Department of Earth Sciences, Montana State University: Assessment Plan 2017

Department Vision and Goals

The Department of Earth Sciences engages scholarship about the complex Earth system: the interactions among the solid Earth, hydrosphere, atmosphere, cryosphere, climate, biosphere, and humanity. The department is committed to excellence in discovery of new knowledge about Earth, enabling learning by all students about Earth processes and the impacts on and by humanity, and engagement of faculty, students, and the community to address the challenges of stewardship of the planet.

Role of the Department of Earth Sciences

The Department of Earth Sciences makes essential contributions to the academic and land grant missions of Montana State University. The role of the Department of Earth Sciences is to offer courses, conduct research, and provide services which integrate geographic and geologic principles to better understand the history and dynamics of the Earth system, and the relationships between Earth and it's inhabitants. Scholarship in the Department of Earth Sciences is focused on Earth system science, which encompasses the physical and human dimensions of the planet including the atmosphere, biosphere, lithosphere, and hydrosphere, as well as societal, cultural, historical, and economic perspectives. Integration of learning, discovery, and engagement are central to the mission of the Department of Earth Sciences, which is to prepare students to succeed in the workforce and/or in continuing education so that they can address the grand challenges facing humanity and its stewardship of Earth.

The Department offers BS, MS and PhD degrees in Earth Sciences with program options in:

- Geography
- Geology
- GIS/Planning
- Hydrology
- Paleontology and
- Snow Science

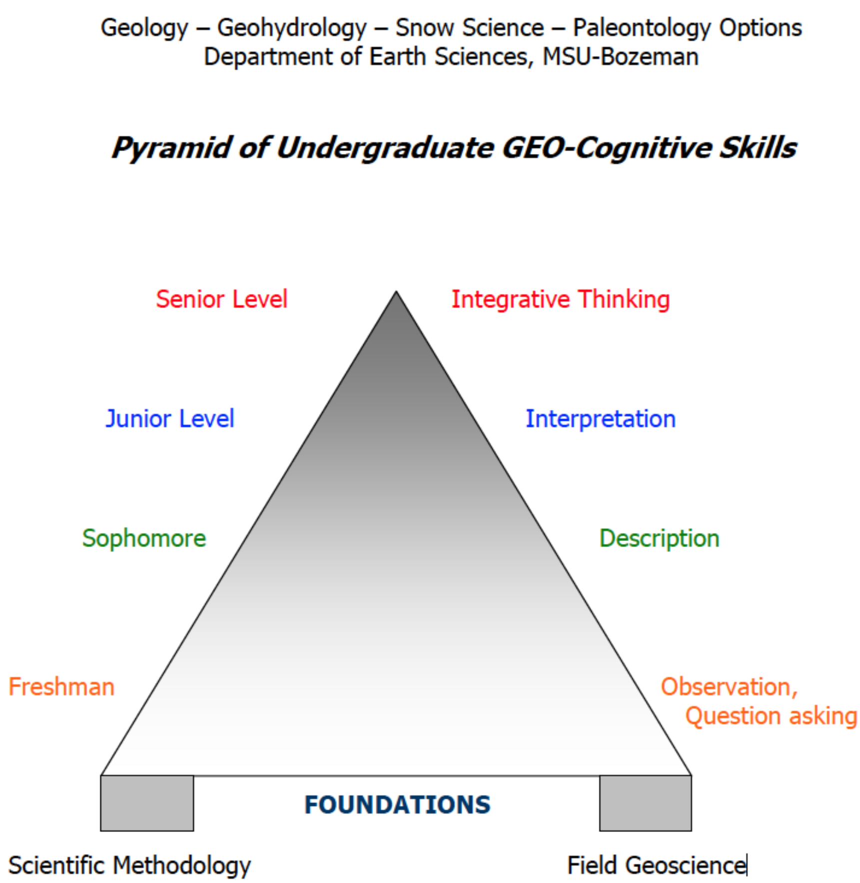
We recognize that learning, discovery, engagement, integration and stewardship are closely interrelated, and all contribute to the professional development of students in the Department of Earth Sciences.

