

PROPOSAL:
INTEGRATED REFORM
ACROSS THE GEOLOGY DEPARTMENT CURRICULUM

Submitted by:



Peter D. Crowley



Tekla A. Harms



David S. Jones



Anna M. Martini

INTEGRATED REFORM ACROSS THE GEOLOGY DEPARTMENT CURRICULUM

SUMMARY:

Four of five Geology Department faculty (Crowley, Harms, Jones and Martini) will spend academic year 2016-17 developing a framework by which we may more systematically teach both writing and quantitative skills through the vehicle of geology content in courses across our major. We will also work to design more successful capstone experiences for our majors, including a fall semester seminar for seniors and a new format for our comprehensive exam.

INTRODUCTION:

The impetus for curricular reform across the geology major has its basis in two intensive department-wide experiences in 2015-16. The first was our year-long decadal self-study, culminating in a review by a distinguished external committee; the second, a faculty seminar on the teaching of writing in science led by Jyl Gentzler and hari kumar for four geology faculty over the course of the spring semester. Both involved weekly discussion meetings and a review of our practices and pedagogical principles. Both asked (among many questions) how our courses and our curriculum as a whole support our students in achieving departmental and College-wide learning goals. Our department pedagogy has for many years been founded on our shared conviction that geology courses and the geology major should: (1) welcome any Amherst student to participate regardless of the student's academic preparation in science and math, providing each with the tools needed for accomplishment in our courses; and (2) develop in all majors the foundational skills necessary to pursue graduate study in the geosciences but at the same time generalize those skills so that our majors can succeed in any profession or career path they choose. This is a very difficult balance to strike and an ever-moving target as the Amherst student body undergoes profound demographic shifts. Our curriculum, therefore, bears periodic reassessment.

The Geology Department's self-study, on the whole, was quite positive, with present students, alumni, and the external review committee broadly validating the program structure and geologic content. Nevertheless, the review process and the faculty writing seminar helped to clarify aspects of our academic program that could serve today's Amherst students better and motivate us to innovate aspects of *how* we teach without fundamentally changing the geology that we teach. Because we are positioned to build on the results of the self-study process and the writing seminar for faculty, 2016-17 is the optimal time to accomplish this work.

Our assessment process identified the following critical points:
Geology majors are not well enough prepared for the writing component of a senior honors thesis. Although writing assignments have been spread throughout our curriculum, we have not been focused on the idea of "scaffolding" assignments within and between courses, thus many exercises aimed at learning scientific writing have not allowed for rewriting or revision, and few skills have been practiced from one semester to the next. We have not provided enough of the kind of exercises that allow our students to learn thinking through writing. Finally, we have provided insufficient direction in understanding the structure and syntax of the component parts of scientific writing in geology prior to asking our students to put it all together in a major project with the scale and scope of a senior thesis.

The Amherst geology major does not engage our students with the breadth and depth of quantitative skills that are typically a required component of geology curricula at peer institutions (see Table 1). We have deliberately constructed our geology courses to be math-light and we do not require ancillary math or other science courses of our students so that we can keep our major open to the

broadest possible spectrum of Amherst students regardless of their K-12 math and science preparation. We think this is a significant part of our success (relative to the field as a whole) in attracting underrepresented minority students to geology and do not wish to sacrifice this objective. Nevertheless, both our external review committee and the recent alumni we polled during our self-study noted this aspect of our curriculum and encouraged us to seek some solution.

Geology students typically get off to a slow start on their senior theses in the fall semester. Faculty recognize that there are significant unknowns at the outset of any research program, but our students are novices at managing uncertainty. For our best students, the freedom to experience and conquer this uncertainty is empowering and can lead to spectacular scientific insights, but for many other students the uncertainty can erode self-confidence, delay tackling the substantive investigation and thereby diminish results, and ultimately serve as a deterrent to persistence in the field.

In its present format, our Comprehensive Exam emphasizes content knowledge over synthetic thinking, which is inconsistent with the pedagogy of our courses and with our goals for the Comprehensive Exam experience. The Geology Comprehensive Exam is a 30-minute oral exam given individually to each student early in the fall semester. It is administered by the entire geology faculty and covers topics across the curriculum, with an emphasis on the four core required classes (GEOL 111, 121, 271, and 291). The Geology faculty agree that one of the most important aspects of the comprehensive exam is that it provides the impetus for seniors to take time to survey and integrate their knowledge across the geology courses they have taken. The exam format, however, calls for brief factual responses to questions; it does not provide an opportunity for students to exercise many of the higher order thinking skills prized by the department or to demonstrate their ability to synthesize their knowledge.

