Approaching Curricular Re-Design: How and Why?

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Summit Organizing Team

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First: Why?

- **External Forcing**: states, regional accreditors, and Federal agencies are more and more demanding evidence for effectiveness and cost-effectiveness, and putting ***$$*** teeth in their demands.
  - **FL examples:**
    - ***SUS Performance Metrics***, which determine the distribution of $10-100M of state funding each year, depend on improvements in measures related to "student success" (graduation, job placement, cost per degree, etc.)
    - ***SACS regional accreditor requirement***: annual collection and analysis of data for student learning in degree programs, with defined plans for annual improvement
      - ***Newly added: "third party measures" of student learning (validated testing instruments (!!))***
  - **Other examples?**

[To document success, you need to know how your courses/programs are working…]

More Why…

- **Supporting your students, and your local/regional/national employer communities**
  - **Are your Bachelors graduates moving easily into the workforce and/or onto graduate degrees?**
    - ***FL example (again):***
      - **USF Alumni/employer network provides real-time feedback on the suitability of our BS graduates for the environmental industry in the SE US**
        - » See https://www.youtube.com/watch?v=6FYebZpRQPg (webinar recording) and/or http://nagt.org/nagt/profdev/serving/posts/177387.html (blog post)
    - **Do you have linkages or make connections to your local/regional employers re: the readiness of your graduates?**
    - **Do your good students get into MS/Ph.D. programs, as appropriate?**

How…

Resources:

- **Mogk, 2013: "Curriculum by Design"**
  - (https://serc.carleton.edu/earthandmind/posts/curriculum_desi.html)
- ***"Backward Design"***: Identify the **learning outcomes** you seek (what should students know/be able to do when they're done), and then build your program to provide instruction/practice to ensure students attain them.
  - **Evaluation measures track progress and document success (to students and faculty)**
    - (This approach scales to course development, activity/exercise development, etc.)

DEPT EARTH SCIENCES, MONTANA STATE UNIV., UNDERGRADUATE COURSE MATRIX

(Required Courses ONLY Offered in the Dept. of Earth Sciences, exlusive of Independent Study, Thesis, etc.)

Unifying Themes:	Earth History, Deep Time, Evolution	Earth Composition and Architecture	Surficial Processes, Water, Climate	Human Dimensions
Degree Option:	**Paleontology Option**	**Geology Option**	**Hydrology, Snow Options**	**Geography Options, Including GIS Minor**
Upper Division Electives (4xx)				
Capstone Courses	GEO 429 Field Geology			GPHY 425 Geog Thought
Major "Enrichment" Courses (4XX)	GEO 417 Taphonomy	GEO 433 Tectonics	Other electives from LRES, CE, Poli Sci.	GPHY 431 Historical Geog
Cognitive Skill Level: Analysis and Synthesis	GEO 411 Vert Paleo	GEO 440 Volcanology		GPHY 461 Tourism Plan
Mastery of content and concepts	GEO 413 Macroevol	GEO 408 Meta Pet		GPHY 441R Mountain Geog
	GEO 419 Field Paleo	GEO 406 Igneous Pet.		GPHY 445 Regional Geog
		GEO 480 Petroleum		GPHY 480 Water and Soc.
		GEO 480 Geophysics		GPHY 480: American West
	GEO 407 Sedimentary Petrology			GPHY 446 East Asia
		Geohydrology		GPHY 411 Biogeography
		GEO 445 Glaciology		
		ERTH 450R Snow Dynamics		
				GPHY 426 Remote Sensing
				GPHY484 Applied GIS
Major "Core" Courses by Option (3xx)	GEO 310 Invert Paleo	GEO 302R Mineralogy		GPHY 321 Urban Geog
Cognitive Skill Level: Interpretation (process, history…)	GEO 330 Paleo Lab Technique	GEO 309 Sed and Strat		GPHY 322 Economic Geog
Competence with content and concepts	GEO 316 Comp Vert Anatomy	GEO 315 Structural Geol		GPHY 325 Cultural Geog
	GEO 312 Dinosaur Paleo			GPHY 357 Fund App Map
				GPHY 365 Geog Planning
	GPHY 384 Advanced GIS			
	ERTH 303 Weather and Climate			
	ERTH 307 Geomorphology			
"Foundations" Courses (2xx)--Concepts/Skills required of ALL E Sci Majors AND Allied Depts.	All Majors are expected to fulfill prerequisites in cognate courses: Chemistry 141, Chemistry 143, Physics 220, Physics 222, STAT 332, Math 171 Calc I, Math 172 Calc II, (Math 273, 274 Diff Equations			Stat 216, 217;
Cognitive Skill Level: Description	GEO 211 Historical Geology			1 year foreign Language
Familiarization with content and concepts	GEO 205 Earth Materials			
	GPHY 284 Intro to GIS			
Introductory Courses (1xx)	ERTH 101 IN Earth System Science			GPHY 121D Human Geography
Cognitive Skill Level: Observation, inquiry, discovery	ERTH 102 CS Topics in Earth Science			GPHY 141D Geog of World Regions
Initial Exposure to content and concepts	GEO 103 CS Environmental Geology			
	GEO 111 IN Dinosaurs	GEO 140 IN Planetary Geology	GEO 105 IN Oceanography	
		ERTH 212R Yellowstone Scientific Lab		

Learning Outcomes?

