VISION AND CHANGE: CRITICAL SKILLS and COMPETENCIES - UNDERGRADUATE and GRADUATE

Summit Convening Team

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WHERE DISCOVERIES BEGIN

- **Summit on the Future of Undergraduate Geoscience Education (2014 -)**
- **Improving Geoscience Graduate Student Preparedness for the Future Workforce (2017-)**

  NSF-supported efforts to seek community consensus on what undergraduate and graduate programs in the geosciences should do for students to prepare them for success as professionals in a rapidly changing discipline, and world.

- **Vision and Change in the Geosciences:**

  Outlines the consensus view of >1000 geoscience professionals in academia and the private and public sectors.

Key Consensus Findings:

- Geoscience curricula should be built around critical skills and competencies
  - Both conceptual and practical competencies
  - A specific corpus of courses is NOT essential
- Undergraduate AND graduate geoscience students both need learning and practice in key professional skills

Academic/Employer Consensus: Conceptual Competencies

- **Systems Thinking**
  - (lithosphere/atmosphere/hydrosphere/biosphere and their interactions; Earth in the Solar System)
- **Processes**
  - Geochemical (Thermodynamics, crystallization/melting, water-rock exchanges, global chemical cycles)
  - Time (deep time, Earth Evolution)
  - Geomechanics (structure, tectonic processes, geodynamics
  - Earth Surface processes (deposition, erosion, landforms)

Graduate Level Conceptual Competencies:

- **MS, Ph.D. Graduates both need expertise and depth in their core areas**
  - Mastery of core technical/scientific skills in their area(s) of expertise are absolutely necessary
  - They need a deep understanding of the fundamentals, techniques and methods used in their work
  - Per employers: Graduates generally are coming out with strong technical and academic skills
    - Deep knowledge in their geoscience field
    - Good research skills and field skills

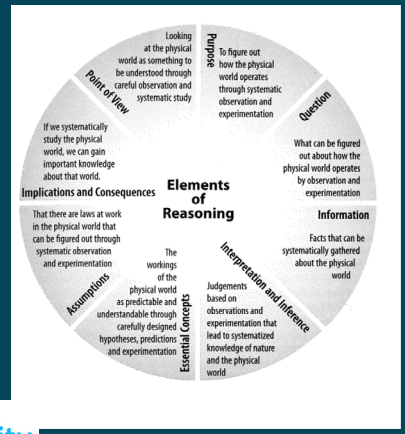
Academic/Employer Consensus: Important Skills/Tools

- **Statistics and Probability**
- **“Higher” Math: Linear Algebra, Differential Equations**
  - Modeling (numerical/analytical)
- **Geospatial skills (Mapping, GIS)**
  - Field skills
- **Geochemical tools** (instrumental analysis, age dating)
- **Geophysical tools** (gravity/magnetics/seismic/ geodesy, etc.)

Technical Skills: Data Management & Data Analytics

- **NEW – not clearly called out during 2014 Summit events**
  - **Reflective of the dramatic growth in "big data" applications in earth/ocean/atmospheric fields**
    - Data Acquisition Management, Analysis, Integration, Assimilation
    - Visualization and modeling; AI, VR, robotics, Machine Learning, etc.
    - Valuation (monetization) of data
- **Related Computational Skills**
  - Coding and basic Programming
    - Esp. updating old software to new/better programming languages
  - Analyzing algorithms (re: machine learning, AI)
  - Conversant w/ cloud computing vs. supercomputing (re: big data storage/analysis)
    - Statistics for characterizing uncertainty
    - Comfort with higher math (Calculus, Diff. Equations, Linear Algebra) a given

Professional Skills and Competencies - Graduate AND Undergraduate



- **Problem solving & critical thinking**
  - Defining problems, devising appropriate & sufficient solutions
  - Articulating the primary and broader outcomes of their work, especially from professional/business perspectives
  - *Employers: Many graduates struggled defining problems, but address them well once they're defined.*

- **Teamwork, Collaboration, Leadership**
  - Working in diverse teams of trained individuals towards common goals
  - Ability to get others to work together; dealing with conflict
  - Being coachable; taking directions; leading AND following
  - *Geoscience graduates generally have limited experience in professional collaborations and teamwork*

