

Preparing Students for Careers in the Atmospheric Sciences

Deborah Bathke

The University of Nebraska's Department of Earth and Atmospheric Sciences offers a program leading to the Bachelor of Science degree in Meteorology-Climatology. By combining hands-on education in atmospheric science with training in mathematics, computer science, and physics, our degree program is designed to prepare students for professional career paths in federal, state, and private agencies which are involved in the many applied fields of the atmospheric sciences. Our degree program also serves as a springboard for students wishing to pursue graduate-level studies in the atmospheric sciences and a variety of other disciplines.

Our program is designed to be rigorous, but flexible. It fulfills the recommended curriculum of the American Meteorological Society (AMS) and the University Corporation for Atmospheric Research (UCAR) and meets or exceeds the minimum hiring requirements for employment as a meteorologist with the Federal government (e.g., National Weather Service, Environmental Protection Agency, National Aeronautics and Space Administration etc.). However, students are given the flexibility to pursue their own interests within the broad field of atmospheric sciences through the selection of electives (over 20 courses offered) and a capstone course (2 offered).

Whenever possible, our courses provide field-based and research experience that helps our students "think like scientists". These experiences teach students to not only collect and analyze data, but also communicate their results and conclusions. In addition, many of our courses integrate computerized weather data visualization and analysis tools into lab and homework exercises, which allow graduates of our program to enter the market with a highly valued skill set.

In addition to their regular course work, our students are presented with opportunities for professional internships, increasing their skills and competitiveness for job placement. Recently, students have participated in competitive and/or professional internships at NASA Jet Propulsion Laboratory, NASA Goddard Space Flight Center, Scripps Institute of Oceanography, the National Weather Service, climate service centers, and local television stations. In conjunction with our Alumni Advisory Board, our department sponsors an annual professional development workshop which connects students with atmospheric science alumni to explore career paths, receive career advice, and network with other professionals.

Our program only recently began tracking employment information. Upon completion of our program, approximately 1/3 of our students attend graduate school in Atmospheric Science or related fields. The majority of our remaining students have successfully obtained employment in the following areas:

- Employment with federal agencies such as the National Oceanic and Atmospheric Administration, National Weather Service, National Aeronautics and Space Administration, Environmental Protection Agency, the National Park Service, and the military
- Private weather consulting
- Broadcast meteorology
- Agriculture
- Education
- Energy
- Business (e.g., insurance, commodities)
- Other professional occupations requiring a strong scientific base

Preparing the Next Generation Atmospheric Scientists from Department of Meteorology and Climate Science, San Jose State University

By Sen Chiao (sen.chiao@sjsu.edu)

A. Preparing students for the workforce:

The department's undergraduate curriculum meets and exceeds the federal requirements for employment as a Meteorologist as well as the minimum requirements of curricular composition, faculty size, and facilities recommended by the American Meteorological Society (AMS). Nevertheless, in order to further prepare our students' ability for the workforce, we will:

BS Program

1. To broaden the metrics of success defined by the department (e.g., program description) to stretch beyond the core goals to progress graduates to advanced degrees in the profession or employment as a federal meteorologist.
2. To streamline the core curriculum so that it can be taken in two years. Work on this has begun: we are seeking to put our core sophomore-level classes (METR 60 & 61) online so that they can be taken in community college.
3. To consider converting some of the current required courses (e.g., senior thesis) into elective courses (e.g., internship/co-op)

MS Program

1. To define clearly that the graduate program's metric of success is completion of a M.S. degree (i.e., thesis, conference presentations, journal publications).
2. To consider allowing graduate students without B.S. degrees in meteorology to take the courses required to meet the federal requirements. This can be done via MS curriculum changes (with the proviso that a certain number of courses for the MS must be at the 200-level).
3. To develop certificate programs (Professional Masters Degree Programs) that may include large online enrollments.

B. Alumni are employed

http://www.sjsu.edu/meteorology/people/alumni/alumni_by_year/index.html

C. The knowledge and skills that have been most important in supporting success.

For college level students, my primary strategy is for them to obtain a well-rounded education that will prepare them to apply their knowledge upon graduation for future employment. As an instructor, the most important job is to spur interest and motivation in the subject matter. Emphasis must be made on the comprehension of concepts and application to real life examples. Hands-on experience for students is essential. Through some specialized field projects and co-op, juniors and seniors can apply their acquired knowledge and develop new skills to solve real-world problems.

Graduate level students are expected to perform at a higher level, and to work independently and creatively. A significant portion of graduate education is associated with research. Graduate students need to increase their level of knowledge above an undergraduate understanding. This is an important component and allows for creative and independent problem solving. Research skills should be prepared include computational skills, the preparation of a final report (i.e., thesis) and publication in a peer-reviewed journal. Technical writing and presentation should be incorporated into class assignments whenever possible. Acquiring a variety of tools is an important part of any research endeavor and enables students to solve problems independently. Guidance on course work is important in order for students to be prepared for the desired topic. The ultimate goal of the graduate school experience is to conduct original, independent and innovated work. Before a grad student can be granted with a M.S. degree, the requirements for the individual are to prepare a manuscript that can be submitted to a peer-reviewed journal, as well as conference presentations.

A growing major in Earth Sciences at UCSD

Geoffrey Cook

We have a relatively new (since 2007) undergraduate program in Earth Science at the University of California, San Diego (UCSD). The program is unique in that it is taught, administered, and run by Scripps Institution of Oceanography (SIO), which is a graduate-oriented entity within UCSD. As a program we are still dealing with the challenges associated with defining the direction and goals of the B.S. degree in Earth Science.

In part due to the newness of the program, we have a limited amount of data regarding the employment of our graduates. We are highly cognizant that we need to do a better job following up with our students after they complete their degrees. We conduct exit interviews, but these are currently limited in scope. We have identified several career/postgraduate tracks our majors tend to follow including, but not limited to: 1) environmental consulting and hydrogeology; 2) post-graduate study, some at other institutions, but recently a number of graduating seniors have taken advantage of our contiguous B.S./M.S. program in Earth Science in which they are “fast-tracked” through the admissions process and work at SIO on their research; 3) teaching, both in K-12 settings and also at community colleges; 4) economic geology (mainly mineral exploration but a handful of students have found employment with petroleum companies).

Prior to 2007, our major existed mainly as a joint “geology specialization” within the Chemistry and Physics departments. As such, the major was designed to be highly quantitative in nature, and followed a decidedly a non-traditional geology curriculum. Additionally, the professional goals for graduates were much different—post-graduate study was the preferred career track for majors, and given the small numbers of majors, students were essentially being “groomed” for graduate school both at SIO and elsewhere. With the inception of the Earth Science major, priorities changed for the program. The curriculum shifted towards a slightly more traditional one; although it is still highly quantitatively rigorous and encourages interdisciplinary coursework across a variety of Earth-related disciplines. Moreover, with increasing numbers of majors, it was recognized that students would have a broader range of post-graduation career interests.

My motivation for attending this workshop stems from the understanding that as a program we have a responsibility to our students to encourage and provide them with the best training, mentorship and advisement with respect to their careers. I hope to learn as much as possible in order to best modify our approach to career counseling and preparation. Although our major is relatively young and small, we offer unique opportunities due to our location and the SIO affiliation. Our hope is to build the program always with an eye towards what we can do to best serve our students and graduates. As a developing program, we have the flexibility and opportunity to mold our major to best suit our students; the timing of this workshop is ideal.

Geosciences program at Midwestern State University

Rebecca L. Dodge, Midwestern State University

Midwestern State University (MSU) is a small (~6,000 students) largely undergraduate institution (~90%) in north Texas; we are Texas' only state-funded liberal arts institution and we are a member of the national Council of Public Liberal Arts Colleges (COPLAC). MSU students represent 41 states (including Texas) and 47 foreign countries. Our geosciences program comprises four faculty members, and graduates approximately 10 students per year. We offer two tracks within the Geosciences degree: Geosciences, our traditional major, and Environmental Sciences, which is an interdisciplinary program designed to prepare students for a range of environmental careers.

How Our Geosciences Track Prepares Students for the Workforce

MSU's curriculum focuses on traditional classes including Mineralogy, Petrology, Paleontology, Structural Geology, Sedimentology/Stratigraphy as well as Geomorphology, Remote Sensing, Oceanography. Classes at every level emphasize laboratory and field observations and data collection and analysis, using appropriate tools. We have our own dedicated computer laboratory with software tools designed to support processing and analysis in multiple disciplines, including image process, hydrology, structural interpretation, and petroleum applications.

Field trips a particularly important component of upper-division classes. MSU has a dedicated field station in the Big Bend region of Texas, which is being developed, through external funding, as a field-based educational resource and research site. Undergraduate research is supported through grants, institutional funding, and special topics courses. Research, writing and presentation skill are targeted in multiple classes, beginning at the freshman level and including a capstone research class with two required presentations. Group projects are also an important aspect of learning in classes at all levels.

Our students (and faculty) share a strong sense of belonging to a geologic community, maintained through broad-based membership in the Geosciences club, Sigma Gamma Epsilon Chapter, AAPG Student Chapter, and membership in the North Texas Geological Society (NTGS). NTGS supports student attendance at short course, conferences, and monthly luncheon meetings. NTGS, and the entire local petroleum geology community, supports our program through donations of time, materials, and funding.

MSU also has a strong emphasis on working experiences; multiple internship opportunities are supported locally in petroleum geology and geohydrology. Most of these working opportunities are near campus and students often work year-round for local companies. Many of our

undergraduates are also employed by the Department as laboratory teaching assistants for introductory courses.

Our geosciences degree produces articulate, focused students who are well prepared for applied careers or for research at the graduate level. They are three-dimensional thinkers who can analyze, integrate and visualize diverse data sets. They know how to present their work in writing or through poster or oral routes. Most importantly, they know how to participate with others in geoscience organizations; we conscientiously develop their networking skills and their abilities to plan and organize events.

Areas in Which Our Alumni Are Employed

Many of our undergraduates go to work in the petroleum industry, in exploration, development, or production. Some go to work for state or federal government agencies (mostly in geohydrology), and a significant portion go on to graduate school.

Knowledge And Skills That Have Been Most Important In Supporting Success

1. Data collection and analysis skills
2. Field experiences
3. Research projects, including group projects
4. Presentation skills
5. Analytical skills using software

85 years of Geosciences at Pasadena City College

The Geoscience program at Pasadena City College began in 1927 primarily response to a need for a greater number of trained geologists in the local workforce - namely the petroleum industry. Since that time the program has obviously changed in many important ways, yet there are still some core principles which the program continues today. These core ideals include integrated lecture and laboratories, hands-on rock and mineral identification and an emphasis on field experiences in the geologically rich southern California region. In the last decade, what began strictly as a Geology Department has evolved into a much broader Geosciences Department that includes a new Environmental Sciences discipline and Geography (after a friendly acquisition from the Business Department).

