Some Reflections on Curriculum Design and Program Assessment:

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2016 Heads/Chairs on the Future of Undergraduate Geoscience Education Summit

http://serc.carleton.edu/107251

We do a pretty good job presenting scientific content to students:

- Taxonomies
- Methods
- Problem sets and worked examples….

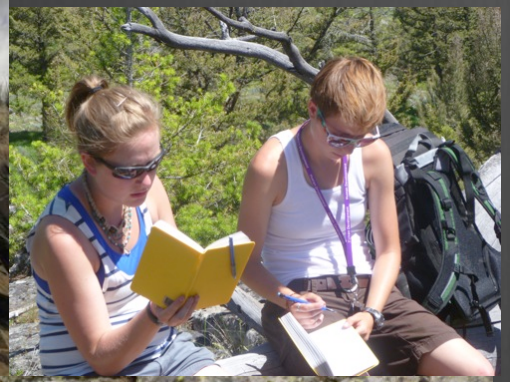
But, are we doing a good job producing good Scientists?

- What are the attributes required of being a good geoscientist?
- Where in your curriculum professional development as a scientist explicitly addressed?
- What other extracurricular training is needed?
- Who has responsibility?

Whole Student Approach

- Define programmatic student learning goals
- Embed assessments throughout the program to demonstrate mastery
- Align course sequences to reinforce and anticipate essential concepts and skills
- Prepare students to be life-long learners
- Assign responsibilities to ensure these goals have been met.

The Product



- Students who can
  - Understand geologic context, apply concepts and skills
  - Ask the next question
  - Know where to look for information
  - Formulate a plan to address the problem
  - Become critical producers and consumers of data
  - Integrate multiple lines of evidence
  - Communicate results;
    - write a report, make a map, develop a GIS….
  - Be life-long learners

"Backward Design"

- What is the profile of the student leaving your department?
  - What should they know, be able to do?
- Preparation for the workforce
  - Traditional "geo" employment or grad school: exploration, environmental, regulatory agencies….
  - Non-traditional: policy planning, environmental law, K-12 teaching, business (e.g. insurance….)
- "If it ain't broke don't fix it"
  - But it was broke
  - Need for more efficient utilization of faculty, TAs, course credits and resources;
  - New courses needed, some courses terminated or merged.

Learning Sequences

- Based on Bloom's Taxonomy
  - Observation of Earth (remembering)
  - Description of Earth materials and land forms (understanding)
  - Interpretation of Earth processes (application)
  - Integration of multiple lines of evidence to address geologic (and societal) problems of consequence (analysis, synthesis, evaluation)
- Base curricular decisions on sound Discipline-Based Education Research!

  See: http://serc.carleton.edu/NAGTWorkshops/DBER.html

Rule of 3's (or 4's)

- If something is worth learning, students need multiple exposures and opportunities
  - Exposure
  - Familiarization
  - Competency
  - Mastery

Photo Credit: Jeff Ryan

ALIGNMENT

- Review course sequences
- Scaffolded and articulated?
- Can students see a clear path towards graduation?

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.)

Unifyiing 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	GPHY 431 Historical Geog
Cognitive Skill Level: Analysis and Synthesis	GEO 411 Vert Paleo	GEO 440 Volcanology	LRES, CE, Poli Sci....	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		

Earth Educators' Rendezvous

Rendezvous 2015 > Program > Mini Workshops > Creating the Graduates you Want

Rendezvous 2015

Creating the Graduates you Want

http://serc.carleton.edu/earth_rendezvous/2015/mini_workshops/mw10/index.html

The "Matrix Approach"

Defining and assigning student learning outcomes

Recurring Themes

- History and Evolution of the Earth System
  - Biological and tectonic evolution
  - Historical Geology, Vert and Invert Paleo, Tectonics
- Composition and Architecture of Earth
  - Earth Materials, Mineralogy, Petrology, Sed/Strat, Structural Geology
- Surface of Earth and the "Critical Zone"
  - Weather and Climate, Geomorphology, Hydrology
- Human Dimensions
  - Human, Regional, Resource, Economic Geography
  - GIS and planning
  - Hazards and Earth Resources; units in numerous courses

