The Geoscience Workforce

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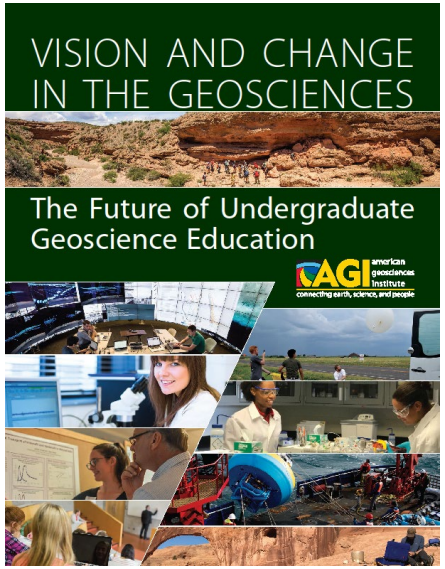
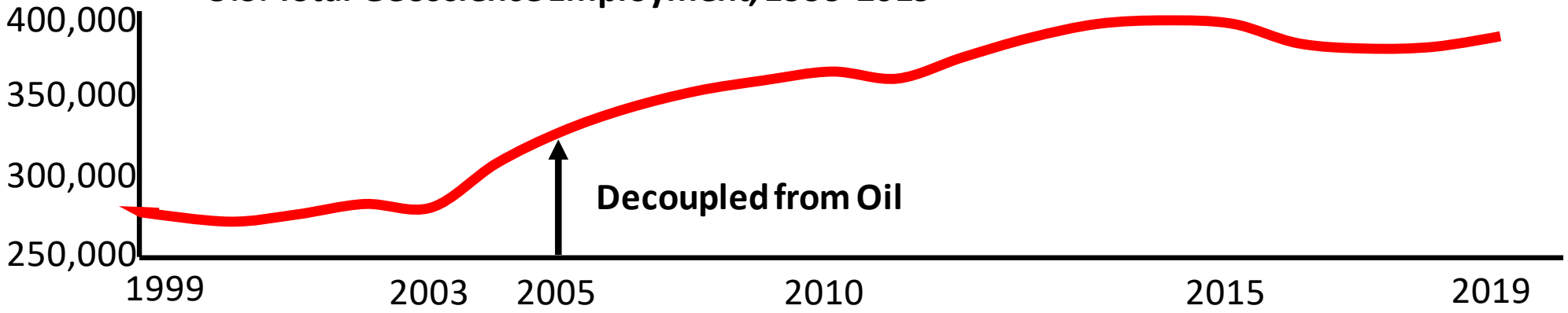


6-year NSF-sponsored initiatives:

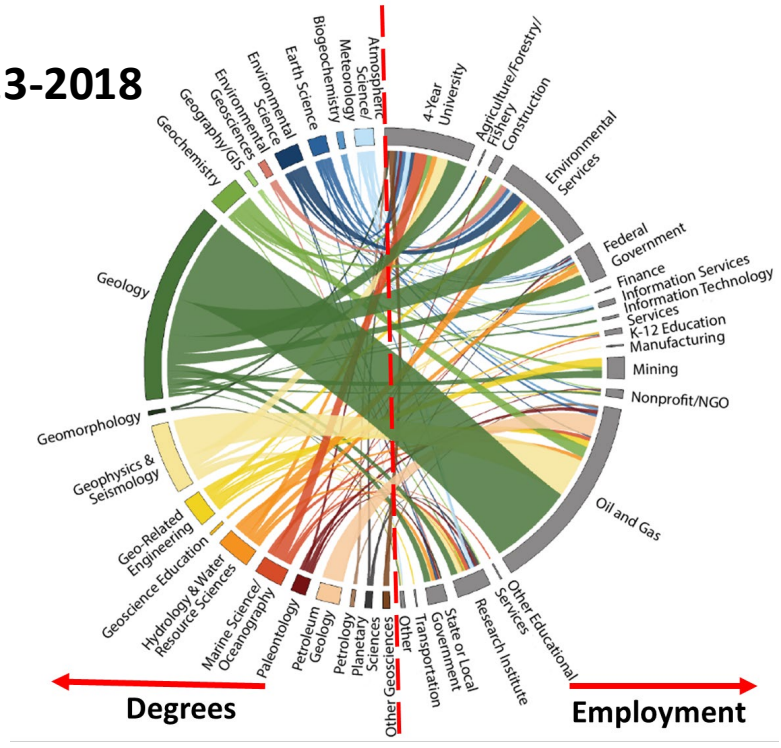
- **Geoscience academic & employer community has developed a consensus on concepts, skills & competencies needed by undergraduates.**
- **Similar skills & competencies needed for Earth, Ocean & Atmospheric Sciences graduate students at a more advanced level.**