PROPOSED PLAN:

The Geology faculty proposes an integrated approach to addressing these curricular issues. We hope to devise a department-wide plan by which different courses will focus on a particular set of skills with room for practice and growth, rather than having each individual professor in his or her courses independently attempt to include a little of everything and little of it successfully. By undertaking this work as a team, we hope to achieve a department-wide curriculum that insures each student who majors in geology will have the opportunity to practice foundational skills regardless of the elective courses chosen.

The core geology curriculum at Amherst (see Table 2) has been quite stable over time and is consistent with discipline-wide norms for undergraduate majors in our field. Thus, we do not seek to radically change our major or to introduce a suite of new courses. Rather we hope to introduce new ways of teaching our subject content across our curriculum so that our labs, assignments, exercises and discussions can serve the dual purposes of teaching geology and of honing fundamental writing, speaking, and quantitative skills in our students. The stability of our core curriculum will insure that the innovations we devise, once implemented, assessed, and - where necessary - revised, will become an ongoing part of departmental instruction.

Our proposed program for 2016-17 consists of:

1) *Implementation of initiatives conceived in our Spring 2016 faculty seminar on teaching writing in science courses.*

Leader: Tekla Harms

Courses impacted:

Required courses - GEOL 111; GEOL 121; GEOL 291

Elective courses - GEOL 251; GEOL 311; GEOL 341; GEOL 401; GEOL 450

During our Spring 2016 writing seminar, Geology faculty focused on ways to introduce short writing assignments into many existing labs and homework exercises. We focused on “short” because such exercises can be focused, can allow revision without a significant time demand, can be implemented into many exercises and thus allow practice, and can habituate students to using writing as a way of synthesizing their learning. We also identified short writing assignments that build skills essential for reading and interpreting earth science publications and for the kind of writing done in senior theses – such as writing rock descriptions, framing a hypothesis, and constructing an abstract.

Examples that we developed include:

- “Exit tickets” for field trips and labs – in which a student must write a short, 10-minute summary of the significant points learned to conclude an exercise.
- “Postcards” where, given a photo of a geologic feature at the scale of a postcard, students explain the significance of the feature on the back of the image.
- Writing an abstract for a published paper they are given to read (from which the author’s abstract has been removed).
- “Matching game” where students write a succinct rock description that their peers must then match to the correct rock in a suite of rocks.

What is now left to be accomplished is for participating faculty to map out which of these and other writing exercises we intend to adopt in which courses. The department as a whole can then assess how and where a student will encounter each kind of writing in their passage through the Geology major and can work to insure that our students will have systematic scaffolding of their writing skills from semester to semester. During academic year 2016-17, faculty will develop and implement these new writing exercises in their courses. After each semester, in January and May, the four faculty will come together for a day-long retreat in which we compare what we did, assess the effectiveness of the exercises, and coordinate integrated scaffolding from course to course – modifying the exercise plans of each course accordingly.

2) A semester-long faculty discussion of quantitative skill training across the geology curriculum, modeled on our writing seminar experience.

Leader: Peter Crowley

Courses impacted to be determined. Likely:

Required courses - GEOL 111; GEOL 121; GEOL 291

Elective courses - GEOL 301; GEOL 311; GEOL 341;

Holding weekly lunch meetings through the fall semester of 2016-17, we will first ask ourselves to identify goals for our students. Which quantitative skills do we want them to have and at what level of proficiency? What habits of quantitative reasoning do we want them to practice? With the help of the staff in the Moss Quantitative Center and in Instructional and Curricular Design Services (ICDS), we will review pertinent literature on cognitive processes. As a group we will brainstorm on how to modify and enhance existing labs and exercises or introduce new activities that best support skill development. It is our experience that quantitative skills become desirable to students when those techniques offer the promise of untangling knotty geologic problems and of providing unique geologic insights - as ultimately it is the geology our majors are interested in. Thus, we will be seeking ways to imbed quantitative skill development into our existing program of geologic content transfer. We expect to mine the resources of the Science

Education Resource Center (SERC) (see <http://serc.carleton.edu/index.html>) – an National Science Foundation (NSF) funded Earth Science pedagogy resource - as we do this.