Currently the program sees about 600 students annually in its foundational Physical Geology course, about 600 students in introductory Geography courses and roughly 400 students in Environmental Science. The primary goal of these courses is for students to meet their general education requirements in Physical Sciences, however approximately 30 students per year continue as "Geology" majors into upper level classes such as Historical Geology and Mineralogy. Currently the college does not track Geography and Environmental Science "Majors" but many go on to complete an Associates degree in Natural Sciences. In 2012 the college awarded 216 of these degrees.

Because we are a 2-year transfer institution, the primary purpose of the program is to prepare Geology students to transfer, with Junior standing, into Geology Programs at 4-year universities. The majority of our students transfer to the University of California (UC) or State University (CSU) systems however a significant number also transfer to private 4-year institutions. The top 10 transfer schools for the college are (in order):

1. CSU Los Angeles
2. CSU Northridge
3. CSU Pomona
4. UCLA
5. CSU Long Beach
6. UC Irvine
7. USC
8. UC San Diego
9. UC Berkeley
10. UC Riverside

In California, curriculum at 2-year colleges is restricted to freshman and sophomore-level courses offered by 4-year institutions. For example, in order to add a course to our curriculum we must demonstrate that an equivalent course exists at a CSU or UC campus which our students typically transfer to (such as those listed above). This leads to some restrictions to what we can and can't do with our program.

For example, because most 4-year schools offer introductory field methods in upper division, we were unable (until recently) to offer a course by that name. As a work-around, we have traditionally embedded Introductory field Geology into our Historical Geology courses. Anecdotally our alumni have told us that these experiences have put them above and beyond their indigenous 4-year colleagues and other transfers at both the UC's and CSU's. UCLA has recently moved Introduction to Field into lower division and so we can now "come out of the closet" and offer Introduction to Fieldwork as an official class at our institution. We like to believe that the success of our transfer students in the program at UCLA helped lead them to the decision to introduce rocks as they appear in the field to future geologists early in their academic career.

Because the vast majority of our geology majors attend other institutions before entering the workforce, our understanding of where they end up working is sparse. Alumni who have kept in touch and are currently working in the geosciences are employed in the following areas:

- Academia (Stanford, University of Florida, Perdue as examples...)
- Paleontology & Archeology Consulting (e.g. Paleosolutions)
- Environmental & Geotechnical Engineering Firms (Engeo, Converse)
- Petroleum Industry

As a department we feel the most important skills our students take forward from us are scientific critical thinking skills, hands-on experience with earth materials, ability and experience of working as a team (primarily through field work), and an understanding of rocks and earth processes in the field.

Developing a Curriculum that Allows Students to Reach Career Objectives

Lynn Dudley, Florida State University - not attending the workshop

The environmental science bachelor's degree program at Florida State University housed in the Department of Earth, Ocean, and Atmospheric Science (EOAS) contains a B.S. degree titled "Environmental Science" and a B.A. degree titled "Environmental Science and Policy." The Environmental Science degree is designed to prepare students for employment technical positions in state and Federal government, consulting companies, NGOs, and prepare students to continue studies in graduate school. The Environmental Science and Policy is designed to give students expertise that would lead to law school and eventually to environmental law, and positions requiring expertise in environmental policy. The Environmental Science degree has implicit flexibility to tailor a degree that matching a student's career goals by emphasizing geology, meteorology, oceanography, or a more integrated curriculum. The degree also has explicit tracks for emphasis in environmental engineering, and peroration for graduate school.

Because the program has only been in place for three years, the number of graduates is small and employment feedback limited. Thus far, students are reporting that they are finding employment in state government and private consulting companies. The curriculum for the policy degree is less rigorous in preparatory courses in math and science, but gives students the option of taking philosophy, political science, and social science courses. There is a capstone requirement for each degree, but the capstone courses differ. The science degree requires a field based capstone in which students gain hands-on experience in collecting and analyzing water samples, collecting soil samples, determining surface and subsurface hydrologic properties, and land survey. The objective is to give students fundamental exposure to determining environmental properties related to assessing a contaminated site. Students are required to use GIS to map the properties they measured and provide a site analysis. The policy capstone is led by an environmental lawyer. The course introduces students to the legal aspects of resource management. The course reviews environmental law and landmark cases. The mechanisms for policy creation related to resource management are explored. Students are required to provide a review and analysis of a topic of their choice.

SUNY Oneonta: Workforce Preparation for Majors in Geology, Water Resources, Earth Science and Meteorology

As a multidisciplinary Department of Earth and Atmospheric Sciences, we provide four majors for our students: Geology, Water Resources (hydrogeology), Earth Science and Meteorology. Each of these majors prepares students for distinct career paths. In addition to coursework in the majors, many of our students engage in undergraduate research, which commonly results in presentations at conferences and papers in journals. This is a notable strength of our program.

Geology: Our major in geology is rigorous and rather traditional, though it also includes broad use of technology. The curriculum emphasizes instruction in the field, along with practice in defining geologic problems, gathering data to solve those problems and presentation of findings. Mapping skills and quantitative techniques are focal points within the major. We also require at least one course in hydrogeology (See <http://www.oneonta.edu/academics/earths/geology.html> for a general description of the program and link to required courses.).

The knowledge and skills developed in the geology curriculum have proven to be useful for our graduates in both graduate study and the workforce. Graduates have told us specifically about the advantages they have as a result of their preparation in field techniques, GIS and quantitative methods. Currently, about 40% of our recent graduates are seeking master's degrees at a variety of colleges and universities. The majority of our graduates find employment in environmental consulting. The strong foundation in geology that our curriculum provides, along with coursework in hydrogeology, has served our graduates well; they compete successfully for positions in environmental consulting. A few graduates have sought positions in the petroleum and mining industries. A small number of graduates have pursued law degrees and careers in environmental law.

Water Resources: As one of the first undergraduate hydrogeology programs in the nation (1980), our students have competed successfully with other job candidates that have masters' degrees. Our curriculum is rigorous and requires courses in geochemistry, groundwater modeling, watershed management and applied hydrogeology in addition to foundational courses in geology (See <http://www.oneonta.edu/academics/earths/waterresources.html> for a general description of the program and a link to the required courses.). Field-based projects and an emphasis on quantitative skills are strengths of the program.

Most graduates in Water Resources find employment in environmental consulting. A few have found positions in state regulatory agencies or federal agencies. Approximately 20% of our recent graduates have continued their education through graduate study. Similar to graduates of the geology major, a small number of water resource graduates have pursued law degrees and careers in environmental law.

Because the program in water resources has existed for over three decades, many of our alumni are now in managerial positions. These alumni have provided valuable insights on skills required in the workforce. Faculty regularly solicit the opinions of alumni on curricular matters and alumni commonly return to campus to share their expertise and advice with current students.

Earth Science: Most students that choose our major in Earth Science intend to become high school or middle school teachers of Earth Science. The major is commonly taken as a dual major with Adolescence Education. The curriculum has been designed to meet the content knowledge specified in the New York State Board of Regents Core Curriculum in the Physical Setting: Earth Science. Therefore, the major includes coursework in meteorology, oceanography and astronomy in addition to significant coursework in geology. As such, our graduates are well prepared to execute the Regents curriculum.

A particular strength of the major is a course dedicated to development of pedagogical content knowledge. This course bridges Earth Science content with inquiry-based pedagogy. The course is taught by geoscience faculty and has been praised by graduates of the program as the single most useful course in their undergraduate preparation as teachers. Details of the course may be found at <http://serc.carleton.edu/teacherprep/courses/SUNYO-LabInv.html>. Offshoots of this course have included undergraduate research projects (e.g., see Downey and Ebert 2013) and pre-service teacher candidates (students) conducting professional development workshops for in-service teachers.

Prior to the recession, it was common for our graduates to receive multiple job offers for teaching positions. With the recession, many schools in New York were shedding teaching positions, closing schools and consolidating. Despite this, all recent graduates from our program have secured teaching positions. We view this as a testament to the quality of our program, which enjoys a regional reputation for excellence.

Meteorology: Our major in meteorology follows curricular guidelines from the American Meteorological Society. The curriculum stresses the AMS subject categories of physical, dynamic, synoptic and mesoscale meteorology along with climate dynamics and a capstone experience (See <http://www.oneonta.edu/academics/earths/meteorology.html> for a general description of the program along with a link to the required courses.). The field measurements component of the AMS guidelines is underdeveloped owing to staffing limitations. Despite this, our majors in meteorology excel in their studies and most participate in significant research projects. Many of our students have presented at national and regional conferences and three current students are co-authors with one of our meteorologists on a paper that is in press in a major meteorological journal.

An additional strength of the program is the inclusion of experiences with Linux-based programming for majors and extensive use of Unidata-based data, models and visualizations that are utilized throughout the curriculum from the introductory course through the senior capstone.

The majority of our graduates in meteorology continue their education through graduate school. Some graduates find employment in entry-level positions with governmental and private forecasting agencies, despite the relative scarcity of such positions.

References Cited

Downey, A.C., and Ebert, J.R., 2013, Providing Authentic Research Experiences in Geoscience and Geoscience Education for Pre-Service Teachers: NAGT In the Trenches, v. 3, n. 1, p. 1-3.

The Geosciences and a Career in Business

Gerald Fine, Boston University

I write not as a member of a geoscience department, but as a geologist who leveraged his training into a long and varied career.

I graduated from Amherst College in 1980 with a B.A. in geology. I then received my Ph.D. from the California Institute of Technology in 1986, again in geology. Since that time, I have not practiced geology nor thought of myself as a geologist. Indeed, I scarcely remember any geology.

Despite this, I firmly believe that my training in the geosciences was the key enabler of my career and that I would not have been successful without that training.

A brief synopsis of my career arc follows: After leaving California, I spent eight years working in R&D at Corning Incorporated, followed by another ten years in Corning in various general management positions, primarily working in the telecommunications and flat panel display industries. I left Corning as an Executive Vice President of the company. I then spent three years as a Professor in the Department of Manufacturing Engineering at Boston University, followed by three years as the President and CEO of Schott North America, a large manufacturing company, where I was responsible for businesses in fields such as pharmaceutical packaging, military armor, and solar power. I am now back at Boston University as a Professor in the Department of Mechanical Engineering. I have also served on the board of numerous start-up companies in industries as diverse as water purification and data networking.

A prudent reader might be inclined to doubt my assertion that geology had anything to do with this trajectory. Without question, the particularly unique, trial-by-fire character of the education provided me by Amherst and Caltech would have provided skills I needed for the workplace regardless of major or field of study: the ability to function under pressure, an aptitude for assimilating massive amounts of information quickly, even a knack for extemporaneous presentation despite a lack (or even reckless disregard) of subject matter knowledge. But I assert the following:

Mineralogy and petrology are excellent preparation for a career in high tech. I was mostly interested in igneous and metamorphic petrology in school and, in essence, have spent my career capitalizing on the materials science I learned.