TEXAS Geosciences
The University of Texas at Austin
Jackson School of Geosciences

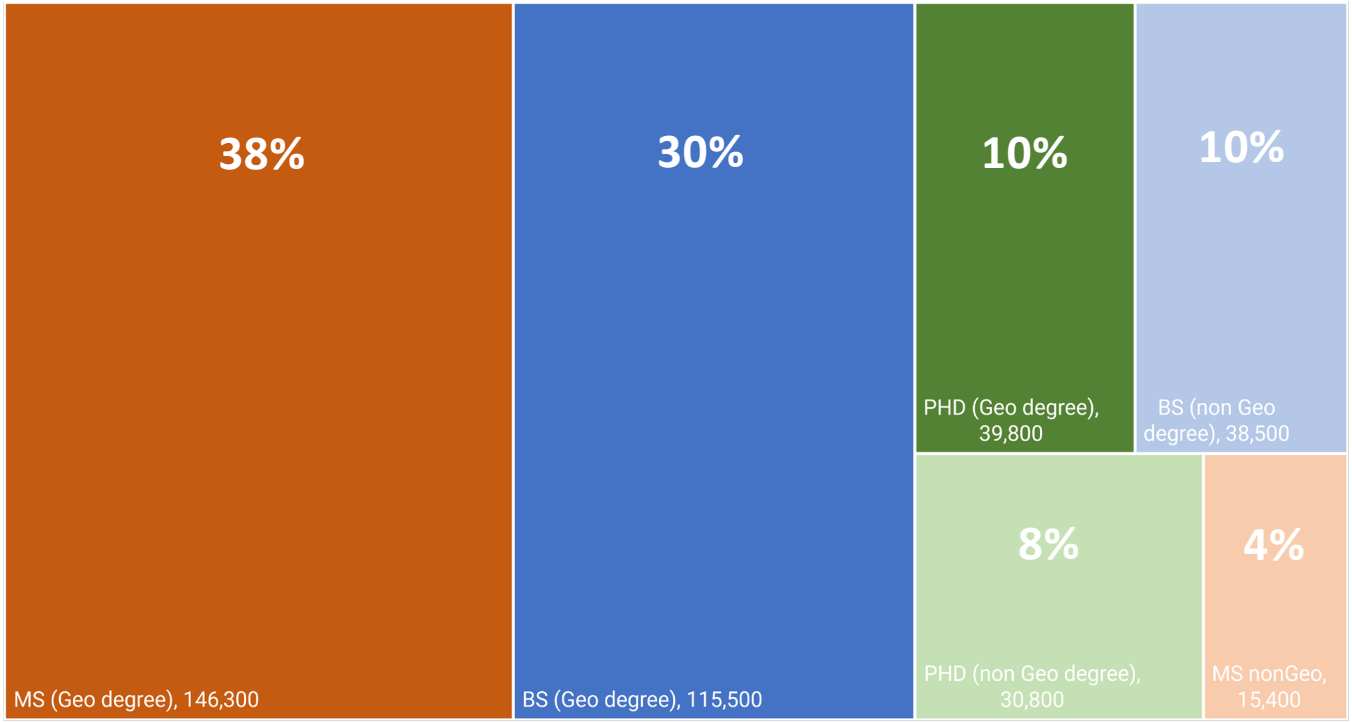
U.S. Total Geoscience Employment, 1999-2019