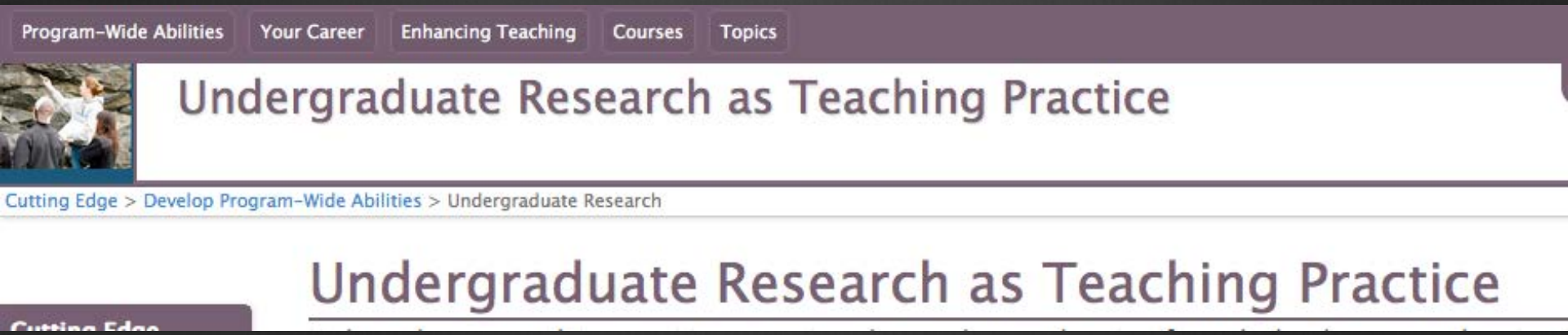
Geoscience Habits of Mind

- Earth System: heterogeneous, dynamic, complex, open system;
- Incomplete geologic record;
- Processes not directly observable on human scales (temporal or spatial)
- Ambiguity, uncertainty, inference.

Students need practice early and often!

Provide Students Opportunities to DO Science

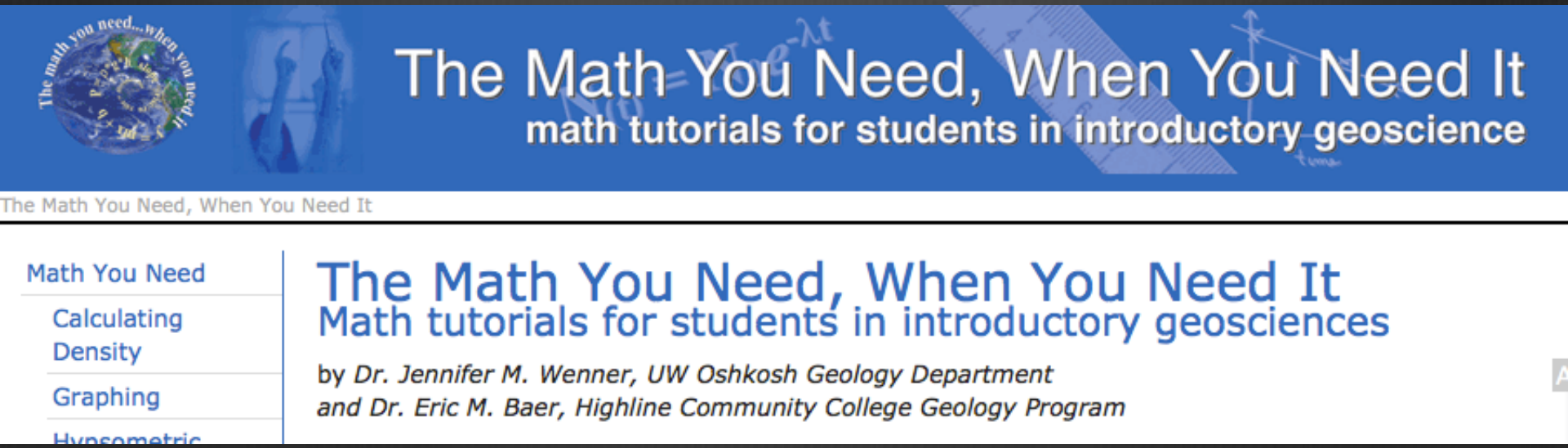
- Research Opportunities
  - Intro course (PCAST)
  - Embedded in courses
  - Independent study projects
  - REU sites