Summit Findings:

- https://www.youtube.com/watch?v=RosA1hODdQov (AGI Webinar)
- http://www.jsg.utexas.edu/events/future-of-geoscience-undergraduate-education/summit-materials-powerpoints-and-webcast-archive/ (archive of materials, maintained at the Jackson School of Geosciences)

Overview of Geoscience Employers Workshop Outcomes

General thoughts on concepts: From Geoscience Employers Workshop

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

- Geochemical Cycles: C, H2O, N, P
- Thermodynamics: energy, kinetics, diffusion, heat, mass transfer, fluid flow
- Geomechanics/Stress State/Rheology
- Geological Time/Earth Evolution
- Plate Tectonics/Geodynamics
- Tectonic Processes
- Depositional Processes
- Crystallization Processes

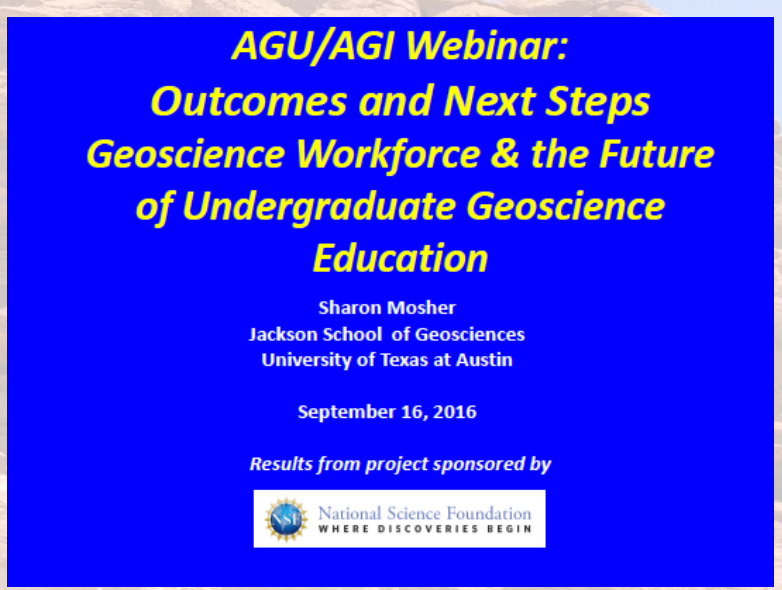
Tools

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

Geoscience concepts: Identified by 1st Summit, validated by survey; granularity added at Geoscience Employers Workshop

Earth as a Complex System

- Nonlinear complex systems



Consensus view of ≈1000 geoscience educators, employers, and dept. leaders on what a B.S geoscientist should know/be able to do!

- A good starting place for faculty discussions
- **Not one-size-fits-all** **(and not intended to be!)**

Best Pedagogical Practices:

- **Evidence-based teaching practices: there are many…**
  - ***What they have in common (see McConnell, 2014:*** http://www.jsg.utexas.edu/events/files/McConnell-David.pdf)
    - **Interactivity** (student response systems, "just-in-time" strategies)
    - **Collaboration/cooperation** (think-pair-share, jigsaws)
    - **Inquiry** (PBL, Case studies, studio classrooms, CUREs, undergraduate research)
      - **MINIMIZING straight lecture for content coverage!**
      - **Frequent, low-stakes assessments (tests)**
  - **Where to find more information:**
    - **SERC (Teach the Earth: https://serc.carleton.edu/teachearth/index.html)**
    - **National Association of Geoscience Teachers: https://nagt.org/nagt/teaching_resources/index.html (Teaching resources)**

Transitioning to Evidence-based pedagogies involves risk….