At the Corning R&D laboratories, at least in the 1980s, we had a very specific philosophy: we only hired chemists, physicists and geologists, and then “taught them the trade.” This was because geologists were the only people we could find with sophisticated training in silicate chemistry. Only a mineralogist would appreciate that most catalytic converters are essentially cordierite, or that Corning Ware is simply a form of spodumene or that the transparent armored windows used in military vehicles are actually eucryptite. Only an igneous petrologist would comprehend Soret diffusion in a glass furnace. One of the most prolific inventors at Corning and a man who greatly

influenced me, generated most of his ideas simply by reading the back pages of *The American Mineralogist*. After years of looking down a petrographic microscope, it took only a few minutes to realize that the physics of light moving through an optical fiber is no different than the physics of light moving through a thin section (albeit with considerably different length scales.)

The business world that most graduates now enter is highly technical; the technical knowledge that I acquired as a geologist was relevant in almost every business in which I subsequently became involved.

The specific oral and written communications skills required by geoscientists are universally required. In my view, the essence of leadership is simple: “when you are in a dark cave, everyone follows the person with the match.” The question, of course, is how leaders convey that they, in fact, “hold the match”. Obviously, this can only happen with exemplary communications skills. I learned more about oral communications preparing a fifteen-minute presentation for my first AGU meeting than from any other single event in my life. (Although, to be fair, after 30 years I still harbor a slight grudge against my thesis advisor for the living hell he created for a week prior to that talk.) My experiences in a college structural geology course were equally grueling and helpful. Further, the written communications required in business are very similar to the lab reports and scientific papers I wrote throughout my training. They placed an emphasis on problem statements, data, facts and conclusions, all delivered tersely and dispassionately. Arguably, these skills are taught by every scientific discipline; I learned them as a geologist.

The geosciences prepared me for a life of organizing, leading and participating on teams. I know that every science department in every college and university declares that they teach teamwork and I have no doubt that there are pockets of excellence. Short of military service, however, I postulate that some of best leadership training comes from coursework in the geosciences. Group mapping exercises, in particular, taught me that cooperating with others, despite time pressure, honest differences in interpretation of results, and occasional differences in ability, is essential to getting things done. Four days in field camp in Elk Basin, Wyoming, spent with people that I had met two days before, mapping an anticline in 100-degree temperatures and surrounded by rattlesnakes and dead cows, turned out to be a fairly apt metaphor for business.

The geosciences honed my observational skills. Most successful general managers in large businesses require finely tuned antennas. In my business career, I often needed to walk into troubled manufacturing plants and, in a day or less, assess the situation, then propose and implement remedial action. It is often difficult to separate symptoms and root cause in such a situation and the clues are often subtle: poor maintenance of a piece of equipment, the body language of a plant manager, the work patterns on the plant floor all may be signs of an underlying problem. Then again, they may not be signs of anything. In the aforementioned Elk Basin, I spent four or five hours one day, desperately looking for a fault that might explain the data. Finally, a kindly faculty member decided to ask me to look between my knees; I was sitting on the slickensides.

The ability to think in three dimensions, assemble visual clues before jumping to conclusions and then fit those visual clues into a cogent hypothesis is a skill I learned as a geologist, not as a businessman.

Geology is a hard science and taught me hard science skills required for success in the workplace. It also taught me softer skills, many of which are unique to the geosciences. In my view, conveying the essence of geology to the many non-geologists in the workplace is a fundamental challenge. The unique training afforded by an education in the geosciences is something that should be built upon, not lost.

A Non-Traditional Geoscience Degree for Non-Traditional Students: Applied Environmental Geosciences at Weber State University

Richard Ford

Weber State University (Ogden, UT) is an open-enrollment, dual-mission institution within the Utah System of Higher Education (USHE). As a dual-mission institution, Weber State serves as both a regional, master's-granting university and the community college of northern Utah. The open-enrollment policy presents many challenges, and rewards, for the various academic departments that are focused on their 4-year baccalaureate mission. The Department of Geosciences, one of seven departments in the College of Science, has been awarding Bachelor of Science degrees in Geology and Earth Science Teaching since the institution gained 4-year status in the mid-1960s.

For several decades, the majority of geoscience majors at Weber State have been non-traditional students – they are generally older than 24 years of age; many are married, with children; most are working at least 20 hours per week off campus; many are military veterans; many are first-generation college students; and virtually none of them came to university planning to major in the geosciences. Female students have comprised approximately 35-50% of the total geoscience majors during this time.

During the early 1990s the Geosciences faculty came to two important realizations about our students and our curriculum. First, we were losing majors to other departments, despite the student's interest in the geosciences, because our traditional BS degree in geology presented several insurmountable roadblocks to these non-traditional students – most notably the summer field camp requirement. Our non-traditional students, many of them spouses, parents, and breadwinners, simply could not work a 4- to 5-week summer course, away from their home and family, into their program of study. Second, the vast majority of our graduates did NOT aspire to attend graduate school shortly after graduation – instead they wanted to find an entry-level, applied-geoscience job along the Wasatch Front in northern Utah. They were not training themselves to become “geologists” in the strict sense. In response, we designed the BS in Applied Environmental Geoscience (AEG) to meet the needs of these students and this degree has been offered since 1996.

The important features of the AEG degree include:

1. The program of study emphasizes the applied aspects of the geosciences and our current faculty expertise and course offerings allow AEG majors to specialize in water resources/hydrogeology or GIS/remote sensing.
2. The degree does NOT require a summer field camp, and is therefore friendly/welcoming to non-traditional students.
3. The degree does NOT require calculus, and is therefore friendly/welcoming to students at an open-enrollment institution. The AEG program does require college algebra, trigonometry, and statistics.
4. Our department values and emphasizes geoscience “in the field”, during both afternoon “labs” and multi-day field trips. With a campus located along the Wasatch front, straddling the Wasatch

fault and the shoreline bench of Pleistocene Lake Bonneville, WSU is surrounded by an amazing outdoor geosciences laboratory.

5. The AEG degree includes a capstone course (Geoscience Field Methods) that requires students to work as a team for a simulated geotechnical company to prepare a geologic site assessment for a location near campus. The Field Methods class is taught during the fall semester and includes a 5-hour field session each week. This course is designed to develop many of the same skills taught as part of a tradition summer field camp.

At the end of Spring Semester 2013 the Department of Geosciences had 102 majors, distributed as follows:

• Geology:	46 (45%)
• Applied Environmental Geoscience:	40 (39%)
• Earth Science Teaching:	16 (16%)

We have averaged 8.8 total graduates per year for the past 6 years (2007-2013). The average number of AEG graduates has been 3 per year, or 34% of the total, over the same time period. Between 2007 and 2012, thirteen (13) students graduated with a BS in Applied Environmental Geoscience. Our current information indicates that 6 of these graduates (46%) are working as applied geoscientists, 4 (31%) are working in a non-geoscience position, and 3 (23%) are out of touch with the department. Those graduates employed as applied geoscientists have the following job titles: Environmental Scientist; Environmental Professional; GIS Analyst; Geologist; Environmental Protection Specialist; and Environmental Health Specialist. They are employed by the Department of Defense, U.S. Forest Service, a county health department, and private geotechnical companies. Prior to 2007, we have also had AEG graduates go on to law school and graduate school in the geosciences. Five students graduated from the AEG program this year (2012-2013) – 38% of our total graduates (13). One graduate has secured a position as a Reclamation Specialist, working for a private mining-services company. The others are actively looking for positions.

Although there is still a need to produce well-trained geologists for today's geoscience workforce, it is also clear that the geoscience workforce today is much broader than positions labeled geologist or geophysicist. Geoscience Departments can take advantage of that fact by offering students multiple avenues to entering the geoscience workforce. The Applied Environmental Geoscience program at Weber State University is an example of how an applied program, focused on preparing non-traditional students for entry-level STEM jobs, can co-exist alongside a traditional geology program.

Development of student skills and employment by graduates of the FHSU BS Geology program

The BS program in Geology has been offered by Fort Hays State University for over 40 years, almost entirely through on-campus instruction and organized field experiences. The program is divided into two parts: the core curriculum and the specialty areas. Within the core curriculum students obtain general knowledge and skills by mastering topics associated with introductory courses in calculus, chemistry and physics. This knowledge of cognate disciplines prepares the student to master the foundation knowledge in geology, including physical and historical geology, mineralogy, petrology and structural geology. Needed skills are obtained via laboratory experiences associated with physical and historical geology. After mastering the core curriculum, students complete a curriculum in one of the specialty areas of traditional, paleontology, environmental, technology, or petroleum geology. Completion of a focus in paleontology requires additional courses in biology, the environmental focus requires hydrology, the technology focus requires courses in computer applications and Geographic Information Systems, and the petroleum geology focus requires courses in petroleum geology and business.

All of our graduates with BS degrees in Geology typically find their employment in Kansas (especially in Western Kansas). Graduates of this program hold positions in Kansas at the Kansas Department of Health, the Kansas Corporation Commission, the Kansas Water Office, the Kansas Department of Transportation, and the Kansas Department of Emergency Management among others. Many graduates work for independent oil and gas companies in Kansas, and others are employed by or have founded environmental consulting companies in the state. Graduates with a paleontology focus often work in museums and/or pursue graduate study and are employed in academic institutions where they teach and conduct research. The Fort Hays State University Department of Geosciences has for the past 5 years (FY2008-FY2012) placed 36 out of 37 (97.3%) of its undergraduate students in jobs or advanced graduate programs; and 12 of 12 (100%) of its graduate MS students were placed in jobs or PhD programs. Placement data from FHSU Career Services for the BS Geology program are included below.

Academic Year	2008	2009	2010	2011	2012
Number of Graduates	3	6	1	5	11
Employed in Major Field	1	1	1	2	4
Employed Outside Major Field	0	4	0	0	2
Continuing Education	2	0	0	2	2
Not Seeking Employment	0	0	0	0	0
Still Seeking Employment	0	1	0	1	3
No Info	0	0	0	0	0
Success Rate	100%	83%	100%	80%	73%

Workforce Preparation by a STEM educational component of the USGS National Cooperative Geologic Mapping Program

Douglas A. Howard, USGS NCGMP and Edmund A. Walsh School of Foreign Service, Science Technology and International Affairs Program, Georgetown University

The three primary goals of the National Cooperative Geologic Mapping Program (NCGMP, Public Law 111-11) are to (1) Produce high-quality multi-purpose digital geologic maps and accompanying information to solve diverse land-use problems in high-priority areas and develop three-dimensional geologic frameworks that extend into the subsurface for use in a variety of predictive models; (2) Make geologic map information more accessible to the public by providing geologic maps, reports, and databases in a variety of digital formats; and (3) Ensure that the NCGMP will have the capabilities/work force to meet the future needs of the Nation. The third goal enabled the formation of the EdMap program as the educational component of NCGMP with its primary goal to train the next generation of geologic mappers in the geoscience workforce. The program is open to US academic institutions and to both upper-division undergraduate and graduate students. To date the EdMap program has funded 1048 students at 152 Universities.

The EdMap program funds students through a competitive application process where academic faculty submits proposals for research projects that include geologic mapping as the primary component. The program is cost shared with a required 1:1 University to Federal match. To ensure that practical knowledge in geologic mapping is gained by the student the program requires a well-conceived faculty-to-student mentoring plan which is a heavily-weighted proposal evaluation criterion. Students are also required to have completed fundamental geologic courses that enable them to successfully complete their mapping projects. Faculty-student mentorships typically include field mapping preparation prior to the field season, in-field hands-on mapping techniques and interpretation skills during the field season, followed by post mapping interpretation and report writing skills and digital geologic mapping techniques.