Department of Earth Sciences Assessment Plan

Assessment is collecting data with a purpose. This assessment plan is designed to provide: a) faculty with an opportunity to reflect on course goals, methods and expected student learning outcomes; b) provide formative feedback to improve teaching and learning in Earth Sciences courses; and c) for accountability, to demonstrate that the departmental and institutional vision and mission are being addressed and that the curriculum is consistent with contemporary professional standards.

Learning Outcomes

In 2012 the Department of Earth Sciences undertook a self-study of the undergraduate curriculum in the physical science program options (Geology, Hydrology, Paleontology, Snow Science). A "reverse design" approach was used (Wiggins and McTighe, 2005) to identify the profile of a model student who will earn a degree in the department, defining what students should know and be able to do as they prepare for graduate school or the workforce. The revised curriculum was developed to: a) better align with advances in Earth science that use an Earth system approach; b) address expectations for a changing workforce; c) identify essential content areas and skill sets, and to develop learning sequences that will lead to students' mastery of concepts and skills; d) apply the tenets of Bloom's taxonomy of cognitive skills to help students develop higher-order thinking skills (see Figure 1 below); and e) to more effectively use departmental human and material resources to support student learning. With the successful hiring of three new faculty in geography (fall 2013), we are currently undertaking the same level of curriculum review for the Geography and GIS/Planning Degree options. The curricular structure, showing the cognitive skills and learning sequences for each of our four major content domains is illustrated in Figure 2. In the four-year degree programs, students experience initial exposure, familiarization, competence and mastery of essential concepts and skills.



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		

The realignment of courses offered by the Department of Earth Sciences included addition, deletion, and changing the focus and level of offering of our courses. These revisions represent a major effort on the part of the faculty to a) formulate programmatic student learning outcomes; and b) develop an assessment plan that evaluates our success in meeting learning objectives. A matrix of individual courses and the array of expected student learning outcomes defined for the Department of Earth Sciences are attached. Specific areas to be assessed include:

1. <u>Discipline-Specific Knowledge</u>: Graduates are expected to have in-depth knowledge the following fundamental concepts in the Earth Sciences: the dynamics of the Earth system, including interactions among the solid Earth,

Earth's surface, hydrosphere, biosphere, and with humanity. Students in the physical science degree options are expected to gain mastery of the concepts of geologic time, evolution life and history of the Earth system; the composition and architecture of Earth; and processes and phenomena observed on the surface of Earth (landscapes, weather and climate, biosphere). Students in the Geography degree option will gain mastery of the social, economic, cultural, and historical dimensions of humanity and their interaction with the Earth system.

2. Discipline-Specific Skills: All students in the Department of Earth Sciences will develop temporal (geologic and geographic history) and spatial reasoning skills (utilizing Geographic Information Science, and including other forms of 3- and 4-dimensional data representations). Students in the physical sciences will master skills required for professional development (e.g. field methods, computer modeling, experimental and analytical methods), and students in the social sciences will master the quantitative and qualitative methods typically used by professional geographers.

3. Earth Science "Habits of Mind": Students are expected to formulate questions; apply concepts, content knowledge, skills and tools; produce, critically evaluate, and appropriately represent data; interpret evidence and report results. Earth Science students must be able to draw inferences from observations or data that are incomplete, ambiguous and uncertain.

4. Professional Skills: a) Communication skills: Earth Science students are expected to present the results of their work in written, oral, and graphical formats; b) Quantitative skills: students are expected to apply mathematical formulations to represent physical and human dynamic systems; c) Interpersonal skills: students are expected to work cooperatively and collaboratively to achieve common goals. d) Information Skills: students are expected to find information and data from multiple sources, to critically evaluate the quality of that data, and to understand these data in the theoretical, historical, and philosophical contexts of the discipline.