http://serc.carleton.edu/NAGTWorkshops/undergraduate_research/index.html

Quantitative Skills

- Take as much math as can be fit into degree program!
- Calc I and II
- Statistics
- Linear Algebra, Diff Eq



http://serc.carleton.edu/mathyouneed/index.html

Collaborative, Interpersonal Skills

- Trust
- Respect
- Responsibility
- Willingness to share ideas
- Common sense of purpose
- Equal ≠ Equitable

Develop Extracurricular Departmental Activities—The "Co-Curriculum"

- Social events
- Journal clubs
- Department seminars and colloquia
- Field trips
- Internships

Expectations for the Workforce

- Quantitative skills
- Communication skills (verbal, written, graphical)
- Collaborative work (interpersonal skills
- Systems thinking
  - Integration of multiple lines of evidence
- Problem-solving
- Research and research-like experiences,
  - Acquisition and use of data, modeling
- Applications to societal issues

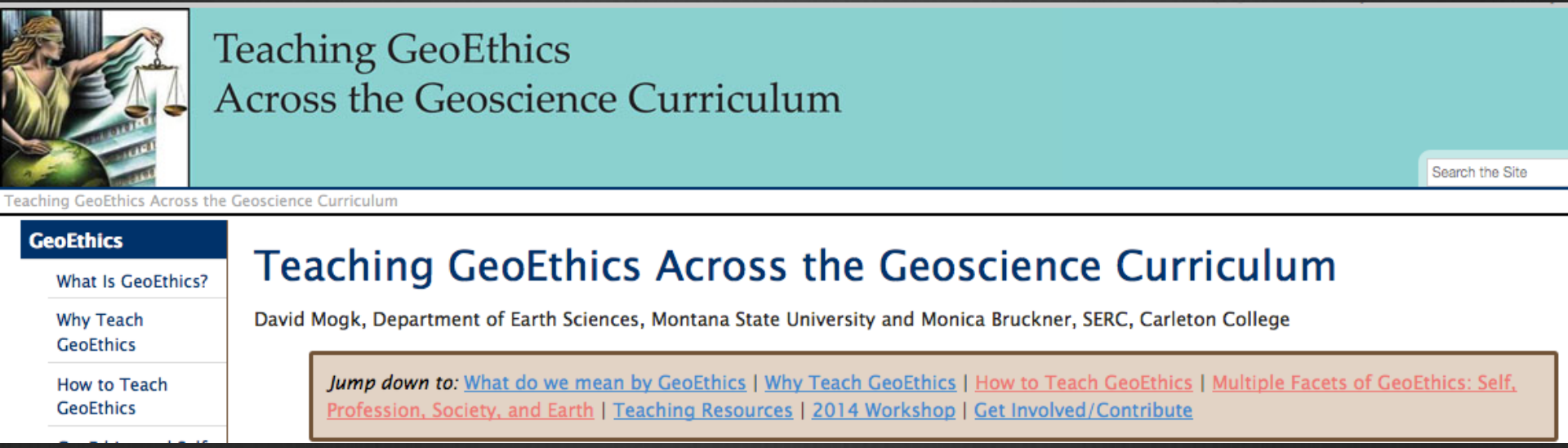
See AGI Workforce Reports: http://www.americangeosciences.org/workforce
2015 Geoscience Employers Workshop
http://www.jsg.utexas.edu/events/files/Employers_Workshop_outcomes.pdf

Workforce Expectations—Personal Traits

- Critical-thinking
- Problem-solving
- Curiosity
- Persistence
- Resilience
- Initiative
- …..

