Universal Skills for Geoscience Graduate Student Success in the Workforce

Geoscience Employers Workshop Results

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WHERE DISCOVERIES BEGIN

Geoscience Employer Workshop
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- **~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

- **Determine next steps towards completing & implementing vision**
  - Role for Industry, Government Agencies, Universities & Professional Societies

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)?
And what do they lack?

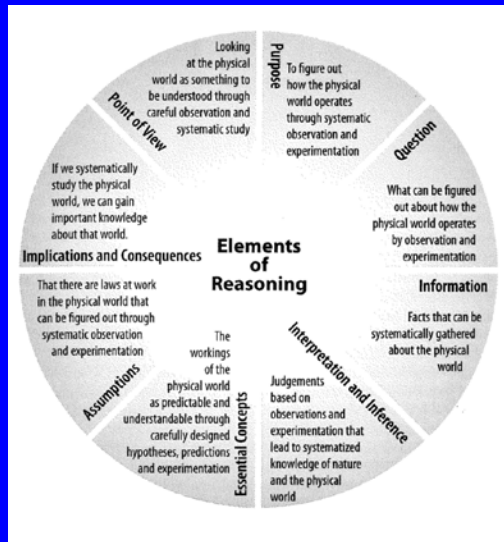
- **Need Expertise/Depth in core area → leads to judgment and confidence**
  - **Core technical skills in relevant area of expertise is absolutely necessary**
  - **Deep understanding of the fundamentals/ mechanics of the techniques/methods using in work**
  - **Having foundational skill set – good education 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 Important Skills – regardless of discipline

- **Problem solving & critical thinking**
  - 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

- ***Independence in critical thinking, and problem development, execution and analysis skills***

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



- **Teamwork, Collaboration** ***(generally lack)*** 
  - Ability to work with other scientists & other trained individuals towards your goal
  - Ability to get others to work together; deal with conflict
  - Valuing diversity of thought
  - Developing self-awareness & recognizing skills among ourselves & people around us
  - Evaluating expertise, knowing your own strengths
  - Being coachable; taking directions; leading

- **Leadership** -- in science, education, public policy/politics, business

- **Communication** (common limiting factor)
  - written, verbal; external and internal

  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**
    - Evaluate/recognize credible sources
  - **Listening Skills**
    - High sensitivity to audience – reading the room
    - Pay attention to what others say
    - Answer questions asked & logically

Research Skills

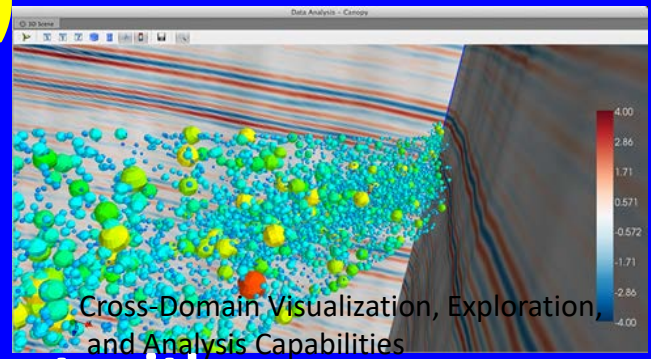
Currently need and increasingly important in the future – across employer spectrum

➢Data Management & Data Analytics

- **Awareness of data analytics, the applications, and usage process** (Answers questions we have not framed yet)
- 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 Management & Data Analytics (cont.)


