ACS Reform of Introductory Science courses for Non-Majors Course Mini-grants
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Redesign of *Exploring Earth;* an inquiry-based studio format geoscience course

Summary
The goal of this project is to significantly improve the student experience in *Exploring Earth* through the redesign of the structure of the course and sequence of topics, and the reimplementation of major student projects that comprise the course. Specific objectives include increasing the role of student inquiry in shaping the scope and methodology of the projects, and making the geoscience content of the course more holistic. The redesign will include (1) developing a new introductory field-based project that poses questions and defines goals for the entire course, (2) reordering and recombining topics into a more articulated sequence of fewer but larger projects, (3) integrating the availability of tablet PCs into the projects as a quantitative tool and source of content information via Just-in-Time-Teaching (JiTT)[1], (4) developing a set of pre-project readings that provide focused content background and stimulate an inquisitive approach to each project and (5) developing a capstone project that provides students with a sense of closure and accomplishment in the course. The vast majority of students enrolling in this course are non-science majors. While our proposed changes will improve the experience for all students, they will have a profound impact on non-science majors by delivering a course that will enrich their lives by providing the experience needed to understand the planet they live on and the impact of the geologic environment on their lives.

Project Description
Goals and Objectives: The goal of this project is to significantly improve the student (and faculty!) experience in *Exploring Earth* (GEOS 1307) through the redesign of the structure of the course and sequence of topics, and the reimplementation of major student projects that comprise the course. Specific objectives include increasing the role of student inquiry in shaping the scope and methodology of the projects, making the geoscience content of the course more holistic, and improving students' sense of closure and accomplishment through the addition of field-based, "bookend," introductory and capstone projects in the course.

Background and Significance: Exploring Earth is a 3-credit "studio" geoscience course that integrates lecture and discussion with a series of hands-on laboratory and field projects. We introduced this course three years ago as a replacement for a more traditional 4-credit lecture/lab course in Physical Geology. This course is now the Geosciences Department's sole introductory offering that fulfills the laboratory component of Trinity's Common Curriculum, our general education distribution

requirement. The department offers multiple sections of the course each semester with a maximum enrollment of 24 students per section.

The 3-credit studio format is particularly appropriate for an introductory geoscience course where most topics involve geologic materials such as minerals, rocks and maps. Students should learn about granite while looking at a specimen with a loupe, not looking at a PowerPoint image on a screen. This format was also envisioned as a prototype for the potential incorporation of of hands-on learning into many introductory science courses offered for non-science majors.

In addition to working with the traditional materials, rocks and maps, Exploring Earth was intended to expose students to modern instrumental and quantitative aspects of geoscience. To that end, the course projects now include the use of GPS technology, geophysical equipment including gravity meters and exploration seismographs, and polarizing petrographic binocular microscopes. Next year, tablet PC computers will be introduced in both lab and field projects.

Based on the results of standard university and custom departmental student evaluations, the present incarnation of Exploring Earth is approximately as successful as its lecture/lab Physical Geology antecedent. That said, the course falls short of our expectations in several key areas. While satisfied with the course, students aren't raving about it. Given our investment of time and resources, we would like to achieve higher student satisfaction with, and demand for, the course. We would like that satisfaction and demand to allow us to offer more sections of this hands-on course in lieu of other, purely lecture, courses. Students and faculty note that the course has a disconnected feeling. Project topics feel disjointed and the pacing of the lecture, discussion and projects is uneven with some topics dragging and others feeling rushed. Of particular concern is the fact that the scope and methods of the projects are overly prescribed and lack the inquiry-driven quality we would like to achieve.

From student feedback and faculty experience, we believe that the shortcomings of Exploring Earth can be traced to two fundamental issues. First, nearly all of the students entering the course lack any significant geoscience content knowledge. It is hard to ask intelligent questions when you don't know anything about the subject. Second, the traditional lecture/lab Physical Geology course accommodated this lack of content background with a constructive sequencing of topics. Minerals are introduced first, then rocks which are made of minerals, finally maps and field work where the knowledge of minerals and rocks can be used. This sequence, although logical, may be inappropriate for an inquiry-driven course. If you have never looked at a rock outcrop or map, you have no reason to be interested in rocks, and if you have never cared what a rock is, you have no reason to be interested in minerals!