- **Broad-based Communication Skills**
  - Effectively conveying technical findings to diverse audiences (Specialists, other STEM professionals, management, pubic, press)
    - » *Effectively communicating societal and/or financial impacts as well as the science*
  - Listening as well as speaking/writing
  - *Graduates struggle with communication to diverse audiences…*

Other Professional Skills/Competencies that are lacking:

- **Project & Program Management**
  - Understanding budgets, project financials, Manage time, people & resources; teambuilding
- **Business Skills**
  - Economic, data-driven decision-making; risk, uncertainty
  - Innovation & entrepreneurship
- **Ethics & Professionalism**
  - Integrity and its importance to science & research process
  - Understanding plagiarism, self-plagiarism, rules for scientific citation and research
- **Career Awareness**
  - Networking – how to do, what not to do, where to go/be
  - Where to search, resumes, applications, interviews,
  - Knowledge of careers and one's career options
- **Virtual presence/brand**
  - Current presence on social media and how that effects hiring/career
  - Representing that extra expertise
- **Corporate skills**
  - Being able to make it relevant to the CEO or Manager
  - Ability to move up & transition within organization (1st job is not the last)

LinkedIn

How do we include all this? Heads/Chairs ideas:

- **Courses/Curricula**
- Mapping competencies across the graduate curriculum (matrix model: Mogk 2013)
- Building teamwork/business-related acitvities into courses (AAPG Imperial Barrel, etc.)
- Elective/special topics courses in big data, coding, statistics, science communication, project management
- Reevaluate the qualifying/comprehensive exam within the context of broader professional expectations- e.g. include a written press release, a 3 minute thesis presentation, a project plan, timeline, and budget

- **Portfolios and Individual Development Plans:** (making these a central part of undergraduate/graduate advising)
  - Customized roadmap for professional training & goals
    - Skills assessment: What skills do I currently have?
    - Career Aspirations – what career pathways interest me? What do I like to do?
    - Desired Skills – setting goals for the skills I want
    - Professional Development – what support can I take advantage of?
    - Reflect on self-assessments & career aspirations / professional values
    - See AAAS Science Careers: my IDP (https://myidp.sciencecareers.org/)

How do we include all this? Heads/Chairs ideas:

Research: students can develop many key technical and professional skills

- **Focused disciplinary & technical knowledge**
  - Field and/or lab skills
  - Computational skills and field-specific "Big data" Analytics/Management
- **Written & Oral communication**
  - Thesis/dissertation, publications, proposals & conference presentation
  - Presentations to research group, department, undergraduate classes
  - Writing press releases before the full proposal & publication -- societal impact, diverse audiences
- **Critical Thinking & Problem solving**
  - Critical reading/evaluation of journal literature
  - Identifying reliable data sources
  - Analyzing & evaluating results, communicating uncertainty
  - Learning to formulate problems & solutions; recognizing societally important problems
- **Ethical (research) behavior & standards of practice**
- **Teamwork (as part of research groups)***
    - Project & time management
    - Conflict Resolution, Diversity and cultural sensitivity
  - (*harder to model private/public sector practices; IODP and like marine research efforts; NSF Traineeship projects, etc.)

How do we include all this? Heads/Chairs ideas:

Co-Curricular activities should be used to support learning key professional skills

- Departmental activities:
  - Clubs, internships, organized outreach efforts, professional organizations, etc.
    - Leadership & management skills, oral and written communication
    - Interpersonal skills
    - Teamwork with diverse groups
    - Informal faculty/staff/peer mentoring
    - Entrepreneurship
- Professional Short Courses, Workshops, etc.
  - Through Geoscience Professional organizations
    - AGU, GSA, NAGT, others
  - Via Alumni organizations, returning interns & other "real world" presenters
    - Case studies - involve industry partners; industry retirees
  - Teacher training workshops (NAGT-EER, GSA K-16 short courses)
  - Others (Industry-based research/field/other training activities, etc.)

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Thanks for your attention!

Questions?