2013-2018

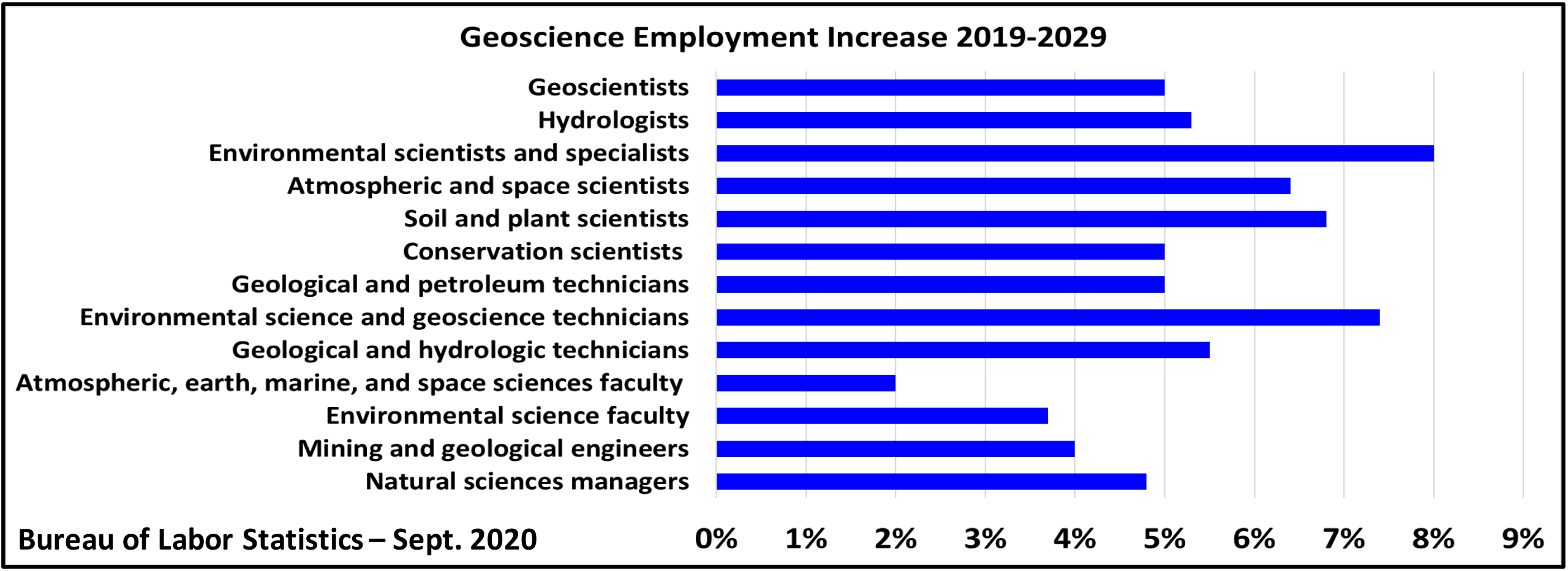


US Geoscience Employment by Highest Degree Level, 2017



Employment for Geoscientists is Expanding

AGI predicts shortage of 35,000 FTEs by 2028



Careers of today will not be those of the next decade

Geoscience Education – what employers expect*

Foundational knowledge – good education in geosciences

- Breadth in geosciences, grounding across all sciences

Understand geoscience concepts & processes

Develop scientific, technical & professional skills

Build Competency – ability to successfully accomplish something using knowledge & skills

- Diverse and adaptable skill set
- Intellectually flexible
- Ability to learn

*Employers Workshops: undergrads 2015; grads 2018; Summits 2014, 2016, 2019; 2014-2015 survey; Workshops 2015, 2017, 2019; multiple employer focus groups

Skills Needed for Success

Ph.D. & M.S.