Ethics and Values

- Ethics and Self
- Ethics and Profession
- Ethics and Society
- Ethics and Stewardship of Earth

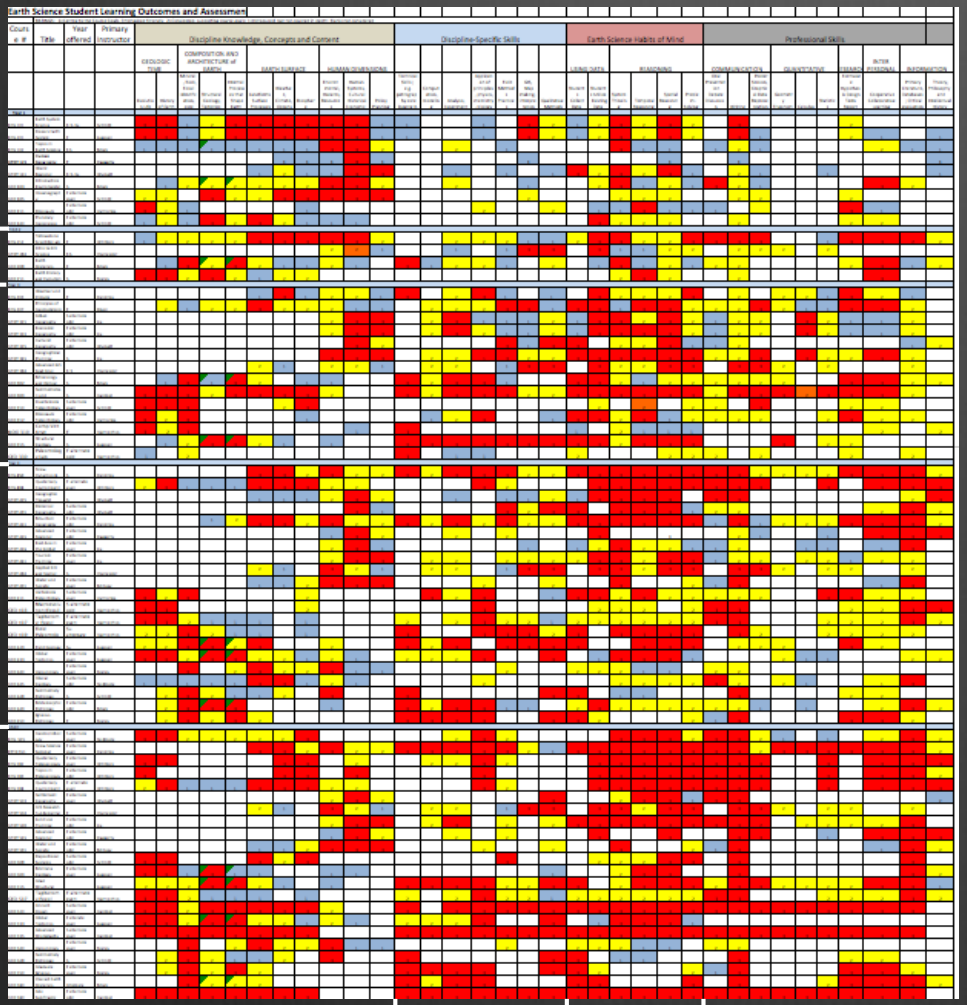


http://serc.carleton.edu/geoethics/index.html

Essential Steps

- Align with institutional Mission Statement and Departmental Role and Scope Documents
- Know your students.
- Identify the "Ideal Student" who graduates from your dept.
- Address new realities
  - Changing nature of Geoscience, Workforce, Emerging Research….
- Identify essential: Concepts, knowledge, geo-skills, professional skills, "Habits of Mind", experiences, values….
- Create your matrix: Skills/content v. course sequence
  - Faculty input…

Student Learning Outcomes and Program Assessment—the Matrix Approach



Curricular Claims:

- Earth System Approach
- Multiple exposures to key concepts
- Reinforcement of skills
- Workforce expectations
  - GIS
  - Communication
  - Problem-solving
- "Habits of Mind"
- Articulation of curriculum
- Formative assessment
  - Changes in emphasis
  - "Gap" analysis