Detailed Project Plan: The plan for the redesign of Exploring Earth includes (1) developing a new introductory field-based project that poses questions and defines goals for the entire course, (2) reordering and recombining topics into a more holistic sequence of fewer but larger projects, (3) integrating the availability of tablet PCs into the projects as a quantitative tool and source of content information via Just-in-Time-Teaching[1], (4) developing a set of pre-project readings that provide focused content background and stimulate an inquisitive approach to each project and (5) developing a capstone project that provides students with a sense of closure and accomplishment in the course.

Staring into a box of mineral samples is no way to begin an inquiry driven geoscience course! We will develop a two-week opening project that takes students into the field. A possible destination is a nearby spring along a fault. Students would use GPS to locate themselves on a geologic map which portrays the rock types, contacts, and the fault. The goal of this project is to stimulate the questions that will drive the remainder of the course: what are these rock types, how did they form, how did the fault form, what is the geologic history of the region and how do the rock types and fault govern the distribution and flow of groundwater?

Several of the existing, successful projects, will be reordered and recombined into two-week projects. For example, rather than the traditional sequence of igneous, sedimentary and metamorphic rock projects in three successive weeks, we envision a two- to three-week project that involves igneous rocks and the volcanic landforms they are associate with. This project would integrate hand specimen and microscope analysis of rock specimens with PC based 3D visualization of the digital topography and remotely-sensed imagery of volcanic landforms. Our plan is to develop at least four of these longer projects using the successful components of the existing projects along with new materials and PC support.

In order to support the new projects we will develop a set of pre-project readings that will provide tailored content background for each project. These readings will include specific content material, suggestions for further web-based information on the topic, an article from a recent journal (e.g. American Scientist or Geotimes) on the topic. Each reading will culminate in one or more essay questions designed to illuminate the areas of inquiry for the upcoming project. Students will be expected to complete their responses to these questions before the first class period of the project. A class discussion of those responses will be used to launch each project.

Finally, we will combine an existing field trip and an existing project on interpretation of geologic time into a capstone project for the course. This project will draw on the skills and content of the previous projects. For example, the project will include hand specimen and microscopic analysis of rock specimens, use of paper and digital geologic and topographic maps and web-based access to paleogeographic maps. One goal of this capstone project is to place local and regional geologic processes and history in the context of global geologic processes and history. The other goal is to provide students with a sense of closure and accomplishment that we feel is particularly important for the non-science major in an introductory science course.

Prior Activities: During the three years of Exploring Earth offerings, many aspects of the projects have been developed and refined. Materials and procedures for hand specimen and microscopic analysis of rocks are in good shape. The two major field trips in the class have been refined and field guide materials have been written. During the spring semester of 2003, Glenn Kroeger experimented with resequencing existing one-week projects into two-three week projects in a section of Exploring Earth. Software for the 3D visualization of digital topographic data and remote sensing data has already been acquired and tested with potential data sets.

Projected Timetable: Kroeger and DeGraaff-Surpless will each devote at least five full-time weeks of this summer to the reorganization of the major course projects and the creation of the new project materials. They will be supported by the departmental technician and an institutionally funded student worker. In mid-August, Kroeger and

DeGraaff-Surpless will conduct an afternoon workshop for student mentors introducing them to the concepts and structure of an inquiry-based studio science course. We expect this to channel accurate information about the course to incoming first-year students. Kroeger and DeGraaff-Surpless will each teach a section of the course in the fall of 2004. In January 2005, the course materials will be updated and two more sections of the course will be offered in the spring of 2005.