- Problem solving & critical thinking
- Written & oral communication / listening skills 😔
- Capacity for learning/adaptable
- Systems thinking & approach
- Expertise/depth in core area, strong technical skills 🙂
- Data Management, Data Analytics
- High level quantitative skills
- Computational skills, programming, modeling
- Project management, teamwork, leadership 😔
- Ethics & professionalism
- Social dynamics - interpersonal skills 😔
- Understand societal relevance, global perspective

More detail:
https://www.youtube.com/channel/UCuUh_ZRxipieB3dnkvd0l_Q

Undergraduates too!

Earth Science Habits of Mind

Undergraduates

Ph.D. & M.S.

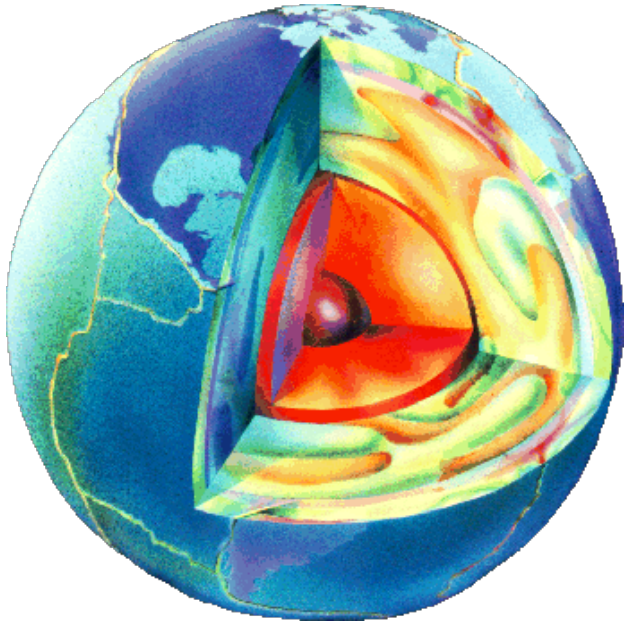
Geoscientific & Systems Thinking

- How systems work & interact
- Earth as a complex, non-linear, coupled system of interacting parts & processes
- Temporal & spatial thinking – 3D & 4D

Understanding processes

- Linkages, feedbacks, driving forces
- Impacts

Geologic reasoning and synthesis



Systems Thinking

Ph.D. & M.S.

Employers stressed Systems Thinking – all types of systems – is critical

- **Consider entire systems & recognize that any parts in isolation may act differently than when within the system**
- **Start at the system level & evaluate interactions & limitations of its different parts**
- **Look at the big picture first, then drill down to details, & bring that information back up to the system level.**

Goal setting

- **Solution-oriented approaches**

Critical thinking & problem solving

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

Undergraduates

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 & apply
- Make predictions with limited data

- Work on problems
  - In an open & dynamic system
  - With no clear answers, high ambiguity
  - By analogy, inference and limits of certainty

- Visualize and solve problems in 3D & 4D
- Understand & manage uncertainties
- Understand importance of scale – space & time
- Critically evaluate literature

Critical thinking & problem solving

Most Important Skill – regardless of discipline

Independent critical thinking, problem development, execution & analysis skills

- Pragmatic, logical thinking
- Flexibility, open-mindedness
- Good grasp of uncertainty

Ph.D. & M.S.

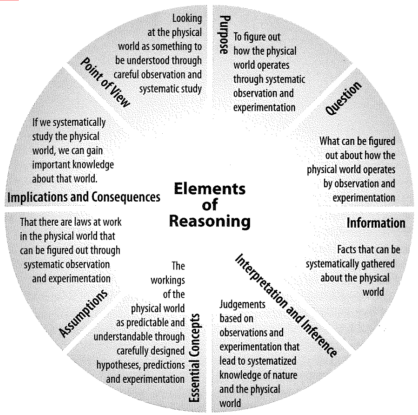
Define problem & apply an appropriate solution

- Sufficient solution vs. a precise, complete solution

Translate problem to -- so what?

