Universal Skills for Geoscience Graduate Student Success in the Workforce

Geoscience Employers Workshop Results

(preliminary)

Sharon Mosher, University of Texas at Austin

Jeff Ryan, University of South Florida

Sponsored by

National Science Foundation
WHERE DISCOVERIES BEGIN

Universal Skills for Geoscience Graduate Student Success in the Workforce

Project Goals:

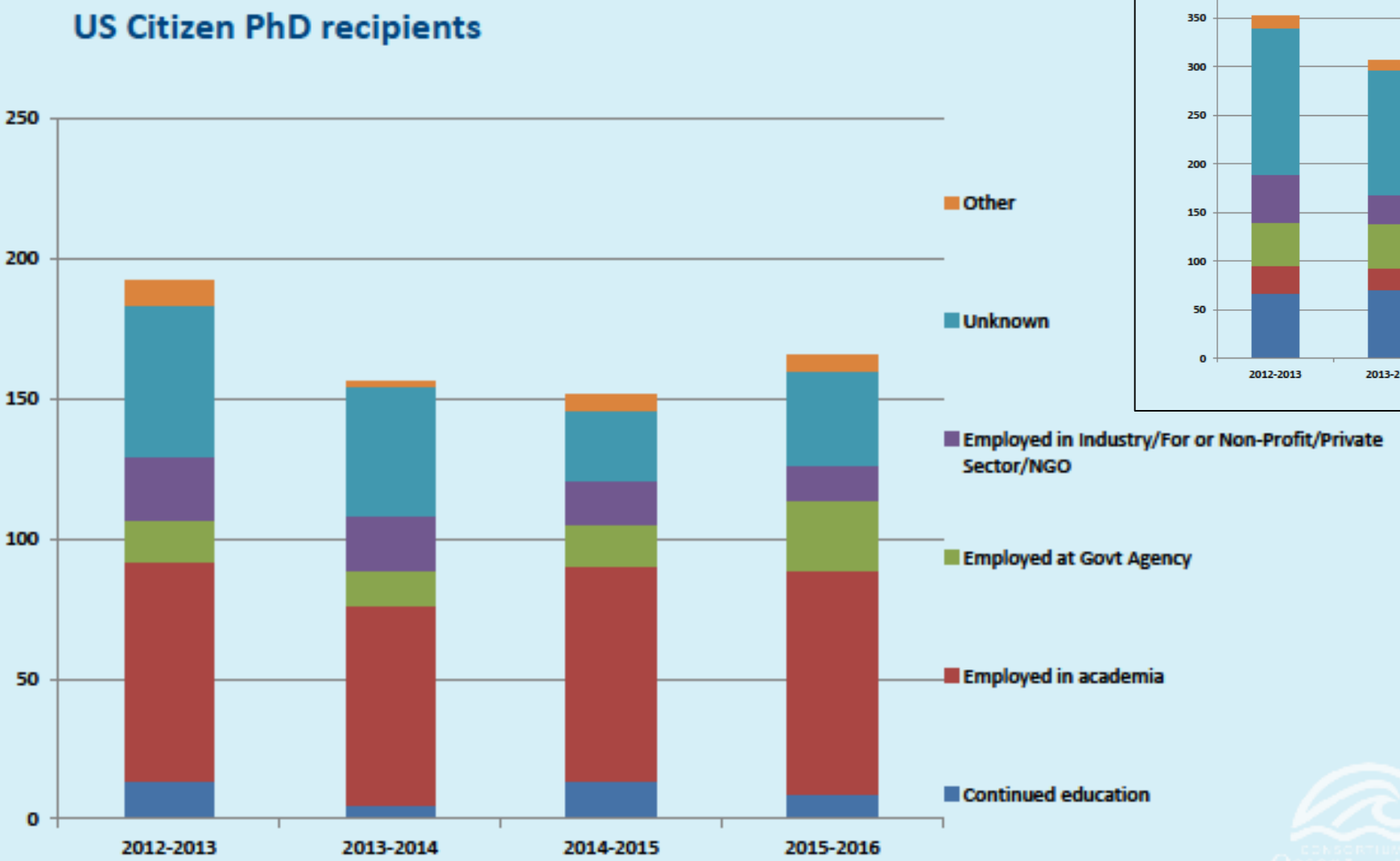
- Identify the skills and competencies that should be part of graduate geoscience education for PhD & MS students in Earth, Ocean, & Atmospheric Sciences
- Investigate best means of developing these in graduate geoscience programs nationally
- Work with Heads/Chairs and Graduate Program Directors on implementation strategies to develop the skills and competencies identified by the geoscience employers workshop & other studies