As part of this initiative, we propose to make a site visit (tentatively in Spring 2017) to the Geology Department at Carleton College in Northfield, MN. Among all Carnegie 1 institutions, Carleton College consistently ranks highest in the production of future PhD's in all STEM disciplines combined and in geology, specifically (see Table 3, based on data compiled by the NSF). Carleton was recently named a HHMI Capstone Institution (one of 11 in the country) for its incubation of new ideas and models for improving science education in higher education (see: <http://serc.carleton.edu/liberalarts/capstones/index.html>). We expect that Carleton has practices surrounding quantitative skill enhancement that we can investigate, adapt to our unique student body, and adopt to great advantage. As a Carleton alumnus, Dave Jones is uniquely positioned to help us in this translation exercise.

3) Consideration of a fall semester capstone course that would provide more structure and shared experience to the initial stages of senior independent research projects.

Leader: Anna Martini

Course impacted: GEOL 498

To a certain extent, the core of the independent research experience for each student lies in finding a way to manage inherent unknowns – to conceive of a hypothesis, to formulate a means of data gathering and analysis to test that hypothesis, and to think objectively about the meaning of the results. We do not want to supply seniors with a step-by-step recipe for senior theses. Nevertheless, our discussions over the past year suggest that there might be a middle ground. Geology faculty will focus on the possibility of instituting a more structured fall semester for senior theses, in which seniors would meet weekly in a seminar setting with a series of milestone deadlines that would be appropriate for all projects in any subdiscipline of geology, and that would give seniors a method for moving forward in the face of unknowns. Such a seminar would constitute the fall semester of the senior thesis and be required for all thesis students but could be open as an elective to non-thesis majors.

As part of this initiative, we hope to bring one or two members of the faculty of the Department of Earth and Environmental Sciences at Furman University in Greenville, NC to campus to consult with us, tentatively in Fall 2016. (Alternatively, two Amherst faculty could make a site visit to Furman.) Furman has a well-established history of undergraduate independent research and has recently developed a new cohort model for how their year-long senior projects are organized. They have found this model to be very successful in improving the success – both scientific and educational – of their thesis program for their students. Furman faculty presented the pedagogy of their cohort program in a Geoscience Education session at the Geological Society of America Annual Meeting in 2015 (abstract appended); Harms was in attendance and found the presentation most persuasive. Because he is an Amherst alumnus who completed a senior thesis as part of his geology major, Wes Dripps '92, Associate Professor and Chair at Furman, is ideally positioned and willing to introduce us to the Furman model and to help us brainstorm on how best to adapt it for our purposes.

We expect these discussions could result in a new course proposal in 2016-17 to be implemented for the class of 2019.

4) *Re-envisioning our Comprehensive Exam.*

Leader: Dave Jones

While we value the ability to think and speak extemporaneously based on one's geologic knowledge, this is not a skill we emphasize in the geology curriculum. As a result, most students' first experience with an oral exam occurs in the high stakes environment of our comprehensive exam. While this serves as a motivator for the kind of integrative studying the faculty mean students to undertake, the exam itself holds little educational value. In fact, we want our students to understand that content knowledge is necessary but not sufficient and want to design a comprehensive exam that better reflects our pedagogic values. Such an exam would call on our students to use the knowledge, skills, and experiences they have gained across the geology curriculum to solve a scientific problem. Preliminary ideas focus on a written component that poses a complex problem or suite of questions followed by a brief oral presentation of conclusions drawn by each student.

Faculty will do the bulk of the work of designing a restructured exam during the summer of 2017. A revised comprehensive exam would be ready for the class of 2018.

IMPACT AND ASSESSMENT:

Geology courses impacted by the four components of this proposal have been a part of the Geology Department curriculum for as long as the present faculty have been teaching at the College – well over a decade in most cases. This curricular stability means that the exercises in writing and quantitative reasoning that we develop and introduce in 2016-17 and 2017-18 will be practiced by the department on an on-going basis, whether in required or elective courses, scaffolded from the introductory level through intermediate and upper level courses to senior independent research.

Throughout the period of this grant, and in subsequent semesters as appropriate, we will seek assistance from the College's ICDS on how best to assess the efficacy of our initiatives. Faculty hope to learn how to devise assessment tools that are more productive and more specific than our present semester-end course evaluations and will rely on ICDS for help. In the longer term, we are prepared to survey our alumni with the same instrument used for our extensive alumni survey associated with our self-study and thus should be able to compare responses from before and after instituting the initiatives proposed here, although it will take some time for alumni to enter STEM graduate programs and to learn if our quantitative skills initiatives left them better able to perform at that level. Similarly, it may take several years for the "trickle up" of writing skills to produce better results in our senior theses and/or to hear from seniors whether or not they felt well prepared to handle thesis writing.