- **This process has to be iterative**
  - **Successful strategies need to be adapted to your institution/classrooms: they won't work perfectly the first time!**
  - **Students may (will) protest, initally, even if faculty are clear on the how and why of their new pedagogies**
- **Faculty will require encouragement, support, and protection to make major changes in their courses**
  - **Annual reviews**
    - **Raises tied to annual review/teaching averages (a USF issue…)**
  - **Tenure/promotion concerns**
    - **Junior faculty should be encouraged to build in such strategies in their courses at the outset**
    - **The Early Career Geoscience Faculty workshop offers good guidances here: https://serc.carleton.edu/NAGTWorkshops/earlycareer2017/index.html (just ended!)**
- **Professional development for helping your faculty transform their courses:**
  - **NAGT Traveling Workshop Series (https://nagt.org/nagt/profdev/twp/trav_departments.html)**
  - **Earth Educators Rendezvous (check the program…)**

How to start to revise/revision…

- **You MUST have faculty buy-in to initiate the process and move it forward!**
- **Strategies:**
  - **Faculty retreat devoted to the topic**
  - **Special committee (with a charge and calendar for deliverables)**
  - **Find your heroes!!**
  - **Time at MULTIPLE faculty meetings to discuss issues/progress.**
- **(for me, at USF, this meant…)**
  - **Not "protecting" faculty from the external/internal pressures– they saw what was coming and grasped the need and urgency!**
  - **Major topic at a faculty retreat (kickoff)**
  - **Primary charge for our Undergraduate Committee**
    - **Adapted the Mogk (2013) matrix to our program to define outcomes and "fit" to our existing program**
  - **Repeat topic at faculty meetings (ongoing….)**
- **Strategies from others?**

Big Challenge: Knowing (and showing) it works!

- **Evaluation:** Does the program succeed in attaining its targeted outcomes?
  - Should include "throughput" measures (no. graduates, avg. GPA employment success, grad school admits, etc.) as well as learning assessment data for students.
- **Assessment:** Do students gain the targeted competencies and skills by the end of the program?
  - Student learning assessment data ≠ GPA!
    - Assessment data needs to be collected at the course level to attain program-scale results
      - Measurement at several stages (freshman/sophomore, Junior, Senior-level courses)

Learning Assessment "instruments" for concepts/knowledge

- **Surveys**
  - **SALG - Student Assessment of Their Learning Gains** (http://www.salgsite.org/): a customizable instrument that allows faculty to tailor questions to their courses.
    - Includes both conceptual and attitudinal (affective) measures
    - Can be designed (by instructors) for any course
    - Limitations: student self-reporting, participation
- **Concept inventories**
  - Validated measures (questions) targeting **conceptual understanding**
  - Mostly for introductory courses, but expanding….
    - Geoscience Concept inventory (GCI) (https://geoscienceconceptinventory.wikispaces.com/)
    - Conceptest collection (SERC): originally designed for "clicker" use, but has broadened out (https://serc.carleton.edu/introgeo/interactive/conctest.html)
    - Oceanography Concept Inventory (Arthurs, Hsia, Schweinle, 2015, J. Geosci. Ed., 63: 310-322)
- **"3rd Party Instruments":**
  - ASBOG Fundamentals of Geology: conceptual exam now available in some states for graduating Seniors seeking Geologist-in-Training (GIT) certification (http://www.asbog.org/)
    - Departments get anomymized results,
    - NOT FREE…

Assessment of Skills Development?

- **Capstone/integrative experiences**
  - **Geology Field Camps**
    - Mapping and other field data collection/interpretation (geophysics, hydrology, etc.)
  - **If your Dept. doesn't teach field camp, other courses/assignments may be appropriate (at USF we do both…)**
    - **rubric based, multiple raters…**
- **Undergraduate Research**
  - **High Impact Pedagogy (PCAST 2012; Lopatto 2007; 2010)**
  - Develops key scientific skills + technical + "soft" skills
    - **Senior Theses** (some do this as a capstone...)
    - **Course-based undergraduate Research Experiences (CURES)** – advocated by PCAST and by the National Academies **(NRC 2015; 2017)**
      - Research products (papers, presentations) can provide evidence of accomplishment/success in a course or a program, as can perspectives from students and their mentors
      - See Singer and Mogk for strategies/background: https://serc.carleton.edu/NAGTWorkshops/undergraduate_research/assessment_pedagogy.html

(None of these are very easy to do, but they're important...)

Assessment/Evaluation/Curriculum change doesn't happen…

…Unless a Department is willing to do it!

- **Chair leadership is critical!**
  - "sticks"
    - **An annual requirement, an evaluated activity**
      - **(everybody plays: participation can't be optional…).**
      - **Data collection, and data review/analysis has to occur routinely.**
        - » **At USF: our undergraduate committee compiles annual data for faculty review/discussion.**
  - "carrots"
    - **Re-assign time for curricular work**
    - **Professional development for course transformation ($$)**
    - **Granting opportunities (IUSE-EHR, the ICT track…)**