- Articulate importance of outcomes
- What decisions will be made

Understand broader impacts of research & how to communicate those impacts



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

Data Management & Data Analytics

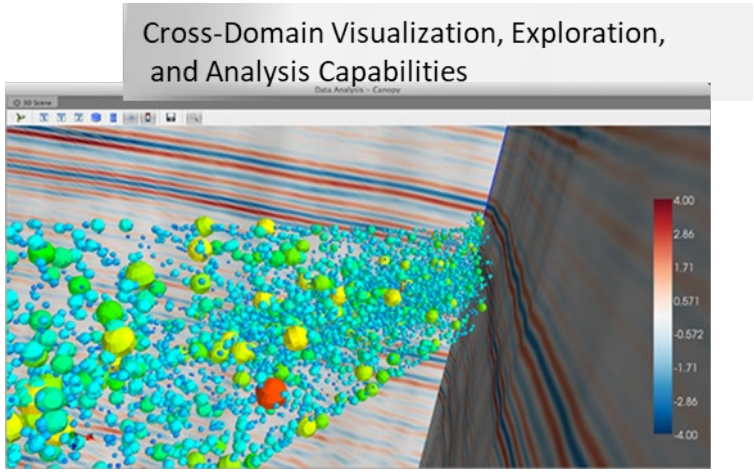
Ph.D. & M.S.

Undergraduates

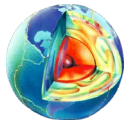
Currently need & increasingly important in the future – across employer spectrum!

- Awareness of data analytics, applications, processes for using data
- Handle large datasets
- Examine datasets to draw conclusions about information contained

- Data acquisition -- data collection
- Data management & analysis – effectively organize, manage, synthesize
- Data manipulation
- Data integration
- Data assimilation
- Data quality
- Visualization & modeling
- Valuation
- Other data science– increasing in future



Earth as a Complex System



Non linear complex systems
Energy, mass, fluid transport (movement and flow), residency, and cycles
Work/changes that affect the Earth's systems
Solar system interaction

Deep Time

Conventional concepts of geologic time
Impact on processes
Events and rates
Temporal reasoning

Undergraduates

Concepts

Earth Materials

What is a rock, mineral? Rock cycle
Rocks: physical and chemical properties
Processes that form rocks and minerals
Resource applications, organic-inorganic materials

Earth Structure

Structure of Earth
Plate Tectonics
Deformation
Structural controls on resource accumulations

Surface Processes

Sediment deposition & erosion
Terrestrial & marine surface interactions
Landscape alteration (geomorphology)
Habitability, sustaining life

Hydrogeology

Water cycle
Groundwater/aquifers
Biogeochemistry & aqueous geochemistry
Subsurface-surface water interactions
Economics & public policy

Natural Resources

Understanding "natural resources"
Solid vs. liquid resources, geographic distribution, uses
Ecosystem services, renewable & non-renewable resources
Resource dependency & limits

Climate Change

What is climate change? Geologic scale vs. present
Driving forces & causal mechanisms
Carbon cycle
Impacts of climate change

Undergraduates

Skills

M – master
P- proficient
Geoscience-specific skill

Ph.D. & M.S.

Experts!