Motivation: Career Statistics

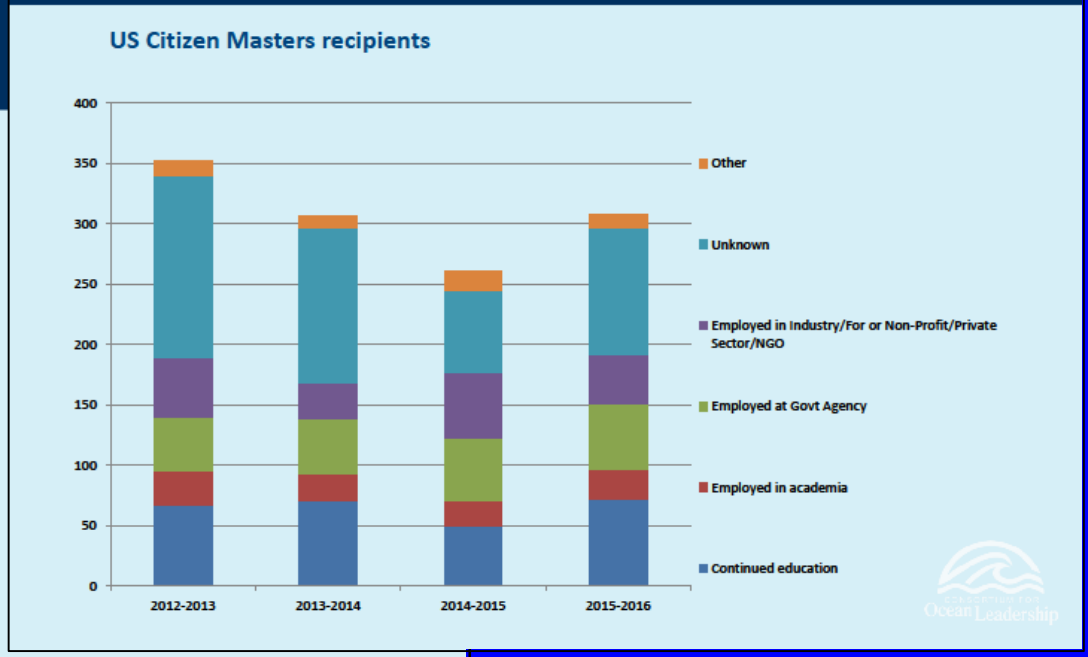
- **STEM PhD students: 45% business; 46% academia** [NSF NCSES, 2013].
- **Geosciences: 51% PhD & ~4% Masters students in academia** [Wilson, 2015]
- **B.S. geoscience graduates plans** [Wilson, 2015, 2016; OOH, 2016]
  - **8-9% Ph.D. and academic career**
  - **20-27% Master's degree**
    - **16% M.S. continue for PhD**

Call from graduate students, employers, professional societies, Council of Graduate Schools, National Academies of Science, etc.

Graduate Data – Employment



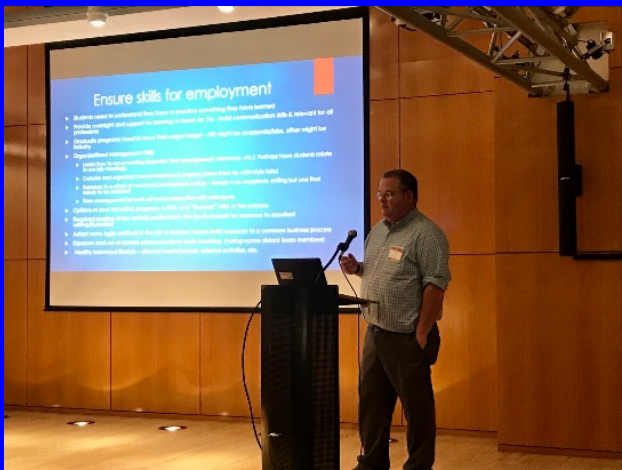
Graduate Data – Employment



Geoscience Employer 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

- **Discuss & provide feedback to academia on skills & competencies needed by PhD & MS students for current and future workforce**
  - Build on results of Future of Undergraduate Geoscience Education initiative & National Academy & Council of Graduate Schools Graduate STEM reports
  - Define geoscience skills & competencies needed for MS & PhD graduates
  - Discuss methods for developing skills & competencies & employers role
  - Discuss balance between preparing for workforce, research and general educational goals