Types of Student Data (Indicators) Collected:

1. Discipline-Specific Knowledge: Learning assessment in courses takes place through a) problem sets b) lab exercises c) extended class projects d) written assignments and e) quizzes and examinations. Key concepts and competencies in the many sub-disciplines in the Earth Sciences are well-established and all Earth Science courses are delivered according to disciplinary norms. It is the responsibility of individual instructors to assess student mastery of concepts and content knowledge in the context of their classes.

2. Discipline-Specific Skills: Technical skills include observation, measurement, description, use of instruments and tools, computer modeling, experimentation, field methods, and collection of quantitative and qualitative data. Mastery of

these technical skills is closely integrated with content knowledge, and is assessed by instructors through successful applications to problem sets, written and oral exams, case studies, and class projects.

3. Earth Science "Habits of Mind": The Earth system is open, heterogeneous, dynamic and complex, and requires modes of thinking that allow for uncertainty, an incomplete record, and evidence that is often ambiguous. Hypothesis testing in the Earth sciences relies on compiling multiple lines of evidence through observations and modeling. Earth system thinking involves working with deep time, understanding the Earth as a complex system, spatial reasoning, and direct observations of the Earth and humanity in the field. Problem sets, case-based studies, and extended projects are used to demonstrate application of Earth Science habits of mind. Assessment of the quality of student work is the responsibility of the course instructors; scoring rubrics are typically employed, and the *process* of solving the problem is often assessed in addition to the *products* that were created.

4. Professional Skills: a) Communication skills: students have opportunities to produce written reports, oral presentations, poster sessions, webpages and participate in class discussions. Assessment of these activities is the responsibility of course instructors (although peer assessments are sometimes used as well), and scoring rubrics are used for grade assignments. b) Quantitative skills: assessments of quantitative skills are based on successful completion of problem sets, lab exercises, and course projects, and are assessed by course instructors; c) Interpersonal skills: students are expected to contribute equitably to group project work; assessments are done via personal and group reflection on the contributions of group members, as well as the instructors' assessment of the overall quality of project outcomes. d) Information skills: class projects require articulation of a central question, discovery, aggregation, critical evaluation, and interpretation of data or other evidence in the context of the historical, philosophical and theoretical traditions of the discipline.

5. Tracking Student Success:

a) In-Class Formative Assessment: In addition to formal evaluations of student performance for the purposes of grading, the use of a variety of formative assessments is encouraged in individual classes to identify students at risk at an early stage in a given course, and to make modifications to a course if barriers to learning are discovered. These include short, in-class activities such as think-pair-share, muddiest point, minute paper, gallery walk, concept sketches, and i-clicker based assessments in large lecture classes. The results of these formative assessments are not collected as they are meant to improve student learning and faculty teaching. However, formative assessments are an important part of this assessment plan.

b) Capstone Experiences: Two courses are recognized in the Dept. of Earth Sciences as “capstone” courses: Field Geology (GEO 429) and Geographic Thought (GPHY 425). Both courses require analytical and synthetic reasoning, and integrate the aggregate knowledge and skills that students have acquired throughout the curriculum. A diverse set of projects and problems are used in these courses that apply the sum of concept and skill mastery. Course instructors are responsible for evaluating the quality of student work, scored against established rubrics. In addition, students in the Dept. of Earth Sciences are encouraged to participate in independent study, senior thesis, or internship projects. The products of these scholarly activities are evaluated by faculty advisors and measured against the standards of the profession.

c) Student Advising: Student advising is an important component of the assessment plan on the programmatic level. Students meet each term with faculty advisors, dates of these meetings are recorded, and progress towards the degree for each student is recorded each term on a tracking sheet to ensure that students take courses in sequence and help plan their academic course of study. Prerequisites are enforced, and students are advised about potential conflicts and barriers to progress towards their degree. Regular contact with students through formal and informal advising (including department sponsored peer-advising) is an important tool for assessment of students’ progress towards a degree.

d) Exit Surveys: The American Geosciences Institute (www.agiweb.org) has recently piloted the development of a national end-of-program survey for graduating undergraduate students. The Dept. of Earth Sciences will be one of the inaugural test institutions. Student responses will be aggregated by institution, and feedback will be provided regarding student satisfaction with the program and student perceptions of their preparedness for the workforce.

