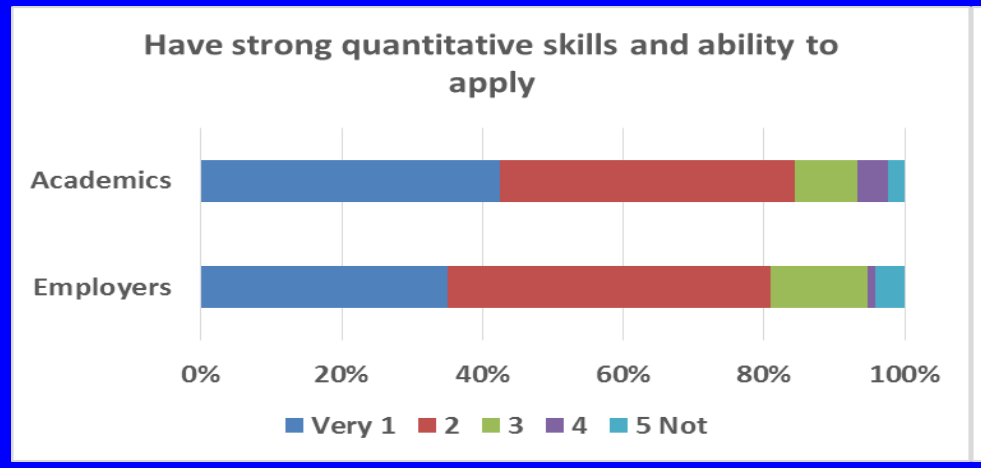
The Geoscience Employers Workshop provided valuable input from geoscience employers on the skills, concepts and conceptual understandings needed by undergraduates for the current and future workforce and the role of employers in helping departments implement the developing community vision. Overall there 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**
- **Summit discussions and findings regularly crossed into issues of graduate preparation, especially with geoscience employers**
  - **http://www.jsg.utexas.edu/events/future-of-geoscience-undergraduate-education/ (for reports and more information)**

National Science Foundation
WHERE DISCOVERIES BEGIN

Summit Outcomes/Survey Results: Science Skills




Have strong quantitative skills and ability to apply
Academics
Employers
0%
20%
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100%
Very 1
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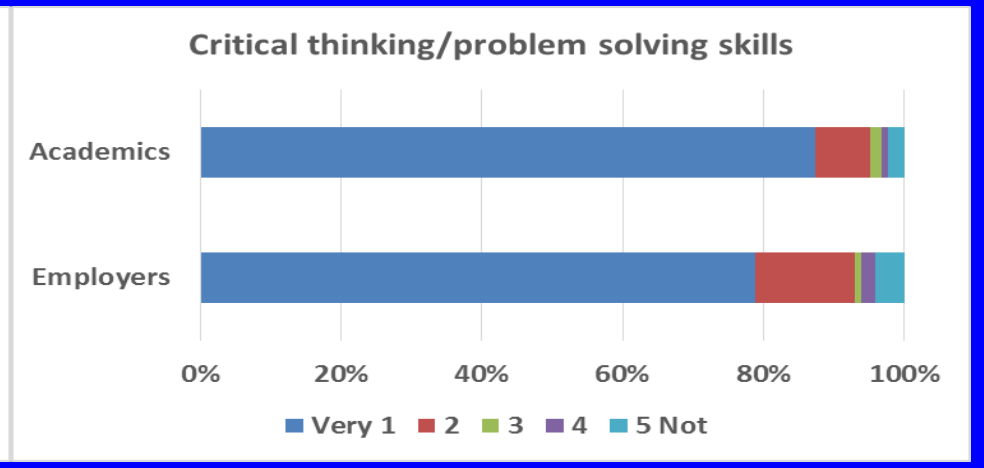
5 Not