- **Next Step - Heads/Chairs & Graduate Program Directors Summit**

Breakout Questions Addressed by Employers

- *What skills and competencies make PhD and MS graduates successful in the workplace today ? Overall, which skills do you find most current graduates have acquired and which do they generally lack?*
- What changes do you see in your field and organization over the next ten years that will require different competencies? What new or improved skills do you predict graduates will need in the future?
- What level of competency is needed? How does the relative weighting vary with employers?
- Which skills and/or competencies can students get from graduate coursework versus student research experiences versus other graduate professional experiences?
- What can we do to ensure graduate students develop a portfolio of skills and competencies that they need for employment in future careers?
- How can employers assist, during formal education, co-curricular opportunities, professional development activities, or other means? What training should be a responsibility for the employer post-graduation?
- Are there specific concepts that all geoscience graduate students should know? Does it vary with employers? What breadth and depth of understanding is needed?
- What balance is needed between the specific skills development process and the fundamentals of learning to and conducting research within a graduate program?
- How do employers value specific skills versus experience conducting research?
- Are there defined learning outcomes graduate programs could use to document skills and competencies beyond just coursework taken by students?

What skills and competencies make PhD and MS graduates successful in the workplace today (and future)?
Overall, which skills do you find most current graduates have acquired and which do they generally lack?

- **Need Expertise/depth in core area, leading to judgment and confidence**
  - **Having foundational skill set – good education in the geosciences**
  - **Breadth in core area, grounding across all sciences**
  - **Course background in their field – even if switched fields from undergrad to grad**
- **Graduates generally are coming with very strong technical skills**
  - **Knowledge in their field of geosciences**
  - **Research skills; field skills**
- **Most discussion focused was on what needed & generally lacked**

Research Skills

Currently need and increasingly important in the future – across employer spectrum

➢Data Management & Data Analytics

- Dealing with Big Data & Datasets
- Knowing how to examine datasets to draw conclusions about the information contained

- **Data Acquisition** --Data collection – types of data, data sources – and credibility, available tools, how to access
- **Data Management & Analysis**
  - Use data effectively & have proficiency at managing
  - Look at data from different perspectives (e.g. air, ground, etc.) & synthesize
  - Understand how to use various types of data; what tools to analyze, how to organize
  - Data Manipulation – adding, deleting & modifying data, retrieving data from dataset
  - Learn/develop new ways for data management & analysis & synthesis
- **Data Integration**
  - Merging information/data to solve problem
  - Integrating different types of data; synthesize
- **Data assimilation** – sequential updating of model forecast with new observations
- **Data quality** –understanding, evaluating, using data of different qualities
- **Visualization & Modeling** -- Data simulation, display; ability to model & know limits of modeling; immersive Virtual Reality data exploration
- **Valuation:** how valuable is the data - monetizing
- **Other data science** - e.g., Machine Learning, AI, computer science, robotics – increasing in future

- **Computational skills**
  - More need for computational skills but within the ability to make observations
    - **Basic programming skills**
      - Scripted languages
    - **Coding** - able to code
      - Translate older code to newer codes and systems that are more effective
    - **Ability to analyze algorithms** (with increase in Machine Learning & AI)
    - **Keep up with transition from Supercomputing to Cloud computing**
      - Cloud data manipulation and storage for big data
    - **Modeling** – be able to develop, analyze and evaluate models
- **Basics of statistics and math** [should have from undergrad]
  - **Statistics** - communicating certainty
  - **Higher math** - including calculus, differential equations, linear algebra

- ***Embracing technology not only as users but as creators***
- ***Willingness to step outside of the box to engage in genuine innovation***

Professional Skills

- **Communication** - written, verbal, external and internal
  (common limiting factor)
  Expressing technical work effectively to appropriate audiences
  - Technical writing & verbal communication
    - within specialty and other science & engineering fields
    - to non-technical audiences, management, pubic, press
  - Be able to convey complex material in a simple way
  - Express ideas logically
  - Be comfortable speaking with people when English is not their first language
  - Be able to communicate societal and/or financial impacts
  - **Skill in editing – evaluate critically & accept criticism**
  - **Listening Skills**
    - High sensitivity to audience – reading the room
    - Pay attention to what others say
    - Answer questions asked & logically

- **Systems Thinking**
  - Need individuals that can look at the big picture of a system, go from big to small to solve the problem; view the whole system and drill down to details and limitation
- **Project & Program Management** (generally lack)
  - Understanding budgets, project financials
  - Managing people, multidisciplinary projects
  - What factors are driving the decision-making process?
  - Manage time & resources
  - Know how to run a meeting (agenda, time management, relevance, etc.)
- **Collaboration, Teamwork** (generally lack)
  - Ability to work with other scientist's and other trained individuals towards your goal
  - Ability to get others to work together; deal with conflict
  - Valuing diversity of thought
  - Developing self-awareness and recognizing skills among ourselves and the people around us
  - Evaluating expertise, knowing your own strengths
  - Being coachable; taking directions; leading