6. Assessment Instruments.

Given the breadth of disciplinary interests, methods, and approaches to instruction in the Department of Earth Sciences, there is not a single set of assessment instruments that can be applied. The Department of Earth Sciences maintains rigorous standards of performance that document students’ mastery of content knowledge, concepts, and skills. Increasingly, problem-solving or case-based instruction is used in Earth Sciences classes, and consequently authentic, outcomes-based assessments are based on established professional standards. Scoring rubrics are widely used to assess quality of writing, presentations, and quality of product (e.g. stratigraphic columns, geologic maps and cross sections). A wide variety of other assessment instruments are typically used, informed by the NSF-sponsored website: Understanding What our Geoscience Students are Learning: Observing and Assessing (http://serc.carleton.edu/NAGTWorkshops/assess/index.htm).

7. Thresholds:
   Students earning degrees in the Department of Earth Sciences must have a grade of C (2.0) or better; student performance is measured by expected competencies for continued professional development in graduate school or in the workforce.

Annual Assessment Process:

Assessments of student performance and student learning outcomes are done each term to assign student grades. However, courses identified as having primary responsibility for addressing fundamental concepts or skills will be selected in a four-year rotation to report on the learning goals, assessment instruments and metrics, and aggregated student performance. The procedures for acquiring these assessment data are outlined below:

1. Data collected from identified courses. Instructors provide data to department office.

2. Collected data are tabulated by members of the Undergraduate Curriculum Committee. Results are reported to the entire faculty of the department.

3. Areas where acceptable performance threshold has not been met are identified. A plan for remediation is developed to address any identified deficiencies or barriers. Actions may include:

- Gather additional data next year to verify or refute the results.
- Peer review of course materials, presentation, and/or assessments.
- Review course goals, methods, and assessments to make sure they are aligned to best promote student learning.
- Change something in the course to try to fix the problem.

Select alternative assessment instruments to better measure expected outcomes.

4. If an acceptable performance threshold has been met, the faculty may still respond to assessment results. Assessment data should be used to continually improve teaching and learning. Revision of courses, based on evidence from assessments, is a valued part of the scholarship of teaching and learning

5. A summary of the year's assessment activities and faculty decisions is reported to the Provost's Office in the Department's Annual Assessment Activities report, prepared by the Undergraduate Curriculum Committee, working with the Department Head.

6. The schedule of courses selected to demonstrate programmatic student learning outcomes is presented below. The rationale is a) one of the large introductory courses will report each year to address student learning outcomes for the general student population who are taking Core 2.0 courses, and b) at least one upper division course will report in each of the major thematic areas for students majoring

in the Department of Earth Sciences. Although these courses are represented by disciplinary themes, in aggregate they also represent the full range of content knowledge, discipline skills, habits of mind, and professional skills encompassed by the Department of Earth Sciences curriculum.

Assessment Schedule:				
	Year 1 (2018)	**Year 2 (2019)**	**Year 3 (2020)**	**Year 4 (2021)**
Geologic Time and Evolution	Historical Geology	Comparative Anatomy	Sed/Strat	Vertebrate Paleo
Composition Architecture of Earth	Mineralogy	Structural Geology	Igneous Petrology	Tectonics
	Earth System Science			
Surface of the Earth	Weather and Climate	Geomorphology	Glaciology	Snow Dynamics
		Yellowstone Res.		Environmental Geol
Human Dimensions	Geographic Thought	Economic Geog	Water and Society	Advanced Regional
		Human Geography	World Regional Geography	
GIS Skills	Intro GIS	Advanced GIS	Applied GIS	