Critical thinking/problem solving skills
Academics
Employers
0%
20%
40%
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Very 1
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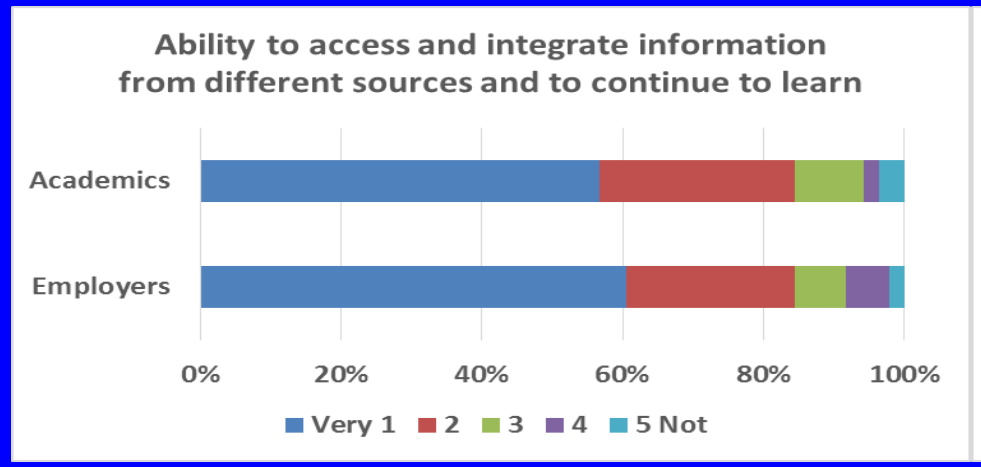
Ability to access and integrate information from different sources and to continue to learn
Academics
Employers
0%
20%
40%
60%
80%
100%
Very 1
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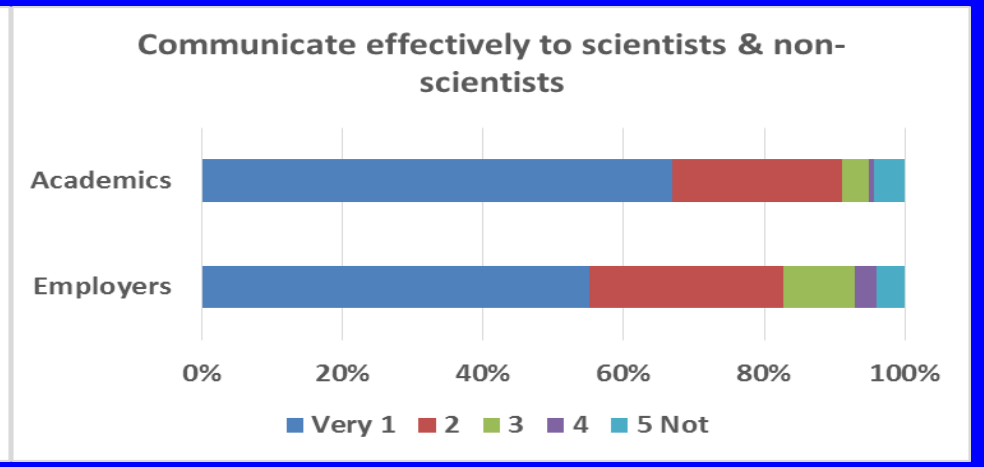
5 Not


Communicate effectively to scientists & non-scientists
Academics
Employers
0%
20%
40%
60%
80%
100%
Very 1
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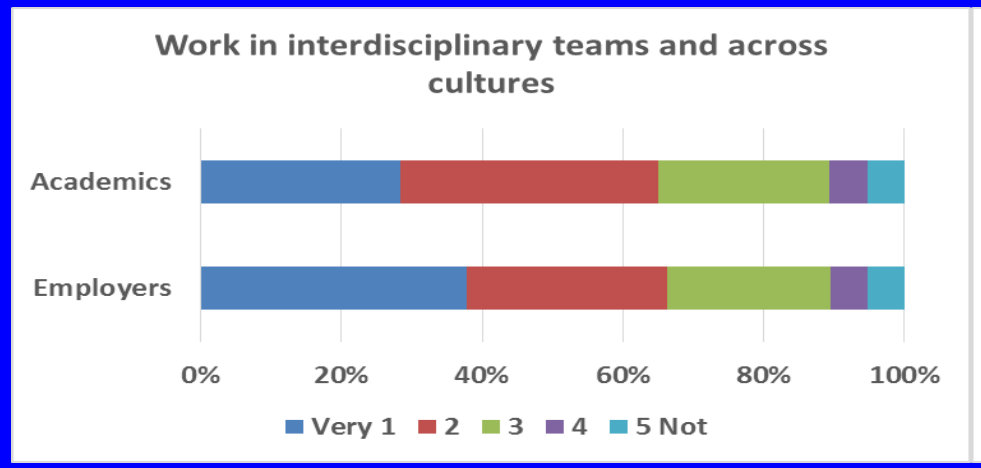
5 Not


