Universal Skills and Competencies for Geoscientists

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December 15, 2015

Results from project sponsored by

National Science Foundation
WHERE DISCOVERIES BEGIN
Future of Undergraduate Geoscience Education

2014 Summit:
• ~200 educators representing broad spectrum of undergraduate geoscience education community
  – R1 research universities with undergraduate programs, 4-year and 2-year colleges
  – Faculty, heads & chairs, education researchers
  – Industry, government & professional society representatives (~20)
• 1st step in development a high-level community vision for the geosciences
  – Surprising collective agreement

Ongoing Community Survey
455 respondents
  – 354 academics (78%), 76 industry (17%), 13 government (3%), 7 other (1%), 5 professional societies (1%)
  – 85% not Summit participants

Geoscience Employers Workshop (May, 2015)
  – 46 participants: 6-7 each from energy, hydro/engineering/environmental, govt. agency, prof. societies, academics; 1 mining
  – Plus ~13 NSF program directors

Summit for Heads & Chairs – January 8-10, Austin, TX
Concepts, Skills, Competencies

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

**Survey Results:**

![Survey Results Chart]

- Competencies, skills, and conceptual understanding vs. specific courses
- Academics: 70% yes, 30% no, 0% blank
- Industry: 60% yes, 40% no, 0% blank
- Govt.: 50% yes, 50% no, 0% blank
- Prof. societies/other: 60% yes, 40% no, 0% blank
Employer Workshop Overview: Systems Thinking

How systems work and interact

- **Atmosphere** – Climate, Weather, Ocean-atmospheric circulation
- **Hydrosphere** – Ocean, Ice, Surface water, Groundwater
- **Lithosphere** – rock cycle, deformation, structure, tectonics
- **Pedosphere/surface** – Geomorphic, Erosion, and Surface Processes, Landscape evolution
- **Biosphere** - Paleontology, Ecosystems
- **Solar/Earth Interactions** – Tidal, Climate; planetary geology
- **Human/Societal Coupled to Earth** – Natural Resources, Energy, Anthropomorphic Climate Change, Natural Hazards
  - Influence of geology on society
  - Influences of society on earth processes
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

- Statistics/Uncertainty/Probability
- Mathematics (differential equations, linear algebra)
- Field Methods
- Cartography
- Geography and spatial thinking
- Potential Fields
- Remote Sensing
- Age Dating
- Instrumentation
- Analytical/Numerical Modeling
- Seismology/Geophysical sensing
Geoscience Work Requirements

• Spatial & temporal thinking – 3D & 4D
• Understand Earth as an interacting system of parts & processes
• Geoscience reasoning & synthesis

• Solve problems
  – Context of open & dynamic system
  – With no clear, unambiguous answers

• Manage uncertainty
  – Work by analogy & inference
  – Make predictions with limited data
Needed Experience

• **Tackle problems using real data**
  – Understand context of problem
  – Identify appropriate questions to ask
  – Determine how to proceed

• **Visualize and solve problems in 3D**
  – Incorporate time
  – Understand importance of scale
Technical Skills Needed

- Integrate quantitative, technical & computational skills
- Be intellectually flexible in applying skills to new situations

- Need experience using
  - High level math & computational methods to solve geoscience problems
  - Probability and statistics to understand risk
  - “Big Data” & visualization and modeling tools
Field Skills

• **Field Camp and Field Experiences**
  • Improves spatial cognition, creative problem solving, teamwork, geoscience synthesis
  • Field skills are unique and essential, difficult to replicate or substitute

• **GIS** – Most essential for building large data sets
Non-technical Skills Needed

• Project management in team settings
  – Goal setting
  – Conflict resolution
  – Time management
  – Being leader and follower
  – Working with people in different disciplines

• Interpersonal skills
  – Ethical conduct
  – Awareness of implicit biases & learning styles
  – Emotional literacy
  – Leadership
  – Ability to work with different personalities
Non-technical Skills Needed

- **Communication skills**
  - Written & verbal scientific communication
  - Knowing audience
  - Public speaking
  - Listening skills

- **Professionalism**
  - Business acumen
  - Risk management
  - Career awareness/resume/interview preparation

- **Global perspective**
  - Cultural interactions, cultural literacy

- **Understanding society relevance**
Survey Results

Skills and competencies as critical for undergraduate education

Critical thinking/problem solving skills
Communicate effectively to scientists & non-scientists
Make inferences about Earth system from observations of natural world combined with experimentation and modeling
Readily solve problems, especially those requiring spatial and temporal (i.e. 3D and 4D) interpretations
Work with uncertainty, non-uniqueness, incompleteness, ambiguity and indirect observations
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
Integrate data from different disciplines and apply systems thinking
Have strong field skills and a working knowledge of GIS
Work in interdisciplinary teams and across cultures
Have strong computational skills and the ability to manage and analyze large datasets
Be technologically versatile (i.e. Google Earth, tablets, smartphones, apps)

1 very important

5 – not important
Work with uncertainty, non-uniqueness, incompleteness, ambiguity and indirect observations

Academics
Employers

Very 1  2  3  4  5 Not

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## Employers Workshop

<table>
<thead>
<tr>
<th>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))</th>
<th>Level of Mastery</th>
</tr>
</thead>
<tbody>
<tr>
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Effective Ways of Developing Skills/Competencies/Concepts

- **Experiential learning**
- Constant engagement in opportunities to practice skills and use concepts
  - Collaborative, interdisciplinary, integrative team projects
  - Fieldwork and field experiences
  - Exercises using and analyzing real data
  - Research experiences/projects/theses
  - Internships
  - Integration and interactive use of technology
    - Visualization, simulation, modeling of real data
- **More active collaboration between academia and the outside employers**
Geoscience Workforce today & in the future...

- Need for multi-disciplinary approaches to problems
  - More integration of different types of datasets
  - Cross disciplinarily teamwork
- Different paradigms – thinking about rocks in fundamentally different ways
- Different types of jobs for geoscientists
- Technological advances – changing skill sets
  - More digital & modeling skills
  - Black box mentality without understanding how works
- BIG DATA – manage, use, model; statistical analysis
- More interaction between business & society
  - Economics/law/business practices/ethics/risk/environment
- Cultural diversity

As the workforce changes – student learning must change
Project Outcomes at:
http://www.jsg.utexas.edu/events/future-of-geoscience-undergraduate-education/

- Summit Summary Report
- Survey - ongoing
- Archived Summit webcasts
- AGU/AGI Heads/Chairs Webinars
- PPT slides

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Or organizing committee:
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