In order to evaluate the effectiveness of the program to provide a well prepared geoscience workforce, students are asked to complete a Student Participant Satisfaction Survey after they have completed the program. The survey asks student respondents to rate their satisfaction with various aspects of their EdMap experience and their overall satisfaction with their EdMap experience. Additionally, students are asked (1) to identify their education and work experience since their participation in the program, (2) if their EdMap experience helped them, and (3) general comments about their EdMap experience. The student surveys are beneficial to the program to understand the workforce and continued education trends of the respondent population. Of those EdMap students that responded to the survey over a 10 year period approximately 90% state that they go on to advanced degrees in geoscience or STEM disciplines while 10% go directly into the workforce in fields such as environmental consulting, the petroleum industry, education (teaching), and US Government and State Government service.

Training the Future Geoscience Workforce

Shelley Jaye

The US Geological Survey (USGS) headquartered in Reston, VA, approached Northern Virginia Community College (NOVA) in September, 2011 with a proposal to partner in training geoscience students for potential Physical Science Technician (PST) positions at the Survey. A PST is an entry level position at the USGS. With this training the Survey hopes that the best and brightest would be offered summer internship positions which may, in turn, lead to full time employment. Statistics show that the population of professional geoscientists and trained technicians is aging (see [AGI Workforce Summary](#)). The significant decline in geology majors during the 1990's (see figure 1) has resulted in a void of trained geoscientists available to step into these positions as retirements at the Survey loom large (see figure 2). Realizing their dilemma, the USGS became proactive in engaging the community college as the initial step in providing trained technicians to add to their workforce. The thought is that with training and opportunity, these students will potentially remain at the Survey as full-time PSTs or go on to pursue Bachelor and advanced degrees in the geosciences, returning to the Survey as associates and research scientists.

Together with several scientists from the USGS (also NOVA adjuncts), the Geology Department at NOVA has worked on defining the curriculum and designing new courses which will lead to a new Associate of Applied Science Degree in Geoscience Technology. We are in a unique position at NOVA to be able to offer not only the common introductory courses in geology, biology and chemistry but also more advanced courses in Mineralogy, Paleontology, GIS, rock preparation and analysis and field techniques courses all deemed necessary by a USGS PST. Although this degree program is in-work and no students have graduated with an AAS in Geoscience Technology, the USGS still has a need and the available resources to hire NOVA interns. We offered this internship opportunity to our cross-campus student body enrolled in our geoscience courses this past summer. Through a competitive process of resume submission and interviews, seven of our NOVA students were offered internship positions at the USGS. In fact, NOVA students worked out so well that research scientists looked within their own program budget to keep three of our students on as part-time employees while they continue their studies at NOVA.

Current and future plans: We are now working on a much larger program at NOVA to develop a new Associate of Applied Science degree in STEM Technology. This program is designed to prepare graduates for employment in entry-level positions in the STEM workforce. The technical workforce has three vital parts to it; the Scientists, the Engineers and the STEM Technicians. STEM Technicians are a critical element of the technical workforce. A STEM Technician will work with Scientists and Engineers to implement designs and approaches, set-up and run experiments, collect and analyze data, interpret results, develop charts and document their work in reports, verbally discuss and share results, maintain valuable equipment and instruments, work as laboratory technicians in research or manufacturing, serve as on-site technical specialist and/or field representatives as well as being a contributing team member of the technical team they are assigned to. Employers are governmental, industrial or non-profit organizations working in STEM-related fields. Coursework for this program will involve a core set

of general educational courses and a series of elective courses in the STEM area that the student wants to specialize in. These areas are Geoscience, Biology, Chemistry, Physics, Environmental Science, Engineering, Computer Science, Cyber Security or a hybrid of the above. We are currently working on setting up focus groups with government, industry, secondary school and higher education partners to access the interest and need within the community for the proposed STEM Technician.

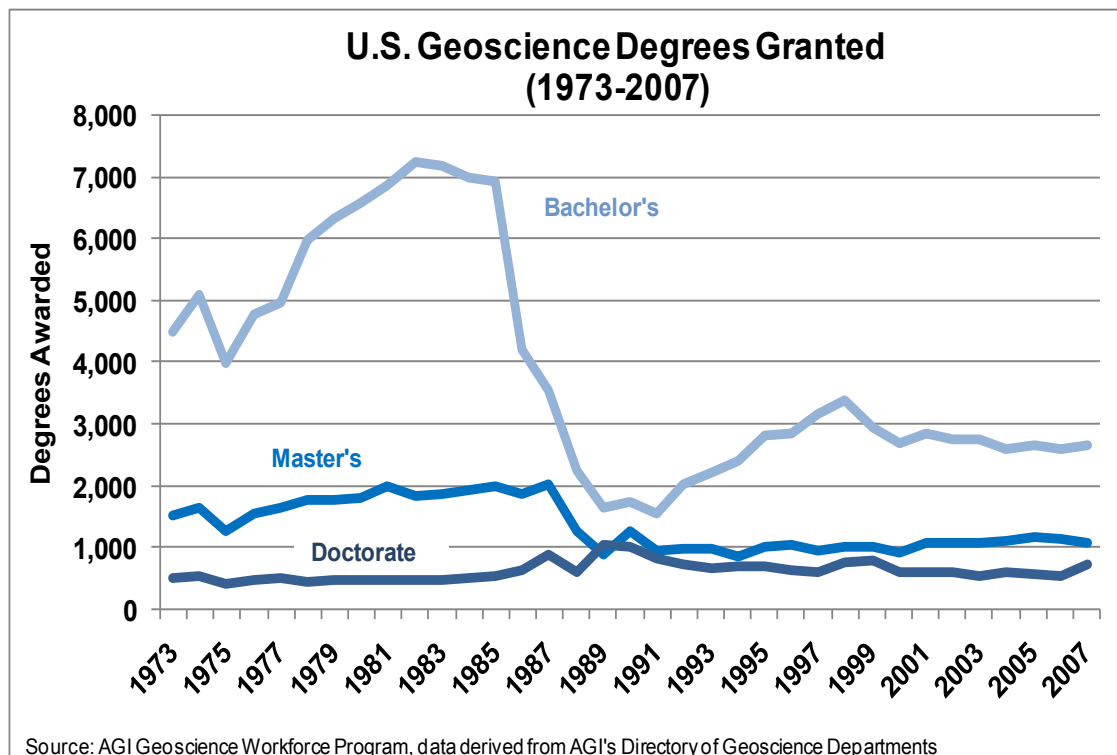


Figure 1.

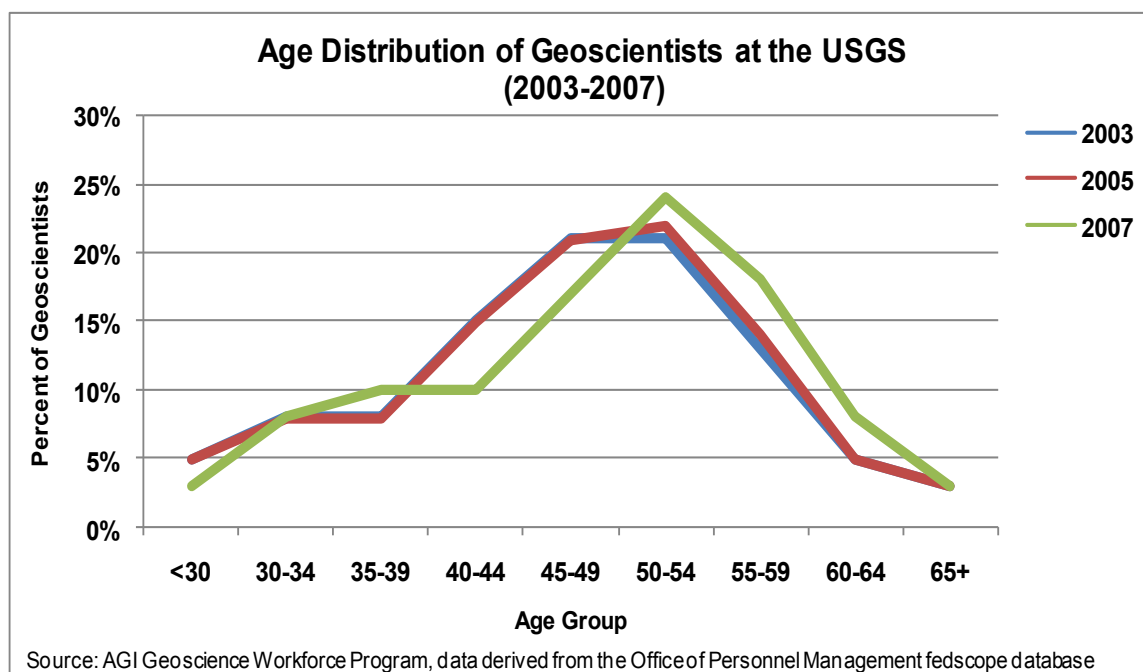


Figure 2.

The Noyce Scholarship Program

George Mason University (GMU) NSF Program Award
Northern Virginia Community College (NOVA) Research Subaward

Shelley Jaye

NOVA Annandale has entered into a partnership with George Mason University to promote the education and licensure of secondary education teachers in STEM. GMU offers paths to licensure through both undergraduate and graduate programs in their College of Education and Human Development. Few NOVA students have been able to follow the path to licensure through the GMU undergraduate program because GMU requires that students apply to the Teacher Preparation Program during the second semester of their sophomore year. Once transferred to GMU, NOVA students discover that they are a semester or more behind in declaring teaching as a major and opt for a major in a STEM discipline instead. If they still want to teach following completion of their bachelor's degree, they must enroll in the GMU graduate program path to licensure. By this time, many potential teachers have been lost.

GMU was awarded a five year NSF grant in September 2012 to establish a "Noyce Scholarship Program". The program aims to identify potential STEM secondary education teachers while still at NOVA. The program provides funds to establish student paid "Learning Assistant" positions within the STEM disciplines of Geology, Biology, Chemistry, Physics and Math. The "Learning Assistants" at NOVA act very much like teaching assistants at universities. They are identified by MSE mentor teachers in each of the disciplines. The NOVA students selected as Learning Assistants will work with their mentor teachers in the classroom to gain valuable experience and insight into their potential profession as STEM educators. The students will work approximately ten hours per week spending their time divided between the classroom, in weekly discussions with their mentors, and participating in workshops and weekly meetings with GMU Learning Assistants also a part of the Noyce Scholarship Program at GMU. NOVA students will also have the opportunity to apply for a \$10,000 per year Noyce Scholarship to continue their studies at GMU. This funding will be available to the selected Noyce Scholars for a period of three years taking into consideration that selected NOVA students may need to spend some extra time at GMU completing all of the requirements for graduation and licensure. It is anticipated that approximately six Noyce Scholars will be elected from NOVA per year.