Work in interdisciplinary teams and across cultures
Academics
Employers
0%
20%
40%
60%
80%
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Very 1
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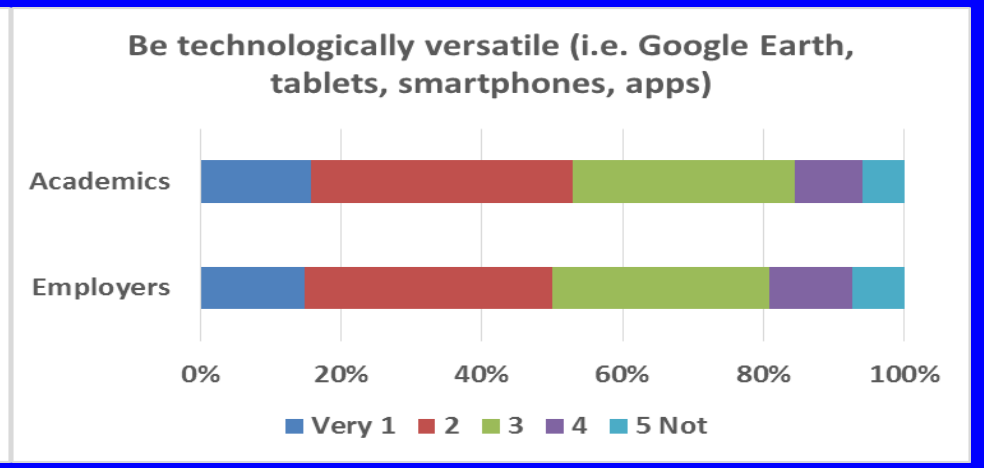
5 Not