Earth Science Habits of Mind						Professional Skills									
USING DATA		REASONING				COMMUNICATION			QUANTITATIVE			RESEARCH	INTER PERSONAL	INFORMATION	
Students Collect Data	Students Utilize Existing Data	System Thinking	Temporal Reasoning	Spatial Reasoning	Problem-Solving	Oral Presentation Debate Discussion	Writing	Poster Session, Graphical Data Representation	Geometry Trigonom	Calculus	Statistics	Formulate Hypothesis Design Tests Report Results	Cooperative Collaborative Learning	Primary Literature, Databases; Critical evaluation	Theory, Philosophy and Intellectual History
1	2	3	2	3	2		3					2			
		3	1	1		1	2	1					2	1	1
				1			1								1
3	2	3	2	3	1		2	1			1				1
	3	1	1	2	2		2	2	2		2				
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3	3	1	3	3	2	2	2	3	2	1	1	3	3	2	
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	3	3	2	3	3		3	3	2		2	2		2	

These are competencies or skills that are not "owned" by any one course, yet are essential for student pre-professional training.

The matrix approach identifies where these are addressed in course work, to what extent, how, and by whom– an important formative assessment for departments!

Support Claims Made About Your Department

- The department contributes to the institutional mission.
- The department is uses an Earth System approach
- The department has an integrated curriculum that is designed with learning sequences that develop higher order thinking skills?
- The department provides authentic research experiences.
- The department prepares students who are prepared a) to go to graduate school, or b) enter the workforce.
- The department serves society by addressing the "grand challenges" of living on Earth..

Building Strong Departments

Developing Pathways for Strong Programs for the Future

This material originally developed for Building Strong Geoscience Departments

Defining Strong Departments

- Characteristics of Strong Departments
- Criteria for Success
- Insights from Across Disciplines

Department Heads and Chairs

- Strategic Planning
- Recruiting and Retaining Faculty
- Managing a Department

Degree Programs

- Envision your Department
- What Makes a strong Program?
- Design Degree Programs
- Program Assessment
- Action Planning
- Profiles and Planning Documents Collection

Making a Case for Your Department

- Becoming a Valued Member of your Institution
- Strategies for Making your Case

Professional Preparation

- Build a Network of Alumni and Employers
- Internships
- Integrating Professional Preparation into Programs

Broadening the Diversity of your Graduates

Resources from InTeGrate »

http://serc.carleton.edu/departments/index.html

Resources

- EER Workshop on Creating "The Matrix" http://serc.carleton.edu/earth_rendezvous/2015/mini_workshops/mw10/index.html
- A Curriculum by Design (blog on coure alignment in curriculum) http://serc.carleton.edu/earthandmind/posts/curriculum_desi.html
- A Curriculum by Design 2 (blog on matrix development)http://serc.carleton.edu/earthandmind/posts/curriculum_desi2.html
- Building Strong Departments http://serc.carleton.edu/departments/index.html

ADDITIONAL SLIDES

Building Strong Departments

Developing Pathways for Strong Programs for the Future

NAGT

Search the Site Go

Becoming a Valued Member of Your Institution

Administrators value departments they perceive as making positive contributions to the institution. There are two steps to becoming valued: making positive contributions, and making sure that your administration knows what you're doing.

Jump down to Build Bridges Within Your Community | Carry Your Weight | Be Visible | References

Building Strong Departments

Developing Pathways for Strong Programs for the Future

NAGT

Search the Site Go

Strategies for Making Your Case

The best time to make a case for your department is all the time, so that your administration never questions your value to the institution. Here are some strategies for making your case, early and often.

Jump down to Do a Good Job With Program Reviews | Arm Yourself With Data | Be Ready to Justify Your Existence | Know Your Supporters | References

Develop a Unifying Vision and Goals for Your Department

We Know "What Works"

- Recruitment and retention
  - Communities of scholars; faculty and peer mentoring; engagement
- How people learn
  - Discipline-Based Education Research
  - Human Cognition, affective domain, metacognition
- Course and curriculum design
  - Student-centered; active learning;
  - High Impact Practices
  - Alignment of learning goals, activities, assessments

We Must Change the Culture

- We don't tolerate poor scholarship in research
  - Why not insist on excellence in education?
- Faculty professional development
  - Staying current in Science and Pedagogy/Practice
- Value Scholarship of Teaching and Learning
  - Creation of validated instructional activities is a major scholarly contribution.
- Awards, Rewards, Recognition
  - It's "Us" that set standards, serve on P/T committees