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

6-year NSF-sponsored initiatives:

Vision and Change in the Geosciences

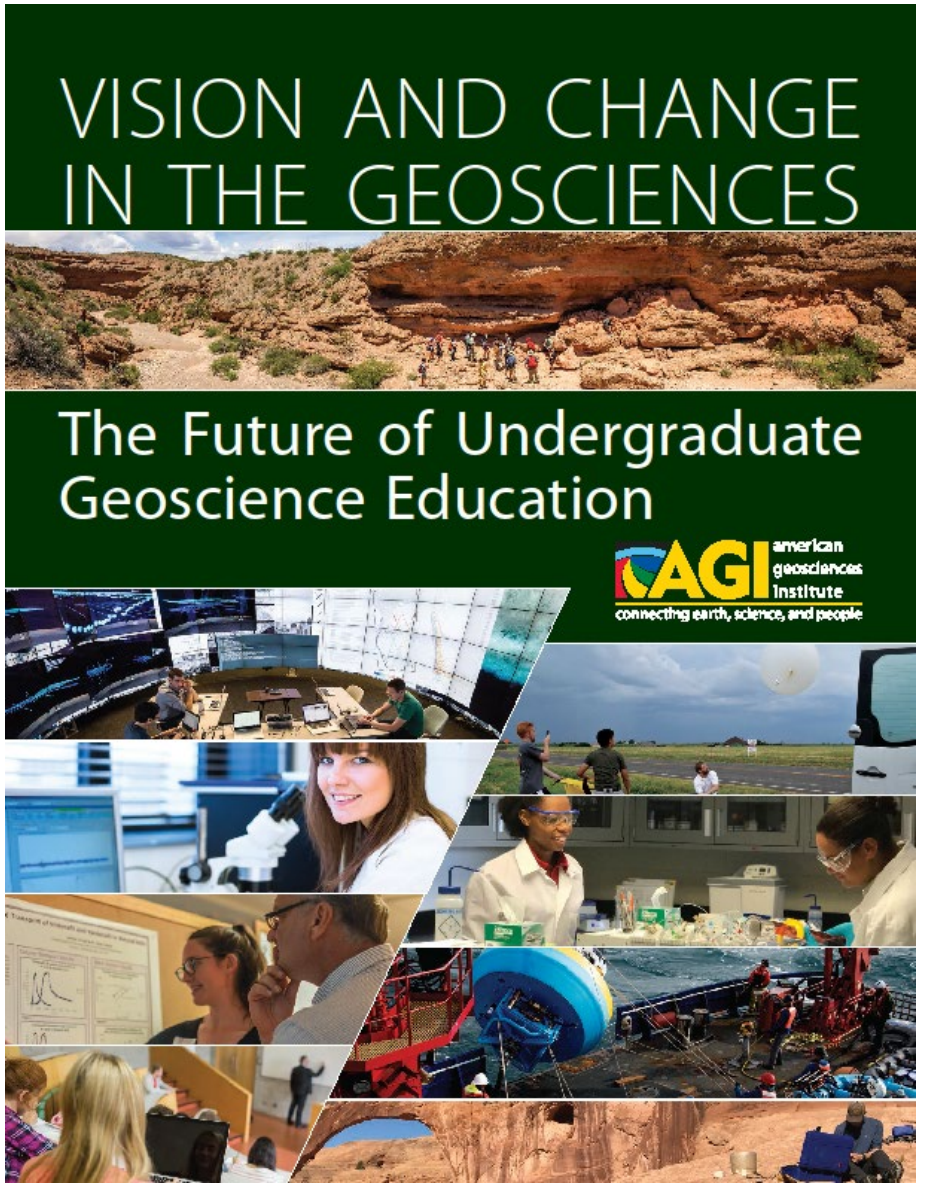
Extensive document containing results of

- **Robust academic & employer community vision for Future of Undergraduate Geoscience Education**
- **Key strategies/recommendations for transformative change**
- **Case studies from department heads/chairs implementing program changes to meet these needs**
- **Plus: Employer view on skills needed by graduate student**

Represents input of ~1000 geoscientists

PowerPoint slides, webcasts & more information:
http://www.jsg.utexas.edu/events/summit-on-improving-geoscience-graduate-student-preparedness-for-the-future-workforce/
http://http://www.jsg.utexas.edu/events/future-of-geoscience-undergraduate-education/

Coming Fall 2020



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