Be technologically versatile (i.e. Google Earth, tablets, smartphones, apps)
Academics
Employers
0%
20%
40%
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80%
100%
Very 1
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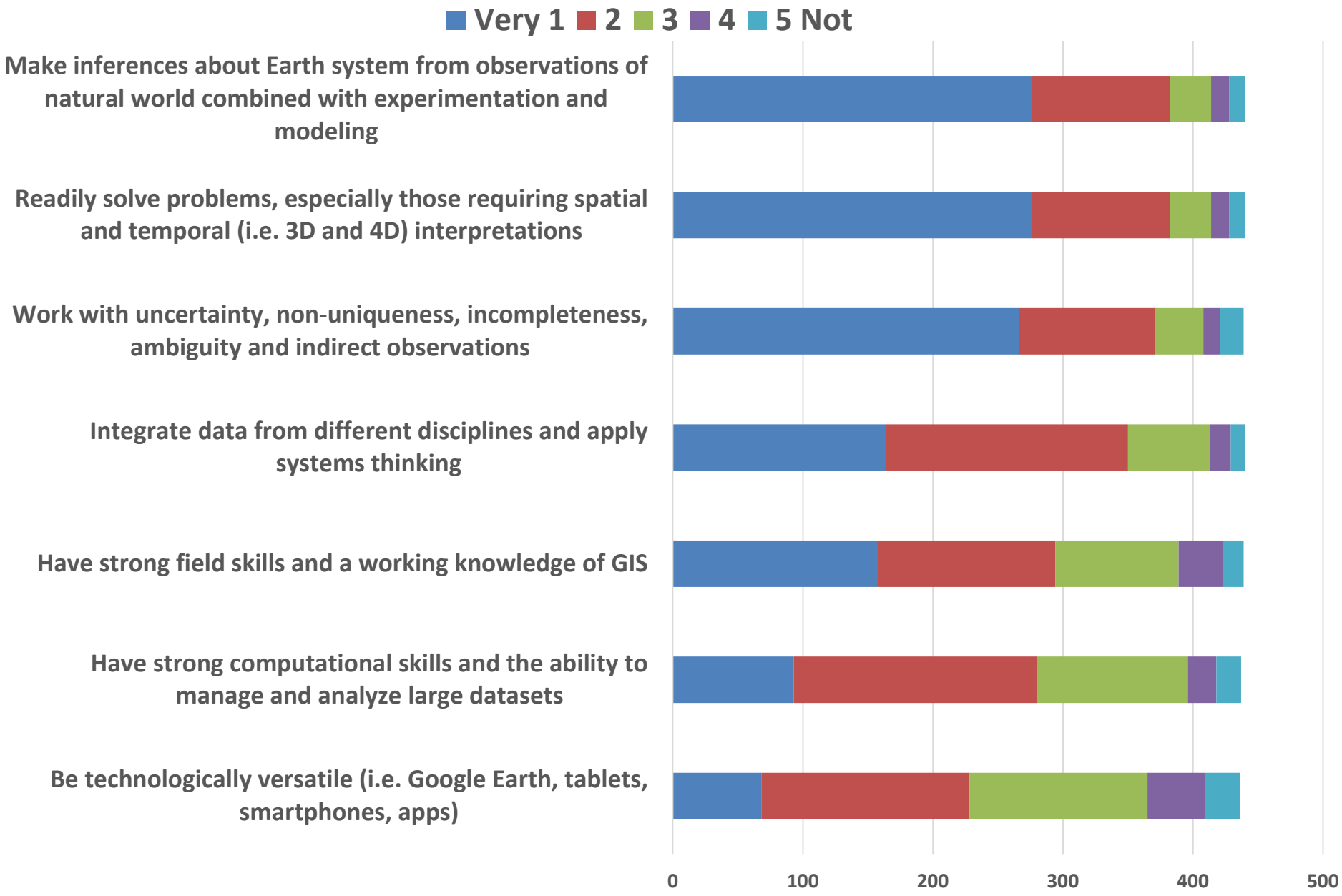
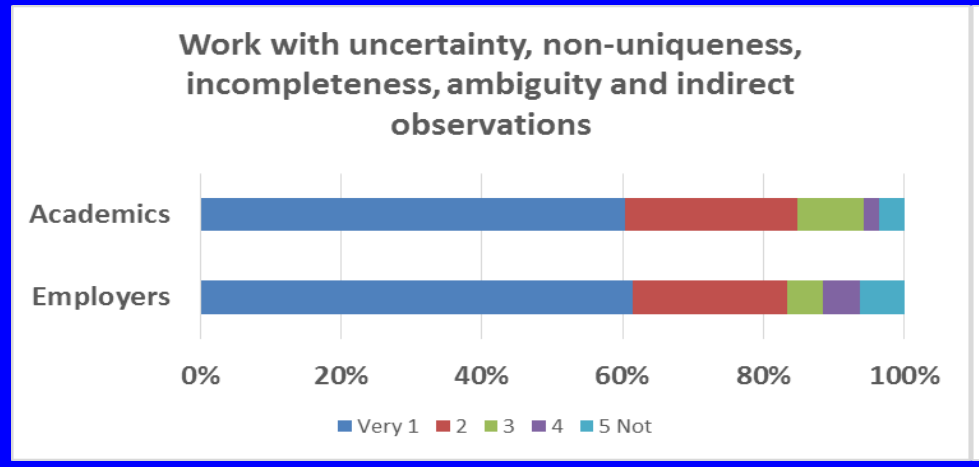
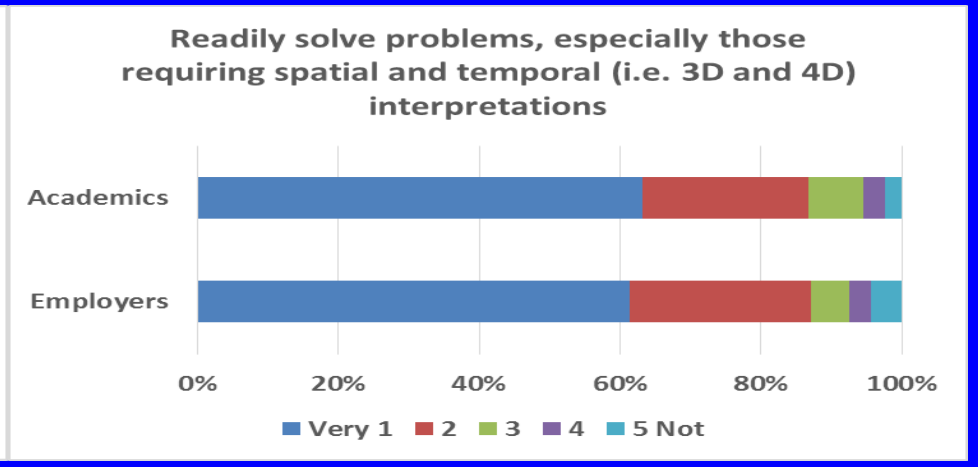
5 Not