- **Problem solving** (elements lack)
  - Pragmatic critical thinking, logical thinking
  - Flexibility, open-mindedness
  - Defining problem and applying an appropriate solution
  - Establishing what is a sufficient solution vs. a precise and complete solution
  - Translating the problem to the so what?
    - Articulate importance of outcomes
    - What decisions will be made based on the work you are doing
  - Understanding the broader impacts of your research and how to communicate those impacts

Many graduates struggle with being able to define a problem and identifying how to apply the solution (but could solve the problem)

- **Leadership** -- in science, education, public policy/politics, business
- **Ethics & Professionalism**
  - Integrity and its importance to science
  - Understanding plagiarism, self-plagiarism
  - Proper attribution to original source
  - Rules for scientific citation and research
  - Knowing how to search for research
- **Social dynamics** (generally lacking; limiting)
  - People skills –interpersonal behavioral and cultural
    - Ability to work with people who are different & from different cultures
  - Corporate skills – culture clash: academia vs industry/government/business
    - Be able to distill everything down to making it relevant to the CEO or Manager
    - Time - value of money
    - Learning how to take direction – directed work
- **Business Skills** (need much better skills)
  - Economic, data-driven decision-making; risk, uncertainty
  - Leadership, teambuilding, finances/budgeting, project management, problem solving

Professional Development

- Training on how to get a job
  - Resumes, applications, interviews,
  - Where to search
  - Knowledge of careers
  - Knowing options & how to leverage their skills or gain skills/knowledge
- Networking – how to do, what not to do, where to go/be
- Virtual presence/brand
  - Current presence on social media and how that effects hiring/career
  - Self marketing
    - Representing that extra expertise
- Internal drive to do well
  - Address inherent risk aversion in adopting new technology to address major problems
  - Address prevalence of fear of failure

What level of competency is needed?

PhD – Expert; MS – Mastery

- Expertise/depth in core area, leading to judgment and confidence
- Critical thinking

PhD & MS – Mastery

- Communication including written, verbal, external and internal
- Flexibility open-mindedness, collaboration, teamwork, networking

PhD – Mastery; MS – Proficiency/Mastery

- Coding, computer science/programming
- Statistics, data analysis, data display, data analytics
- Higher math including calculus, diff equations, linear algebra

PhD – Mastery; MS – Proficiency

- Systems thinking
- Breadth in core area, grounding across all sciences
- Project management
- Real-world career and applications awareness
- Scientific uncertainty

PhD – Mastery; MS – Aware

- Economics, data-driven decision making , risk, uncertainty, general business skills

PhD – Aware/Proficiency; MS – Aware

- Other data science, e.g., machine learning, computer science, robotics, blockchain, etc.

Concepts that all geoscience students should know (irrespective of industry)

Five concepts stand out

1) Communication most critical
2) Teamwork is important
3) Research skills
4) Data skills (stats, data collection, management, awareness and proficiency of large datasets)
5) Innovation/Entrepreneurship

Expectation of Employers

- **What employers expect?**
  - Writing and communication
  - Capacity for learning/adaptable
  - Systems approach
  - Programming, simulation, etc.
- **Employers will provide:**
  - Specialized job training as needed
    - In house or professional programs outside of the company
- **Workforce of the Future (10 years)**
  - Different programming languages
  - More data centric in all fields, changing algorithms and emphasis
  - Visualization and simulations

Mismatch between Graduate Education & Future Careers

- **Graduate programs: too narrowly focused on academic research**
  - Students need to develop professional and personal skills valued by both academic and non-academic employers
  - Teamwork, project management, leadership, communication
- **Students need information to identify career options & needed skills/competencies and mentoring**
  - Need preparation in skills/competencies needed outside academia
- **Transferable skills – for changing world & occupations**

Graduate education

- **Propels societal advancement, innovation and economic growth, strengthens national security, protects environment**

- **Next Step - Heads/Chairs & Graduate Program Directors Summit**
  - 2019 late spring/summer
  - How to accomplish/implement – employers suggestions & more

- **Future of Undergraduate Geoscience Education Update: Vision and Change document – in preparation with AGI**
  - Call for Action
  - Community Consensus
  - Implementation Strategies & Case Studies
  - Toolkits for implementation

  Summit 2014; online survey; Geoscience Employers Workshop 2015; Heads/Chairs Summit 2016

  Workshops – GSA, AGU, Earth Educators Rendezvous

Sponsored by

National Science Foundation
WHERE DISCOVERIES BEGIN