The Geology Department Chair will be responsible for coordinating reports on the results of this proposal. The leader specified for each of the four initiatives will report on that component to the Department Chair. It is our hope that our experiences will be of value to other science and quantitative departments at the College and will assemble our reports with that potential collaboration in mind.

TABLE 1
REQUIREMENTS FOR A GEOLOGY MAJOR AT PEER INSTITUTIONS

	COHORT LIBERAL ARTS COLLEGES											TOP MAJOR UNIVERSITIES				
	AMHERST GEOLOGY	BOWDOIN	CARLETON	COLGATE	COLORADO COLLEGE	FRANKLIN & MARSHALL	MIDDLEBURY	OBERLIN	SMITH	WHITMAN	WILLIAMS	HARVARD	MIT	UNIV. ARIZONA	UNIV. MICHIGAN	UNIV. WISCONSIN
# one-semester courses required for the major	9	10	12	11	11	12	13	10	10	10	9	14	13	21	12	14
# non-elective geology courses in major	4	1	0	5	6	7	3	5	6	2	0	2	5	8	0	5
# ancillary science courses required for the major	0	1	4	2	4	3	2	2	0	5	0	6	1	8	3	6
# ancillary science courses counted toward major but not required	1	1	0	1-2	0	0	0	0	0	0	0					
minimum # geology courses in major	9	9	8	9	7	9	11	8	10	5	9	8	12	13	9	8

Table 2
Geology Course Curriculum
Courses in green have GEOL 111 as a prerequisite
Courses in gold have two or more prerequisite courses (including GEOL 111)