Summit Outcomes/Survey Results: Geoscience Skills




Work with uncertainty, non-uniqueness, incompleteness, ambiguity and indirect observations
Academics
Employers
0%
20%
40%
60%
80%
100%
Very 1
2
3
4
5 Not


Readily solve problems, especially those requiring spatial and temporal (i.e. 3D and 4D) interpretations
Academics
Employers
0%
20%
40%
60%
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Very 1
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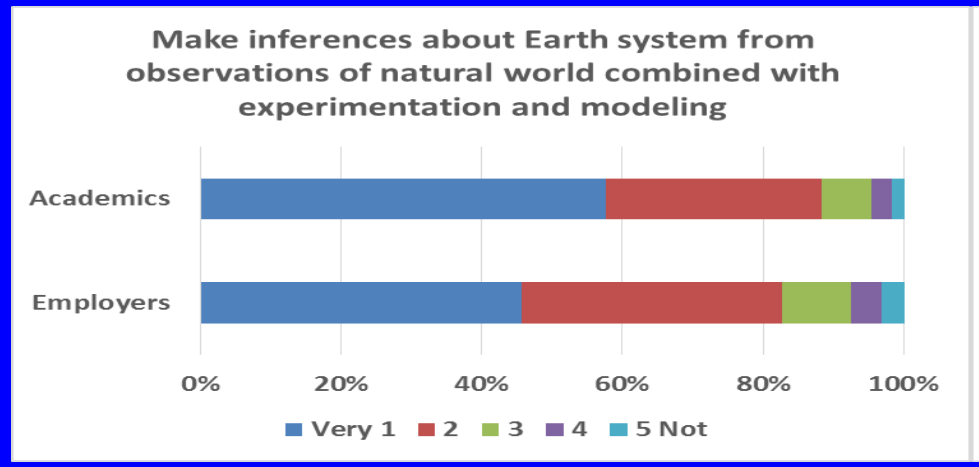
5 Not


Make inferences about Earth system from observations of natural world combined with experimentation and modeling
Academics
Employers
0%
20%
40%
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Very 1
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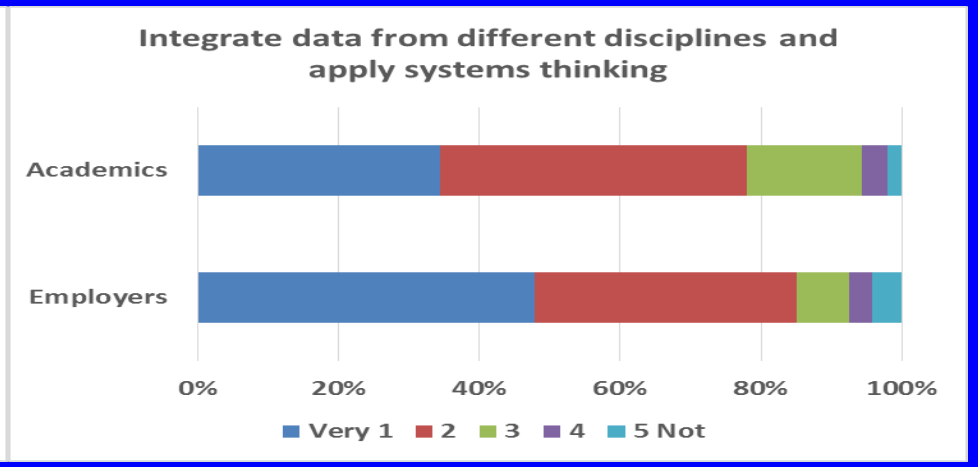
5 Not