Currently, NOVA MSE has hired six students as Learning Assistants (two each in Biology, Geology and Math). These students have been working with their mentor NOVA faculty during the Spring 2013 semester. Our first student is awaiting admission to GMU for the 2013-2014 school year. NOVA faculty in Physics and Chemistry are actively looking to recruit potential Learning Assistants for the Fall 2013 semester.

How My Program Prepares Students to Become Professional Geologists InTeGrate Workshop, Geoscience and the 21st Century Workforce

“The primary mission of the Department of Geological Sciences at SUNY Geneseo is to prepare undergraduate students for a successful life after graduation by providing a high quality, rigorous learning experience in geology and related sciences, with the faculty serving as role models. We do this by requiring a breadth of courses that represents the basic core of geologic subject matter and by offering a range of electives that are more specialized in their approach (e.g., Remote Sensing, Applied Geophysics, Groundwater Hydrology, and Paleoclimatology).”

- Statement prepared for an external review of my department in 2011

Through academic advising and geology seminars, students in my program (undergraduate only) are advised to eventually pursue M.S. degree in geoscience. The long-standing notion that a Master's in geoscience is generally required for most potential career paths in geoscience is reflected in the curricular design of my program. For example, the writing requirement for all required intermediate and upper-level geology courses trains students in researching, analyzing and criticizing primary literature. Additionally, the capstone seminar trains students in doing original research. Although these skills are pertinent to many types of careers in geoscience and are transferrable to other careers, my colleagues and I often emphasize their importance to students by saying “this will help you prepare for graduate school.” The related requirements for the geology degree (calculus, chemistry, biology, and physics) are often justified by the notion that “if students do not take these classes now, they'll have to take them in graduate school”. From 2006-2010, approximately 80% of graduates from my program entered an M.S. or Ph.D. program in geoscience within 2 years of graduation. My colleagues and I viewed this rate of entry into graduate school as evidence of successful preparation of our students. However, this percentage has declined to about 50% over the past three years while the number of Geology, Geochemistry and Geophysics majors has grown from a total of 50 to more than 100 students. The total number of graduates of my program who have pursued a M.S. or Ph.D. in geosciences over the past three years has increased slightly, along with the total number of graduates seeking professional employment upon graduation.

In response to this new trend, colleagues and I have begun evaluating the professional preparation of our program from other perspectives, especially that of students who do not plan to begin a M.S. or Ph.D. in science upon graduation. In general, we agree that the breadth and rigor of our geology program is appropriate for students who plan to become a professional geoscientist. We believe that geology is the ultimate interdisciplinary science, and that the training our students receive in all of the natural sciences adds great value to the Geology B.A. degree from Geneseo. The learning outcomes of the program (see Description of the Geological Sciences Program) align with our mission statement (above) and are assessed regularly. The Capstone Seminar, wherein students practice researching the primary geological literature, oral presentation of the scientific information, and research methods in geology, is our best means of internal assessment of these outcomes.

Over the past three years, more than 80% of geology research completed in the capstone seminar is considered to meet expectations.

Additionally, the research and writing requirements of our program benefit all students, providing a set of transferrable skills that can benefit students in any career path in geoscience. The research requirement includes field and analytical components that help students to synthesize concepts and details they have learned in their core classes. Learning how to study geology in the field (although we do not have a field camp requirement) and realizing the importance of doing careful fieldwork helps students develop skills in three-dimensional observations and spatial thinking that can benefit professional geoscientists at any level. Reporting on geology in written and oral format is also a seminal virtue of any professional geoscientist.

In addition to the curricular design, more than half of geology majors at Geneseo have the opportunity to develop their teaching skills by working as laboratory teaching assistants. My department is required to teach high-enrollment (up to 350 seats per semester) introductory-level courses with labs for non-science majors to service a general education requirement for all academic programs. Geology majors are given an hourly salary or directed study credit for assisting with the teaching of introductory labs. Any geoscience teacher knows that mastering the material is required in order to teach it effectively, and our students are given the opportunity to do this for fundamental concepts covered in our introductory labs. This benefits students pursuing an education degree as well as students who are preparing to become professional scientists.

For the period 2006-10, about 80% of our graduates began M.S. or Ph.D. programs to become professional scientists. Of these, about 60% are now employed in the private sector (e.g., energy companies, environmental consulting firms), 20% are still in graduate school and 10% are teaching geoscience. Of the 20% of our graduates who did not pursue a M.S. or Ph.D. in geoscience, 10% are now teaching geoscience (which requires a M.Ed. in New York State) and 10% are out of the field or unaccounted for. Approximately 10% of more recent graduates (classes of 2011-12) who have not gone on to graduate school are working in entry-level positions for energy companies or environmental consulting firms, chiefly in nearby regions where high volume hydraulic fracturing is being done for the extraction of natural gas.

Preparing Geology Students at the College of William & Mary for Careers

Heather Macdonald

The College of William & Mary is a public university with a strong undergraduate liberal arts tradition. Geology majors select one of two tracks: general geology or environmental geology. Some geology students are double majors (e.g, Environmental Science, Anthropology, Education, English, Government, Public Policy); some graduate with a minor in marine science.

William & Mary geology graduates go on to a diverse array of careers that range from the earth and environmental sciences to law, teaching, medicine, and even the clergy. Many recent graduates are pursuing advanced degrees at universities across the country while others are working as environmental geologists, petroleum geologists, GIS analysts, science writers, and teachers; still others are with the Peace Corps and the National Park Service. Many of our graduates go to graduate school in the earth sciences (45-50%) or obtain another professional degree (15-20%). Long term, approximately two-thirds of our geology graduates are employed in the earth sciences.

Our program prepares students for the workforce in the following ways.

1. Provide information about jobs and careers.

We introduce career options to majors and potential majors in a variety of ways: in our courses, through seminar speakers (face-to-face and virtual), career panels, our annual departmental newsletter, advising, alumni connections, and collaborations with the Career Center on campus. Selected examples follow. In a general education geology course, the faculty member talks about jobs and careers in the geosciences and provides small-group opportunities to learn more about connections between geology and various career options (e.g., meeting with a faculty member from the School of Education, with an environmental consultant). We have collaborated with Cohen Career Center, which organizes career panels with alumni and others on careers in marine sciences, careers in STEM education, and careers in science writing, similar to panels of recent geology graduates who talk about their jobs and provide advice about the job search process (which also supports point 4 below).

2. Provide experiences that develop knowledge, skills, and attitudes important in the workforce.

The geology curriculum is designed to provide majors with a strong broad-based education in the modern earth sciences while being sufficiently flexible to allow students to explore their own interests. Geology courses stress the process of learning about the workings of the Earth. Emphasis is placed on both modern and ancient earth systems as well as the environment and change through time. Quantitative thinking, communication, and problem-solving skills are addressed throughout the curriculum in both individual and collaborative projects. Some courses include assignments in which the students do work similar to work they might do in a job after they graduate. Fieldwork forms a key component of many courses and provides realistic preparation for further graduate studies and the workplace. Some students participate in EdMap projects, further developing their field skills. All geology majors pursue an original senior research project and this yearlong endeavor forms an important capstone

experience. Co-curricular experiences also provide experiences that develop knowledge, skills, and attitudes that will be useful for a range of jobs.

3. Encourage exploration of options

Exploration of options includes course experiences, informational interviews, internships, research experiences (e.g., REUs as well as the required senior research) and teaching experiences (volunteer TA in introductory geology labs, Geology on Wheels local outreach program), and programs offered by the Cohen Career Center.

4. Support students in the job search

We support the job search by providing informational sessions on graduate school, career panels (mentioned above), facilitating networking opportunities for students and alumni, advising students and supporting them in the job search process, distributing job announcements, reviewing resumes and job applications (and getting students to see how the work they've done in classes can be included in their resume), and encouraging students to participate in activities and programs sponsored by the Cohen Career Center.

Essay for InTeGrate Workshop on Geoscience and the 21st Century

submitted by

Kate C. Miller, Dean

June 4, 2013

The College of Geosciences at Texas A&M University offers a comprehensive set of programs in the geosciences including a full suite of degrees from the bachelors through the doctorate in every department. Most degrees are offered through one of the College's four departments: Atmospheric Sciences, Geography, Geology and Geophysics, and Oceanography. The College also offers interdisciplinary bachelors degrees in environmental geosciences and environmental studies, and oversees interdisciplinary graduate degrees in Water Management and Hydrological Sciences.

The vision of the College is to lead in establishing the geosciences as the most important and impactful scientific discipline of the 21st century. The sustainable human society of the future depends more on innovation and application of discovery in the geosciences than on any other discipline. Our field is essential to solving society's grand challenges – global climate change, air and water quality, and adequate energy and food supplies.

By lead, we mean:

- produce graduates of diverse backgrounds who rise to be leaders in private industry, government, and education.
- produce interdisciplinary, innovative, technologically advanced research that is widely translated and communicated for the benefit of a global society.
- prepare all students for thoughtful, life-long participation in public issues related to science, technology, and society.

The mission of the College is to advance new understandings of the Earth System and apply them to the needs of society. To prepare the next generation of geoscientists to conduct research, to find and develop natural resources, and to measure and respond to environmental change.

In this document I describe how our bachelors-level programs prepare students for the workforce, including a discussion of the areas in which our alumni are employed and the knowledge and skills that have been most important in supporting success.

Most graduates of our *Meteorology program*, choose one of four career paths, each of which requires somewhat different skills for success. Graduate who enter the national weather

service or similar organization find forecasting skills and a strong knowledge of basic meteorology to be the most important assets for success. Those who choose broadcast journalism find strong communication skills, practical training through our broadcast journalism course, and participation in a variety of internship opportunities to be the most helpful. Those who enter graduate school need a strong foundation of math skills and competency in atmospheric dynamics, physics and chemistry. Anecdotal evidence suggests that students who are most successful in graduate school are those who also had the opportunity to conduct independent undergraduate research projects. Finally, a growing number of our undergraduates are finding jobs as environmental consultants for consulting agencies or government positions such as with the Texas Center for Environmental Quality (TCEQ). These students benefit from elective courses in air quality and from participating in undergraduate research in laboratory or field measurements.

Graduates of our *Environmental Geosciences* program typically enter careers related to environmental consulting or graduate school, for which their background in math, science, and other technical coursework is very beneficial. The program encourages participation in internships and undergraduate research through course credit, and these are important to career success. Gaps in our technical curriculum that we know would benefit our graduates early in their career include material related to licensing, field work, and health and safety regulations.

Graduates of our *Environmental Studies* pursue some of the same career paths as those from Environmental Geosciences, but more often work in areas such as environmental law and sociology, frequently with non-profit organizations. While a strong science background is still important for them, courses in economics, policy and regulations, and sociology are also very beneficial. Internships and study abroad opportunities are encouraged for these students as well.

Graduates of both of these programs leave with strong written and oral communication skills as well as teamwork and leadership skills, all of which are incorporated into their degree plans. Many of our graduates choose to delay entering the workforce and instead pursue graduate or professional studies in areas such as geography, water management, environmental policy, urban planning, law, and oceanography.