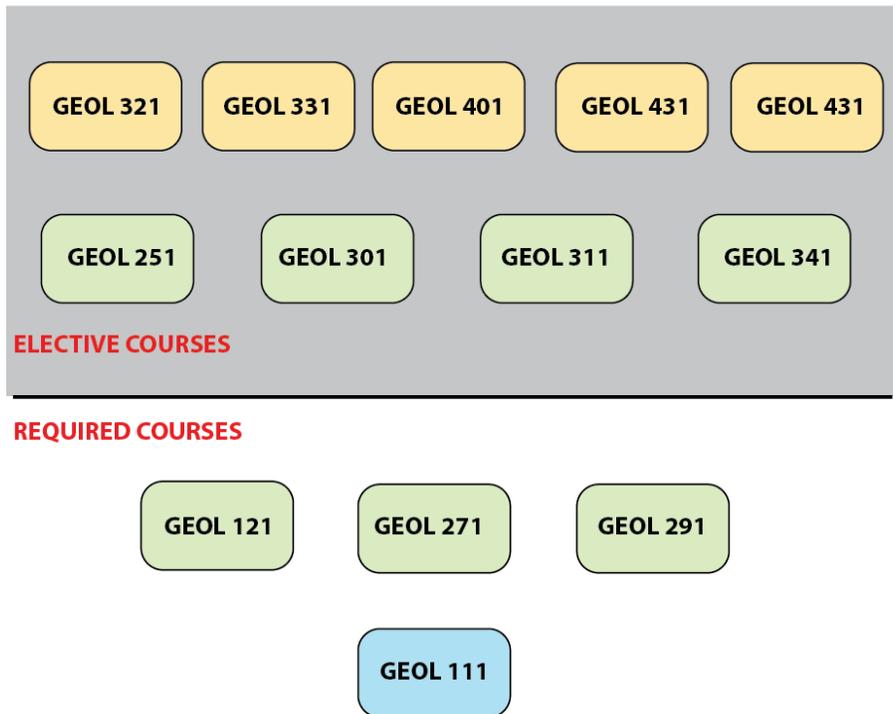


TABLE 3: Earned Doctorates, Carnegie 1, BA=highest degree
2005-2014

Academic Discipline, Broad (standardized)	Math and Computer Sciences			
	Physical Sciences	Geosciences	Sciences	Life Sciences
Carleton College	100	88	51	210
Williams College, Williamsto'	67	31	51	134
Oberlin College	39	30	37	194
Colgate University	34	29	17	119
Colorado College	30	27	9	106
Eckerd College	11	24	5	65
Whitman College	40	24	25	82
Macalester College	40	23	24	97
Pomona College	35	23	31	141
Smith College	30	23	23	142
Wesleyan University	41	22	18	156
Amherst College	36	21	31	108
Middlebury College	26	21	14	104
Bates College	25	19	10	89
Bowdoin College	25	17	18	113
Franklin & Marshall College	51	16	11	66
Colby College	36	15	10	113
Hamilton College	21	15	6	59
Bucknell University	40	13	23	114
Juniata College	31	13	4	66
Mount Holyoke College	27	13	15	133
University of Puget Sound	45	13	16	76
Beloit College	12	12	10	49
College of Wooster, The	55	11	9	79
Hampshire College	5	11	10	47
Occidental College	30	11	8	70
Augustana College, Rock Isla	16	10	8	71
Lawrence University	40	10	13	58
Bryn Mawr College	35	9	17	80
Furman University	43	9	17	76
Gustavus Adolphus College	46	9	10	76
Hope College	43	9	19	74
Richard Stockton College of I	15	9	2	56
Swarthmore College	61	9	47	171
Washington and Lee Univers	15	9	13	45
Dickinson College	18	8	4	71
Haverford College	48	8	25	113
Sewanee: The University of t	13	8	14	40
Skidmore College	8	8	6	78
StO Olaf College	50	8	39	152
Union College, Schenectady	26	8	9	47
University of North Carolina	21	8	6	38
Vassar College	48	8	14	103
Allegheny College	54	7	10	138
Cornell College	10	7	5	33
Grinnell College	55	7	22	145

Appendix: Abstract of Furman faculty presentation at the Geological Society of America Annual meeting, 2015

Abstract: TEACHING THROUGH RESEARCH (2015 GSA Annual Meeting in Baltimore, Maryland, USA (1-4 November 2015))

7/20/16, 6:19 PM



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2015 GSA Annual Meeting in Baltimore, Maryland, USA (1-4 November 2015)

Paper No. 186-5

Presentation Time: 9:10 AM

TEACHING THROUGH RESEARCH

DRIPPS, Weston R.¹, **RANSON, William A.**², **ANDERSEN, C. Brannon**¹ and **MUTHUKRISHNAN, Suresh**¹, (1)Department of Earth and Environmental Sciences, Furman University, 3300 Poinsett Highway, Greenville, SC 29613, (2)Earth and Environmental Sciences, Furman University, 3300 Poinsett Highway, Greenville, SC 29613, weston.dripps@furman.edu

"Teaching through Research" places great emphasis on collaborative faculty-student research and has become the cornerstone of engaged learning in Furman University's Department of Earth and Environmental Sciences. All Bachelor of Science students within the department are required to complete a senior thesis based on original research completed during the summer prior to the senior year. During fall of their senior year, students enroll in "Research and Analysis", a course designed to methodically guide them through the process of writing their senior thesis. Students meet as a cohort with an instructor twice a week and then individually with their thesis advisor on a weekly basis. The course provides detailed instruction on writing the various components to a thesis (e.g., introduction, methods, results, discussion) and requires that students generate multiple drafts of each section of their thesis with set deadlines. Drafts of each section are peer reviewed by classmates and assessed by the thesis advisor. Upon completion of the course, students have written a full draft of their thesis, and have submitted an abstract to a professional meeting. The spring term is used to further revise the thesis, present the work at a professional meeting, and defend the thesis at a public departmental defense. The recent addition of this course to the curriculum has provided substantially more instruction, structure, and collaboration within the research process, has significantly improved the quality of the research work, and has enhanced the thesis learning experience. The cohort model has changed what was previously an individual, independent, fairly isolating thesis experience to a peer supported, communal, collaborative bonding endeavor. This model requires a significant time commitment and active participation by all faculty overseeing thesis projects in order for it to be successful. From a curriculum development standpoint, the course has allowed the department to identify the core skills students need to successfully complete the senior thesis as well as exposed some competency weaknesses (e.g., graphing skills, hypothesis development, working with large datasets), which have subsequently been scaffolded throughout the curriculum, so that students build these skills prior to engaging in the senior thesis.

Handouts

[Dripps GSA 2015.ppt \(7.4 MB\)](#)

Session No. 186

[T81. Intentional Integration of Research into the Curriculum: Undergraduate Research as a Teaching Practice](#)

Tuesday, 3 November 2015: 8:00 AM-12:00 PM

Room 339 (Baltimore Convention Center)

Geological Society of America *Abstracts with Programs*. Vol. 47, No. 7, p. 475

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BUDGET:

Honoraria for four faculty participants (Crowley, Harms, Jones, Martini) at \$5000@
\$20,000

Two-day/three-night site visits to or consultative visits from Furman University and Carleton College;
2 faculty on each visit. \$ 5,200

Per faculty cost estimates:

air fare = \$800

ground transport = \$100

meals and lodging at \$200/day = \$400

Honoraria for those making a consultative visit to Amherst \$ 1500
\$500 per person for (estimated) three faculty

Miscellaneous meals, materials, software, publications \$ 1,000

TOTAL \$27,700