Integrate data from different disciplines and apply systems thinking
Academics
Employers
0%
20%
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Very 1
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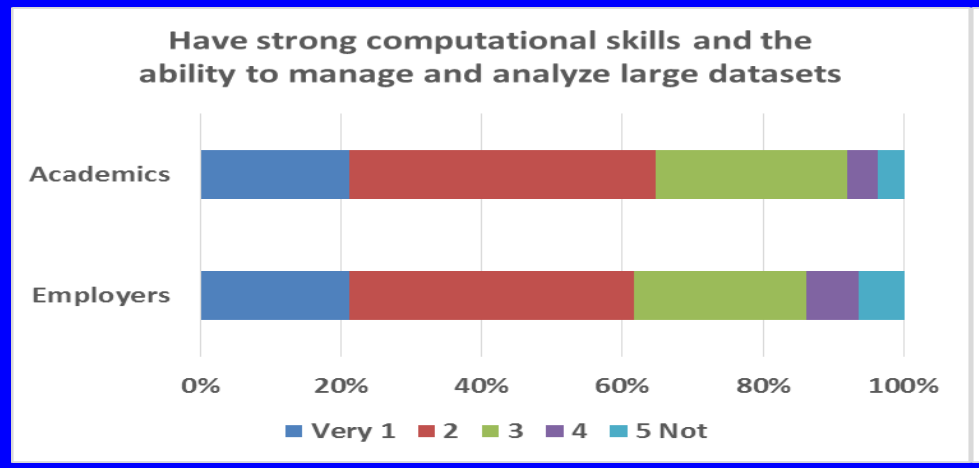
Have strong computational skills and the ability to manage and analyze large datasets
Academics
Employers
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Very 1
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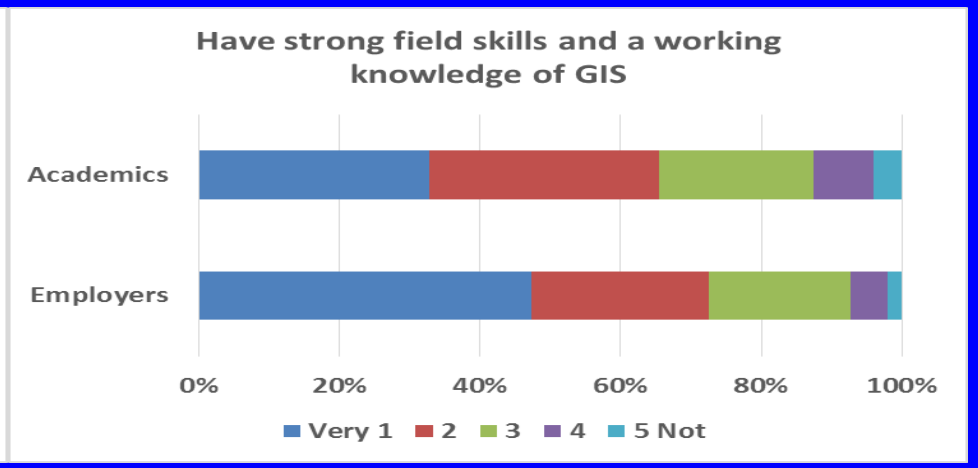
Have strong field skills and a working knowledge of GIS
Academics
Employers
0%
20%
40%
60%
80%
100%
Very 1
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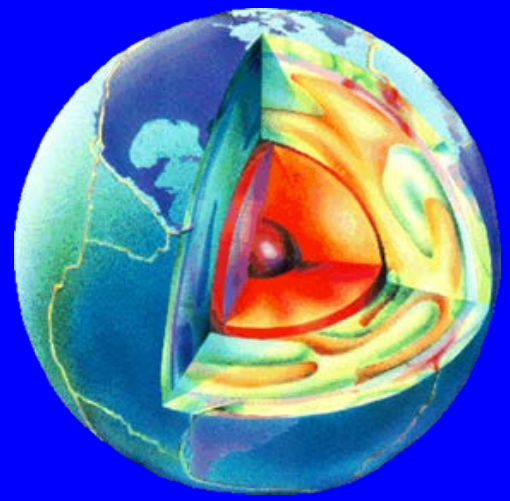
5 Not