Most graduates of our *Geography* programs find employment with environmental consulting firms or with the oil and gas industry. Other types of employment include government agencies, education, and various businesses. It is clear that students with courses or training in GIS, GPS, aerial photography, satellite remote sensing, image processing, GIS programming and geo-computational skills (basically all geospatial technologies) are in great demand in a wide range of fields. Additionally, GIS skills, statistical analysis, business and geospatial tools are also in demand by employers who deploy urban and business oriented technologies. Finally, some graduate pursue graduate studies in geography or related disciplines.

Graduates of our *Geology and Geophysics programs* tend to follow three career pathways: the petroleum industry, academia and government. Most enter industry. For these graduates, employers value their superior quantitative and analytical skills, research experience, their knowledge and skills in field mapping, and their training in both geology and geophysics. In

addition employers tell us that our graduates are valuable because of their strong work ethic, loyalty and first-class leadership skills. These attributes may be traceable to the “Aggie” traditions and core values of the university. For graduates who pursue employment in academia, the most important tools we provide for their toolbox are the ability to conduct research at the cutting edge and the quantitative and analytical skills.

An Earth Science Curriculum by Design

David Mogk
Dept. of Earth Sciences
Montana State University

The Department of Earth Sciences, Montana State University, recently implemented a top to bottom revision of its curriculum. We are a department that encompasses both geology and geography, and we have degree options in Geology, Geography (physical and human), GIS/Geographic Planning, Hydrology (currently on hold pending appointment of a new faculty line), Snow Science, and Paleontology. These latter two degree options are somewhat unique in the US for undergraduate degree programs, and have been hugely successful in recruiting students to the geosciences, particularly out of state students. We currently have a faculty of 11, about 270 majors, 60 graduate students (40 MS and 20 PhD), and provide a large instructional service to MSU, particularly for students from Education, Ecology, Land Resources, and the social sciences.

Our curricular changes were necessitated by both philosophical and practical considerations. Philosophically we were guided by a number of principles:

- We used the “Understanding by Design” approach advocated by Wiggins and McTighe (2005). Using “backward design”, we started by determining the profile of a student who successfully completed our degree programs—what should they know, what should they be able to do? In part, this speaks to the students’ professional development as they prepare for the workforce or graduate school; but also, these students are the best ambassadors of our department to industry and the community and represent the ultimate quality of our program.
- The new curriculum is better aligned with the changing nature of geoscience research and understanding. The most important shift is towards an Earth System approach, moving away from the traditional “silo-ed” disciplinary course structure.
- We have long advocated a learning sequence that emphasizes observation, description, interpretation and integration at each of our four years of instruction (Figure 1). This progression generally follows Bloom’s Taxonomy of Cognitive Skills (<http://www.nwlink.com/~donclark/hrd/bloom.html>): knowledge, comprehension, application, analysis, synthesis, and evaluation. We also apply the “rule of 3’s” (or 4’s): if something is worth learning well, students need at least three exposures. So, our sequence of courses provides exposure, familiarization, competence and mastery of key concepts and skills over the four-year curriculum.
- The “cornerstones” of our curriculum (Figure 1) remain a strong background in cognate sciences (chemistry, physics, biology and math), application of the scientific method (and we understand this to mean “geologic habits of mind”, see <http://serc.carleton.edu/68040>), an emphasis on geologic processes and

the process of doing geologic work, and a strong grounding in field instruction.

- In addition to the “core” of geoscience concepts, knowledge and skills, we are also addressing ancillary learning goals such as development of quantitative skills, communication skills (verbal, written, graphical), use of data in the classroom and modeling, systems thinking, research and research-like experiences, applications to societal issues, and interpersonal skills (cooperative and collaborative learning); these are all part of the department’s assessment plan that we have prepared for institutional accreditation.

The practical drivers for this redesign of the curriculum are quite simple:

- We simply had to make more efficient use of faculty teaching efforts and teaching assistant assignments. Some courses were largely redundant (Intro Physical Geology and Intro Physical Geography covered about 80% of the same material, and have now been merged into a new Earth System Science course); other courses did not draw sufficient students to be offered (minimum of 10 undergraduates, 5 graduate students); some courses were on the books only for historical reasons, and other new courses have been introduced to address emerging new lines of research (e.g. Geomicrobiology). So we started with a clean slate.

The overall structure of our new curriculum is presented in figure 2; vertical columns show the emphasis on high level learning goals: Earth History (“deep time”, evolution); Earth composition and Architecture; Surficial Processes (including water, climate); and Human Dimensions. The rows reflect the learning progressions as described above.

At the introductory level, offer a diverse suite of courses to introduce students to the range of topics covered in the Earth Sciences. The new Introduction to Earth System Science, course is required of all majors, is also required of other disciplines (Education, Ecology, Land Resources) and is available to non-majors seeking “Core Curriculum” credits. A wide array of other introductory courses are offered to stimulate interest among students including: Dinosaurs!, Planetary Geology, Oceanography, Environmental Geology, Human Geography, World Regional Geography, and a special course on Yellowstone: A Natural Scientific Laboratory. These courses are essential to recruiting students to our majors, and we highly value excellence in instruction in these courses (our faculty have earned numerous college and university teaching awards).

We have also developed a new series of one credit “mini-courses” on Topics in the Earth Sciences (following the established model developed at the University of Michigan). In combining our Intro Physical Geology and Geography courses, we had to look for a mechanism to maintain our student

credit hour generation, and these mini-courses provided the opportunity for faculty to teach courses in areas of particular interest to them without requiring a great deal of class preparation. These courses give students the opportunity to explore a given topic in some depth, as opposed to standard survey courses that are “a mile wide and an inch deep”. We will offer 16 different topics in a two-year cycle (4/semester), and students can take any three to satisfy university “Core” requirements in Contemporary Issues in Science. Topics we have covered this past year include: Himalayan Geology (following David Lageson’s expedition to Mt. Everest), Geology and Human Health, Military Geology, Extraterrestrial Impacts, Great Extinctions, Coral Reefs in Earth History, the Montana “Oil Boom”, and Megafires. These courses have already proven to be hugely popular (all sections filled to their caps), and we will be monitoring students’ progress to see if this early exposure to the Earth Sciences in these courses results in recruitment of majors.

Our second year of instruction for majors is our “Foundations” set of courses. For all geology (and hydrology, snow science, paleontology) majors, we expect that they will take Historical Geology, Earth Materials, and our sequence of two GIS courses. Earth Materials has a focus on hand sample identification of rocks and minerals, a knowledge of their occurrences in Earth, and significance in terms of interpreting Earth processes and uses in society. All our majors should be able to identify rocks and minerals and understand their contexts in the Earth system (but don’t necessarily need to master topics such as crystallography and crystal chemistry emphasized in Mineralogy). We require two semesters of GIS because this is arguably the most marketable skill that students need for future graduate studies or to enter the workforce (based on feedback from recruiters). GIS applications then become possible in upper division courses such as Geomorphology, and for independent research projects. We also expect students to complete a year of inorganic chemistry, physics, and calculus by the end of their second year.

The third year of our geology major is really the “core” of geoscience professional training: Mineralogy, Sedimentary Geology and Stratigraphy, Structural Geology, and Geomorphology. Paleontologists have a similar core, including Invertebrate Paleontology, Vertebrate Paleontology, and Comparative Anatomy. Because students have already had hand sample identification in the Earth Materials course, Mineralogy now focuses more on analytical methods (petrographic microscope, XRD, SEM/EDS), and analysis of earth materials, structures, landforms and the attendant geologic processes is emphasized in the other core geology courses. All these courses have a strong field component (we are blessed with a great geologic setting so we can readily get into the field in afternoon labs and on weekends). We also believe that ALL Earth Science majors should have a fundamental understanding of Weather and Climate, so this is now a required course.

Our fourth year courses are largely a series of “enrichment” courses (commonly joint listed as a graduate course, with extra requirements for graduate students). These generally follow instructors’ research interests in topics such as Tectonics, Volcanology, Igneous Petrology, Metamorphic Petrology, Sedimentary Geology, Geophysics, Taphonomy, Macroevolution, Snow Dynamics and Accumulation. Common approaches for these upper division courses include: critical reading and review of the literature; use of modern software; in-depth class projects (field and lab); use of real-time, archived, or student-generated data; and written or oral student presentations. The geology curriculum also requires the Field Camp class as a “capstone” course, which also provides an opportunity for “end of degree” assessment of student learning outcomes. In general, these courses provide authentic geologic experiences for our undergraduates that serve to prepare them for next steps in their professional development.

We are in the first year of implementation of this new curriculum. Initially there was some resistance from some of the faculty had adopted a stance of "if it ain't broke, don't fix it" as we already had a pretty solid undergraduate curriculum. But the redundancies in some course work, gaps in other areas, and need to optimize teaching staff efforts won the argument. Downstream benefits are realized as course pre-requisite requirements are uniformly applied, and students are better prepared to enter our upper division courses. Foundational skill sets are uniformly developed in lower division courses and faculty can expect to build on this early work in the upper division classes as well. Teaching assistants that were once assigned to redundant introductory courses are now available to help teach labs in many of the upper division courses for the first time. Early reviews from students are largely favorable as they realize that these changes will position them well for future opportunities. To prepare students for these changes, and to explain the underlying need and reasoning, I gave the first departmental colloquium of the year on the "State of the Geosciences, State of the Department"; it was very helpful for the students to have the trajectory of their coursework explained in the context of our evolving Science and expectations for the workforce of the future. We are working out a few wrinkles as some students are a bit challenged to reconcile the old and new degree requirements, but we are working through this in our advising efforts. Faculty seem to be happier in the alignment of courses, because it has actually reduced teaching loads to a degree, and has given us flexibility to provide TA support in some courses at the upper division which we were not previously able to provide. The curriculum is in better alignment with the university's Strategic Plan, and we think it also is in better alignment with the changing nature of the geosciences as a discipline. The proof of success of this new plan will ultimately be reflected by the success of our students as they enter the workforce or grad school. I'll keep you posted!