Cross-Domain Visualization, Exploration, and Analysis Capabilities

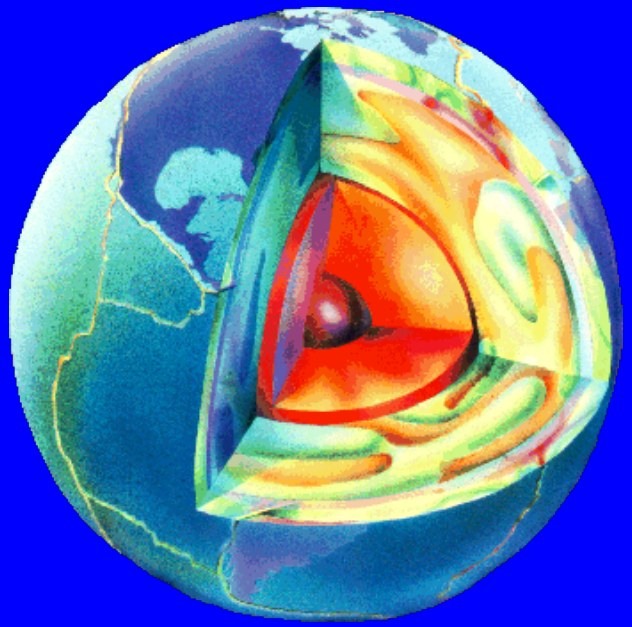
- **Data Integration**
  - Merging information/data to solve problem
  - Integrating different types of data; synthesize
- **Data assimilation** – sequential updating of model forecast with new observations
- **Data quality** –understanding, evaluating, using data of different qualities
- **Visualization & 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***

- **Systems Thinking**
  - Need individuals that can look at the big picture of a system, go from big to small to solve the problem
  - Can view the whole system and drill down to details and limitation

- **Earth System Thinking**
  - Earth as a interactive system
  - Complex, non-linear, coupled system
  - Interaction between different processes



Important Concepts & Abilities


Credit: Storyblocks

- Scientific process
  - Observe, characterize, understand, model, predict, verify
- Importance of simulation
- Good grasp of uncertainty
- Scalability of space and time
- Awareness of Risk and Impact
- Application driven questions

- Internal drive to do well
  - Overcome inherent risk aversion in adopting new technology to address major problems
  - Overcome prevalence of fear of failure
- Willingness to be a life-long learner – learn how to learn
- Societal Connection
  - Understand research needs a purpose

- Diverse and Adaptable skill set
  - specifics less important, but rather evolution potential

Additional Professional Skills

- **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.)
- **Time-value concepts – understand**
- **Business Skills** (need much better skills)
  - Economic, data-driven decision-making; risk, uncertainty
  - Innovation & entrepreneurship
  - Leadership, teambuilding, finances/budgeting, project management, problem solving
  - exposure to basics of business, operations, etc.

- **Ethics & Professionalism**
  - Integrity and its importance to science & research process
  - Understanding plagiarism, self-plagiarism
  - Proper attribution to original source
  - Rules for scientific citation and research
  - Knowing how to search for research

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- **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

- **Organizational Management Skills**
  - How to run a meeting (agenda, time management, relevance, etc.)
    - Students rotate to run lab meetings?
  - Give concise and organized communications to a group
    - AGU-style talks; elevator speeches
  - Exposure to a chain of command and business culture
    - Foreign in academic settings but need to explore
  - Time management for self and in interaction with colleagues

What level of competency is needed?

PhD – Expert; MS – Mastery

- Expertise/depth in core area
- Critical thinking & problem solving

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

What level of competency is needed?

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.

Need for Integration

- **What distinguishes a PhD/strong researcher?**
  - A deep technical dive into one subject
  - Ability to discover, own, and solve a problem independently
  - High level of creativity and innovation
  - Ability to create new knowledge

- **Need to integrate these identified skills without losing the strong research emphasis**
- **Make many of the non-core research skills part of program culture**

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
- Interviewing skills
  - Can be learned
  - Do's and Don'ts
- Ability to move up & transition within organization (1st job not last)

Advice for Students

- **Be ready for dynamic job experiences**
  - Jobs/careers undergoing rapid change/growth
  - Be able to apply what you learned outside your field of expertise
  - Be able to talk to/work with people outside your field (e.g. physical oceanographer and biologist)
- **Show Interest in enterprise**
  - Step out of comfort zone, demonstrate enthusiasm
  - Getting something great done – *it is not having things perfect, it is about getting something great done*

Expectation of Employers

- **What employers expect?**
  - Writing and communication
  - Capacity for learning/adaptable
  - Systems approach
  - Programming, simulation, data skills, etc.
  - Problem solving & critical thinking
- **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

Image Via: acsundergrad.wordpress.com