Skill List (A-awareness (had in class); P-proficiency (had to use/apply); M-mastery (project, etc. requiring demonstration of ability); E-expert (MS or PHD)	Level of Mastery
Critical thinking/problem solving skills	P
Communicate effectively to scientists & non-scientists	P
Readily solve problems, especially those requiring spatial and temporal (i.e. 3D and 4D) interpretations	M
Make inferences about Earth system from observations of natural world combined with experimentation and modeling	M
Work with uncertainty, non-uniqueness, incompleteness, ambiguity and indirect observations	M
Ability to access and integrate information from different sources and to continue to learn	M
Understand and use scientific research methods	P
Have strong quantitative skills and ability to apply	P
Integrate data from different disciplines and apply systems thinking	P
Have strong field skills and a working knowledge of GIS	M, P
Work in interdisciplinary teams and across cultures	P
Have strong computational skills and the ability to manage and analyze large datasets	P
Be technologically versatile (i.e. Google Earth, tablets, smartphones, apps)	M

Geoscience Employers Workshop – skills for undergraduates relevant for graduate students

- **Systems Thinking**
  - Earth as an open and dynamic system
    - interacting parts, linkages/feedbacks
- **Understand Processes**
  - Coupling, interactions
- **Solve problems in 3D & 4D**
  - Space, geologic & real time & scale
- **Geologic reasoning & synthesis**



- **Be intellectually flexible - applying skills in new scenarios**

Preparation for “real world” professional projects and/or future research

Critical thinking & problem solving

- **Problem Solving with real data, non-unique answers**
  - Understand context of problem
  - Identify appropriate questions to ask, data to collect, methods to use
  - Be able to collect data, analyze quality, interpret and apply
  - Make predictions with limited data
  - Understand & manage uncertainties
  - Visualize and solve problems in 3- & 4-D
  - Work on problems with no clear answers, high ambiguity
- **Work by analogy, inference and the limits of certainty**

High level quantitative skills increases employability & resiliency

- **Higher level math & computer programing skills**
  - Differential equations/linear algebra
  - Probability, statistics, uncertainty analysis & risk assessment
  - Computer programming, modeling

Data Analysis Skills

- BIG DATA
  - Integrate multiple large datasets
    - Different types - disciplines
    - Model, statistical analysis
    - Use visual models, modeling tools (Stella, Modflow, Matlab, etc.), simulations
    - Integrate technical, quantitative skills, programming, application development
- Technological diversity

- **Communication skills**
  - **Written & verbal scientific communication**
    - **Tailored to several different audiences**
      - **Scientists, educated non-scientists, potential funders, management & general public**
  - **Listening skills**

Cross-disciplinary Teamwork on Interdisciplinary Projects

- **Project management in team settings**
  - Working in teams with different backgrounds, specialties, experience, personalities
    - Being a leader & follower; listening, sharing
  - Goal setting
    - Solution-oriented approaches
  - Time management
  - Conflict resolution
    - Managing problems on the front end

Fieldwork builds these skills

Non-technical Skills

- **Ethics**
  - Codes of conduct
  - Awareness of implicit biases

Teaching GeoEthics
Across the Geoscience Curriculum
SERC

- **Interpersonal skills - ability to work with different…**
  - Personalities, emotional makeup, viewpoints
  - Specialties, educational backgrounds, abilities

- **Professionalism**
  - Business acumen
  - Risk management
  - Leadership

- **Global perspective**
  - Different cultures

- **Understanding societal relevance & implications**

Most PhD & M.S. students will not go to academia!

So, in addition to their specialty,
what do they need to learn in graduate school?