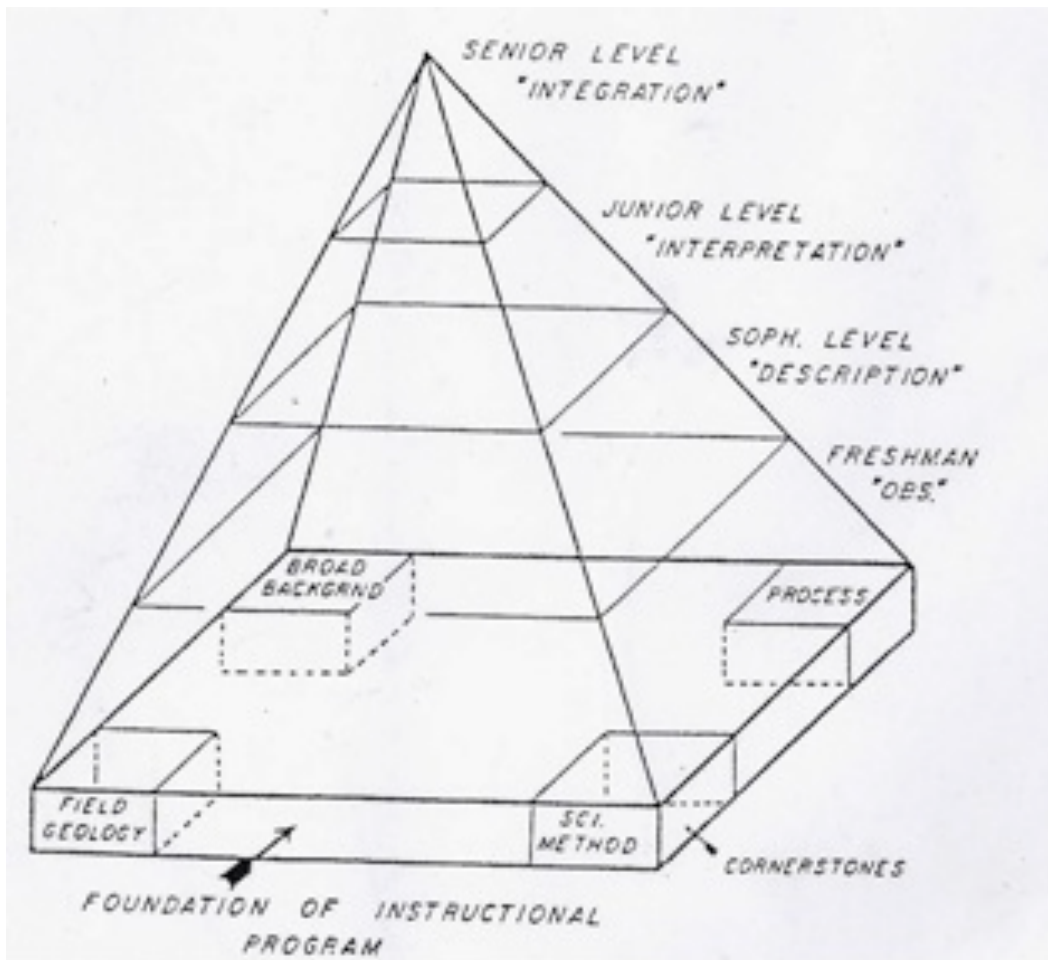


Figure 1: Learning “pyramid” for the Dept. of Earth Sciences, Montana State University, that illustrates levels of skill development (observation, description, interpretation and integration) built on the foundations of a broad scientific background, the methods of (geo)science, Earth processes, and field geology. Figure originally drafted by David Lageson.

DEPT EARTH SCIENCES, MONTANA STATE UNIV., UNDERGRADUATE COURSE MATRIX				
(Required Courses ONLY Offered in the Dept. of Earth Sciences, exclusive 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 Macroevo	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		

Figure 2: Course matrix for undergraduate degree programs in the Dept. of Earth Sciences, Montana State University

Transitioning Undergraduates from Students to Geoscientists for Successful Employment

Megan Pickard

BYU-Idaho

The geology program at BYU-Idaho has been a 4-year program since 2001. We currently have 178 majors and 6 full-time, tenured faculty, and 2 temporary, full-time faculty. Each year we also teach hundreds of non-science majors in our general education courses. Since 2009 the number of geology majors enrolled in our program has increased from 60 to 178 and the number of graduates has increased from 11 to 32.

Our program includes courses in geology, and 2 semesters each of chemistry, calculus, and calculus-based physics to fulfill major credit requirements. We offer many learning-by-doing experiences for our students, including a quality field camp and mentored student research. In our core geology courses, students complete the transition from 'being in college to take classes,' to 'being in college to prepare for a career.' Field camp, course field trips, and mentored research have been designed to help foster our students' abilities to "do" geology in unscripted situations. Students also take 4 elective courses that allow them to emphasize study areas of their choice from topics including geomorphology, applied geophysics, applied GIS, geochemistry, petroleum geology, groundwater hydrology, environmental geology, oceanography, and geology of North America to broaden their background as a geoscientist. As a capstone course students attend a 6-credit field camp that focuses on geologic mapping and sequence stratigraphy.

We recognize that the most employable degree in geology is the M.S. degree. As such, we strive to help our B.S. students prepare for graduate school and for a career in petroleum, environmental/engineering geology, mining, or hydrology. Students who intend to go to graduate school are encouraged to complete a mentored research project, but are not required to do so. The majority of our students are admitted successfully in many graduate school programs throughout the country. Following the successful completion of graduate school, those students are employed and well-compensated. We also have a few students who opt to seek jobs upon finishing their B.S. rather than attend graduate school. We recommend that these students minor in math, engineering, GIS, or computer science as those who do are more likely to find employment in areas such as the petroleum service industry, petroleum geotechnical positions, GIS, and water resources. Other students we prepare include those who wish to be GIS professionals, continue as Law students specializing in corporate or environmental law, or to complete a Masters of Business administration with a focus on mining or petroleum business. These students have also been successful in finding jobs and graduate schools.

In comparison to a recent analysis of national data provided by the American Geological Institute our department has higher graduation rates than the national average with 65%, 82%, and 94% of our freshman, sophomores, and juniors graduating compared to 16%, 33%, and 60% nationally. Our department also has a higher graduate school placement (62% for our graduates) than the national average (15% nationally) and produces students who succeed in graduate school and employment. For example, from 2002 to 2012 all but two of our students who went to graduate school finished successfully.

Next Generation Career Competencies via Interdisciplinary Professional Projects

Essential to any educational process is to clarify “learning objectives”. Typically objectives are defined by educational institutions, based on established discipline areas. Academic disciplines have traditionally been segregated to promote focused study, with standardized curricula. Scholars are expected to select a discipline and join others in the same focus area to share inquiry, challenge hypotheses, perform research and application to develop understanding and pursue ongoing issues in their field. Learning outcomes are measured and typically “validated” by the same institution that has designed the course standards and processes. Teachers are qualified by even deeper and more extensive years of study, research and publication which establishes authority in the discipline. Within universities, departments are similarly segregated, and often it has been difficult for programs to flexibly offer cross-disciplinary coursework. In this way, education has been a relatively cyclical, compartmentalized, self-contained process.

Meanwhile, the “real-world” is a changing dynamic of interactive systems and disciplines, mutually influencing unpredictable new challenges, requiring “interdisciplinary” problem solving. Beyond the classroom, students must be prepared to add value in the context of commercial, government and/or non-profit organizations, which are typically struggling to manage diverse employees with limited resources, in a competitive race, to achieve practical and financial goals. The value of education in this context is measured not just by the “grades” students achieve, but by their “ROI” (return on investment) in terms of position, wages, and lifestyle afforded by job placement. Employers ultimately measure the value of the education in terms of relevance and adaptability to the workplace project at hand. Further, employers are looking for a variety of competencies that may not be taught in the classroom.

Ultimately 21st century workforce “learning objectives” must be defined by multiple stakeholders, including students, employers, educational funding agencies (which may include parents!), as well as educational institutions. Because consumer market forces are driving the adaptive strategies of organizations, the surrounding community is also a vital stakeholder in measuring value. Given our contemporary global issues of increasing populations, climate change, water and food insecurity, necessary transitions to alternative energy, all impacting redesigns for products, services and work systems, our next generation leaders must be prepared to grapple with problems through “multi-focus” perspectives. Their **training must include hands on projects that require working with teammates who may not be of the same discipline**, as each brings vital insight to address complex issues and operationalize solutions. Communications skills must be learned, so that the language of science may be “translated” to provide meaningful insights, while working in cooperation with a business, policy or local community member. Similarly the varied objectives, language[s] and culture[s] of business, government and communities, may inform practical team-based solution building. This collaboration is not easy as we observe increasingly conflicted arguments among politicians, businesses, age groups, cultures and affiliations as we engage in questions of changes for the 21st century society! At the core, cross disciplinary inquiry and dialogue is at least one essential learning objective for next generation leadership, that challenges our standard curriculum for education and corporations alike.

Recognizing the challenge, educational institutions are increasingly building in the “experiential learning” component to challenge students to work in groups and/or take theory to practice beyond the classroom. Students may be required to pursue an internship or project in the community to build

their skills, expand their resume, and possibly cultivate a professional network. However, this can be difficult for students to achieve in a competitive job landscape. They may expect it to be provided by the school, while schools expect students to manage this aspect on their own.

Career Services within educational institutions can be essential partners in helping students find internships. However, in-house services are often segregated from workplace networks just as the students and faculty may be. While career coaches may work with students on basics of resume, cover letters and interview practice, it may not be enough to bridge the “campus to careers” divide. New interdisciplinary partnerships between stakeholders in next generation workforce must be cultivated to achieve win/win/wins. Bridge programs within organizations, associations and external agencies offer a valuable opportunity.

A well-known model is “cooperative education” which offers a 3-way learning contract between a workplace project host, schools and students.

- 1) **Organizations receive help on projects** from a ‘consulting team’. Supervisors define the mission, framework, resources and required deliverables, with performance standards.
- 2) **Projects may be evaluated by academics** to ensure a level of theory-to-practice that may be worthy of academic credit, with additional requirements.
- 3) **Students learn through professional practice, with interdisciplinary teams**, build their resumes, networks, and opportunities for employment.

This is also known as “[Action Learning Project](#)” in Executive MBA Programs , or [Career Practicum](#) as is applied currently at World Learning/ SIT Graduate Institute and many other schools. In government, “co-op” has been known as [SCEP](#) (Student Career Experience Program), but recently transitioning to “[Pathways](#)” Program. Associations such as [WACE/CEIA](#) bring together stakeholders to continually develop new insights for programs and methods of evaluation.

Chesapeake Career Consulting applies these principles of cooperation with candidates from varied disciplines in the DC Metro Region to support competency development required for the changing job market. Interdisciplinary Career Coaching/ Educational Consulting services are delivered in a variety of ways, including individualized and group career coaching, teambuilding workshops, online seminars with professional panels on current issues, guidance in locating and cultivating project opportunities, or supporting organizations in next generation leadership program development as may be relevant. “Career Strategy Projects” are integral to individual development plans, aligned with student-defined career objectives, while building vital networks with professionals in associations and businesses. At Robert H. Smith School of Business, MBA students have contributed insights across sectors, in roles focused on strategy consulting, corporate social responsibility, supply chain logistics, international capacity building through microfinance, alternative energy and technology innovation, as well as venture capital, global markets and entrepreneurship. It is understood that our MBA’s are also becoming hiring managers in the region!

Currently at World Learning/ SIT Graduate Institute in Washington DC, candidates are pursuing roles that reach beyond the NGO sector to join global business teams, consulting groups and public-private partnerships to support social responsibility and sustainable system solutions. *Thinking forward*, we hope to cultivate regional professional community networks that may involve MBA’s, international students across universities in the DC/Metro region to foster mentoring partnerships as well as helping each other navigate the 21st century job market.