Context of the course in the curriculum / Impact on the institution: Exploring Earth is the sole offering of the Geosciences department in the laboratory science component of Trinity's Common Curriculum. It is a major path for non-science majors completing their degree requirements. The Trinity faculty have recently approved a substantial revision to the Common Curriculum that renames this component as "scientific methods" and explicitly supports the importance of 3-credit, studio style, science courses for non-science majors. As the first course of its kind at Trinity, Exploring Earth is now an important model for future course offerings from other science departments. Institutional support: The University and Department are making a significant commitment of faculty and other resources to this course. We have just hired a new faculty member, Kathleen DeGraaff Surpless, who brings significant experience in designing and teaching introductory hand-on geoscience courses. The department will continue to offer at least two sections of the course each semester with occasional summer offerings. The department will continue to support each section with a student teaching assistant. These geoscience majors and minors are supported with both institutional and work-study funding. In the last 18 months, we have invested approximately $38K in new microscopes and $5K in software for this course. In the coming year, we will invest another $10K in new GPS equipment and $22K in computer equipment for the course. Finally, the new Common Curriculum explicitly highlights this form of 3-credit studio format course as mechanism for delivering a hands-on science experience for non-science majors.

Evaluation, Dissemination, and Continued Support

We plan to employ the following forms of evaluation to measure our progress in the redesign of Exploring Earth.

1. Standard Trinity University Course Evaluations: While not a particularly enlightened instrument, this evaluation is required every semester in every section. It consists of a series of agree-disagree questions that cover instructor organization, instructor availability, perceived fairness and feedback of grading, and the overall effectiveness of the course. Each question allows room for student comments. The primary value of this evaluation is our long time history of these evaluations both in Exploring Earth and in other introductory geoscience courses that will allow us to judge improvement (or, heaven-forbid, regression) from previous incarnations of the course.
2. Customized Departmental Evaluations: We have used a variety of these instruments over the last three years, so we have some history for comparison. The primary goal of this form is to evaluate the relative effectiveness of and student satisfaction with the various projects during the semester. As part of our work this summer, we will develop a single version of this instrument to use in all of the sections offered in the 2004-2005 academic year.

3. Content Pre and Post-Test: Since we postulate that one of the problems with the course has been lack of student content knowledge, we plan to try to measure the change that occurs during the semester. We do not plan to develop a detailed content test. Rather, we envision this instrument consisting of a few short reading passages about current issues in geoscience (e.g. scarcity of water resources, danger of extraterrestrial impacts) followed by some questions that investigate the students' comprehension of the issues. The reading passages will be informative, but will depend on some basic knowledge about the Earth.
4. Focus groups: At the end of the fall semester, we plan to convene a small focus group from each section to discuss student satisfaction with the course. A prime question will be whether they will recommend the course to their peers, and the reasons they give for their answer.
5. Survey of Student Attitudes toward Science: We are extremely interested in the instruments being developed by Bruce Callen at Drury University and would like to be included in the pilot program to evaluate changes in student attitudes toward science after taking Exploring Earth.

Dissemination of the results of our redesign of Exploring Earth will occur at several levels. Within Trinity University we plan to meet with our colleagues in the Physics and Astronomy Department and in the Computer Science Department. Both of these departments have expressed an interest in pursuing the development of studio-format courses for inclusion in the new Common Curriculum. Obviously we also want to be included in future course design and assessment workshops sponsored by the ACS. Within the geoscience community, we plan to present our experiences in two venues. First, we will present a paper in the appropriate education session at the annual meeting of the Geological Society of America in the fall of 2005. Finally, we plan to write a short paper describing our results for submission to the Journal of Geoscience Education published by the National Association of Geoscience Teachers (www.nagt.org).

The Department and University are committed to the continuing support of this studio-format course as our primary offering of an active learning course for non-science majors in Trinity's Common Curriculum. In addition to the funds needed for adding tablet PCs we have secured follow on funding that will allow an additional investment of approximately $25K in equipment and materials during the 2005-2006 academic year.

Literature Cited

1. Novak, G., Gavrin, A., Christian, W., and Patterson, E., 1999, Just-in-Time-Teaching: Blending Active Learning with Web Technology, Prentice Hall, pp. 188, ISBN: 0-13-085034-9.