Geology program at Juniata College

Matthew Powell

Juniata College is a small (~1500 students), residential, undergraduate-only liberal arts college in central Pennsylvania. Our geology department, which has existed since 1968, consists of three faculty and graduates approximately 6-10 students per year. We offer three majors: Geology, our traditional major; Environmental Geology, which is tailored for students who expect to become environmental consultants; and Earth & Space Science Secondary Education, which leads to state teaching certification at the high school level.

How our program prepares students for the workforce.—Our program attempts to develop a strong foundational understanding of geology in our students. To that end, we offer a classic curriculum of courses based on traditional subfields of geology, e.g., mineralogy, structural geology, sedimentology, etc., rather than more specialized offerings. Our labs and field experiences emphasize basic skills and practices such as microscopy and geologic mapping, and we provide opportunities for students to collect their own data and perform analyses.

Our curriculum is deliberate in exposing students to the breadth of the discipline. Our intention is to graduate geologists who have seen a wide variety of rocks in distinctly different settings, who have grappled with diverse data-gathering and analytical methodologies, and who are adaptable. We choose not to allow our students to specialize at the undergraduate level; viz we graduate no hydrogeologists, or paleontologists or stratigraphers or geochemists. Most of our students will have experience of all of these areas of geological inquiry and potential employment. We model that behavior in our teaching, intentionally wearing multiple hats and encouraging our students to see that they can as well.

We expect students to retain and use information and skills from prior courses. Our curriculum reflects this emphasis on building in that most of our courses have specific, and sometimes multiple, prerequisites. The fairly strict course sequencing means that students in our upper-level courses generally share a common set of skills and knowledge learned in earlier courses. This allows us to reinforce those abilities and integrate them into the new material. A capstone course is required.

We emphasize project- and field-based learning wherever possible. Many of our courses are deliberately focused on skill-building rather than just content-acquisition, e.g., our Geological Field Methods I and II courses, and the several project-based courses that integrate lecture and lab. Overall, three-quarters (12 of 16) of the course offerings for our majors incorporate project-based learning in some way, e.g., through labs, integrated lecture/labs, or field experiences. Our lecture-only courses also incorporate in-class demonstrations, hands-on activities, and field trips. Three of our courses deliberately work to develop our students' writing and presentation skills, and most courses include experiences that attempt to develop our students' analytical and critical thinking skills. Many of our students also participate in undergraduate student research with a faculty mentor.

Our overarching goal is to produce students who “think like geologists”. Frequent and diverse field experiences, integrative experiences, and a structured curriculum begin the process of building geology professionals. We also encourage all of our students to attend at least one professional

conference (almost wholly funded by the College), even if they are not presenting their own work, so that they experience geology as a larger scientific community. We also take advantage of alumni-led extended field trips for the same reason. Thus, we hope that by graduation our students have acquired a set of knowledge, skills, and experiences that enable them to perceive the earth system as a geology professional does.

Areas in which our alumni are employed.—We closely track the outcomes of our graduates and maintain a nearly-complete alumni database. Over the past ten years, 37% of our students have gone directly to graduate school (17% MS, 20% PhD), 55% have directly entered the workforce, and 8% are unknown or are not employed as geoscientists. Most of our graduates are employed in the environmental consulting industry (~50%), or the oil & gas or mining industries (~30%). A large proportion of the remainder are teachers at the high school, community college, or college/university level.

Knowledge and skills that have been most important in supporting success.—We have found that our most successful students tend to be the ones who are most enthusiastic and passionate about geology. These students are hard, uncomplaining workers, and they are most likely to respond to challenging opportunities that oblige creative thinking across the discipline.

Preparing Students for Careers in Geology at NWMSU

C. Renee Rohs, Northwest Missouri State University

PREPARING Geology students at Northwest

The processes that we use to prepare students at Northwest for careers in geology and related fields are embedded in the coursework and field experiences from freshman level up through their final term. In our general education courses, Earth Science and General Geology, we build a solid foundation for scientific inquiry by engaging students in the classroom with compelling examples while presenting content with relevancy to our students and the world in which they live. This engagement needs to come from a certain level of expertise and credibility, as established by the instructor and reinforced by the instructor's actions and the verification by other faculty and students. The expertise and credibility comes at both the group level and with individual interaction. At the group level, or in a classroom setting, our faculty members share their own experiences, but even more importantly, the scientific experiences of students that have worked with them.

As our program has grown over the past 5-6 years we continue to build on a model of cyclical learning. This cyclical model starts with some knowledge in the classroom setting. That knowledge is then applied and expanded in a laboratory setting. The next step expands those experiences and draws on that knowledge in the field setting where the bigger picture becomes clearer and new pieces of information arise. That additional information is then taken back into the classroom, but now, the students are able to link a personal experience to the knowledge and that promotes a sense of relevancy. Not only does this new knowledge come back with the students but it gets added to the course through the use of photos or samples to improve the course the following year.

In addition to the geology courses, many of our students assist with introductory labs either as a teaching practicum or as a paid teaching assistant. Students may take on this increased level of responsibility as early as their sophomore year where they are guided through helping others to learn the Earth science content in an interactive setting.

After asking our current students, we found that there are some key factors that play into their success that do not take place in the classroom. One of those things is the investment of time and interest. For example, taking a few minutes to stop and talk with students in the hallway. Those short (or occasionally long) discussions build a support system and "family" atmosphere where you know you are welcome and valued for your input. It is also a degree of accountability so that students have some personal reminders of the high expectations we have for them. This "family" atmosphere is further strengthened with field trips. We have field trip opportunities ranging from a 4-day fall field trip, to a single day course field trip, to a 17-day study abroad field trip. The number of students attending these field trips has ranged from 10 to 25 and usually consists of a mixture of upper level and lower level students. It

is on those excursions, that the value of the program is shared between students at different levels.

The following quotes are from a current student and an alumnus

Cody Nichols, Senior Geology and Chemistry Major

"I love that geology immerses you in your field of study through hands-on and field experiences."

Nathan Schmitz, Mining Geologist

"I graduated from Northwest Missouri State University, and I consider higher education the key to not only the future of Missouri, but the future of our nation. Northwest has always been at the forefront of innovation, with going green, alternative energy power plant, laptops for students, and textbook rentals. I can speak for the geology program from which I graduated in 2011. I can say without a doubt that some of the best educators and people I have ever met are within the walls of Garrett-Strong science building, teaching students to the best of their ability, right now."

PLACEMENT and EMPLOYMENT

Our undergraduate placement rate, in jobs in the field or in graduate school, within 6 months of graduation is annually at 100% among those graduates actively seeking employment. On average 30% of our graduates attend graduate school. Most of those attending graduate school in the last 10 years have done so at minimal cost receiving both tuition waivers and teaching or research assistantships.

Employers that have hired Geology graduates from Northwest Missouri State University:

- Terracon
- Burns and McDonnell
- Black and Veatch
- Resolution Copper Mining
- Freeport McMoran Copper and Gold
- Iowa Department of Natural Resources
- U.S. Geological Survey
- National Park Service
- EPA
- Alpha Natural Resources
- Baker Hughes Inteq
- URS Corporation
- Rio Tinto
- EOG Resources
- Numerous Environmental Consulting Companies

A Summary of Career Preparation for Ithaca College Environmental Students

Chris Sinton, Ithaca College

The Environmental Studies and Sciences (ENVS) department at Ithaca College is housed within the School of Humanities and Sciences at Ithaca College. The department offers a BA in Environmental Studies and a BS in Environmental Science and graduates 30-40 majors in the combined degree programs.

Our institution is considered liberal arts and, therefore, our students are expected to have breadth in a wide range of academic disciplines. This is accomplished through the college's recently revised core curriculum. In addition, the ENVS degree program has some breadth requirements as well as opportunities to participate in group or individual research projects as well as local internships. Taken together, these experiences should give our graduating seniors some of the "soft" skills associated with a liberal arts program (e.g., communication, critical thinking, working in group settings). These skills are independent of career-specific knowledge and are transferable to a variety of careers. However, we realize that there are costs associated with this, chief among them being a reduction in occupation- and industry-specific skills and knowledge.

In our Environmental Science program, students do gain some specific knowledge and skills that are directly applicable to environmental jobs and graduate programs. All students are required to take cognate science and mathematics coursework that provide a quantitative background. There are a limited number of upper-level courses that require students to use analytical equipment or field techniques that are common in the environmental business. We find the independent research or internships (either during the school year or during the summer) are most valuable at providing industry-specific skills. Our school provides a limited exposure to Geographic Information Systems and the department plans on increasing the availability of instruction and resources.

Our department has existed for five years so at this point there are limited data on the career paths for our graduates. This is exacerbated by a lack of any organized system to track these graduates. Nevertheless, we know that a subset of our graduating seniors have attended graduate programs in environmental science, law, and policy programs (e.g., Columbia, Tufts, UMass-Boston, Plymouth State, Cornell) while others have successfully found work in government agencies (e.g., US Forest Service, US-EPA, NY DEC), private consulting and environmental services companies, and "green" materials companies. Most recently, there seems to be a trend of students securing short-term jobs but that long-term jobs are more difficult to find directly upon graduation.

Boise State University's Preparation of Undergraduates for Geoscience Careers

The Department of Geosciences at Boise State University has approximately 150 undergraduate majors in two degree programs. The BS in geophysics is a small program with approximately 20 majors. The remaining 130 students in the BS geosciences program are distributed among emphasis areas in geology (60 students), hydrology (60 students), and secondary education (10 students). Boise State has a large population of non-traditional students; the average age of undergraduates is 25 and more than 70% of them work off campus. More than 80% of students are from Idaho.

Most of our graduates look for work in Idaho or surrounding states. Many of them have children a spouse with a job that makes it impractical to leave the area, or they have been in the region for a long time and are happy living here.

Students in our geoscience secondary education program have been successful finding teaching jobs in Idaho. Until recently we offered a separate BS in Earth science education that required fewer math and geoscience courses than the current secondary education emphasis under the BS geoscience degree. Similar changes were made to all science secondary education degree programs at Boise State in an effort to entice more students to prepare for careers in K-12 education. At the same time, the new program provides students with a deeper education in the geosciences so that they would be qualified to pursue jobs outside of teaching if desired.

Most of the recent BS geophysics graduates have entered MS programs in geophysics. A few others have found jobs with environmental or engineering consulting firms.

The majority of our students earn a BS in geoscience with an emphasis in either geology or hydrology. About 15% of each year's graduates enter MS or PhD programs in geoscience fields. Mining companies in Nevada and Idaho employ many of our recent geology, and some hydrology, graduates. Consulting firms and government agencies also hire our geology and hydrology students. Recent students have found employment with the Bureau of Land Management, the Forest Service, the USGS, and the Idaho Department of Water Resources.

Key features of our program that help prepare students for the workforce are:

- 1) an emphasis on developing observational skills, recording observations, and separating observations from interpretations;
- 2) an emphasis on synthesizing information from different branches or subdisciplines of geoscience;
- 3) practice with field, lab, and modeling techniques;
- 4) group projects that require formal reports or presentation of findings;
- 5) broad exposure to geoscience disciplines through the sophomore year as well as specialized upper division coursework; and
- 6) a capstone experience for all students (field camp, internship, or research project).