The course-embedded research project in undergraduate geoscience education: introduction to research, development of communication skills and means of programmatic assessment

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Summary
The Pet Rock Project, a course-embedded research project, in the junior-level Igneous and Metamorphic Petrology course at Louisiana State University (LSU) has been a successful vehicle to provide all undergraduate geology students with a controlled research experience and with an opportunity to instruct students on effective methods of oral and written communication. The rubrics developed for assessment of individual students on this project have been repurposed to examine the level of attainment of the communication learning outcome associated with the BS degree program at LSU.

Introduction
Incorporation of research projects in geoscience major's courses can have a number of benefits that go beyond determination of individual student grades. It can introduce students into the culture of research, generally for the first time. It is also a practical mechanism to educate geoscience students on various aspects of best practices in oral and written communications in the sciences. Finally, it can serve as an effective, relatively noninvasive, means of assessing undergraduate degree program learning outcomes. In the junior-level Igneous and Metamorphic Petrology course at LSU, the assignment called the "Pet-Rock Project" is the course-embedded research project that permits the attainment of these learning and programmatic goals.

Several resources and procedures are in place at LSU that make the approach described here feasible.

(1) There are rock-preparation, petrography and SEM/Electron Microprobe labs that are in operation and permit students to take the progression of steps that would be followed by a professional petrologist to study unknown rock samples. Other analytical equipment could be substituted, depending on the resources available at an individual institution.

(2) The Igneous and Metamorphic Petrology course is designated a communications-intensive (CI) course in oral and written communications. This designation is certified by the Communications across the Curriculum (CxC) Program at LSU. CxC is focused on "*enhancing learning experiences for students and improving their written, spoken, visual presentation, and technological communication skills*"(Communication across the Curriculum, 2010). The implication of the CI certification is that a significant proportion of the student grade is based on communications-based projects (>40%) and that there s adequate feedback time for revision prior to the final products.

(3) The College of Basic Sciences (BASC) at LSU has a communications studio staffed with communications professionals that assist faculty in development and maintenance of CI-

certified courses (Fava and Henry, 2009; Henry 2009a). Early in the semester prior to any oral presentations, the staff of the BASC-CI lab gives a presentation on procedures and best-practices for giving talks.

(4) Distinct and detailed rubrics are used to evaluate a series of criteria meant to relate to the typical requirements of writing a professional-style research paper and giving a professional-style oral presentation in the geosciences (Henry, 2009b). Although the entire class participates in the assessment of oral presentation, only the scoring by the course instructor is used in evaluating the results of the rubrics associated with programmatic oral and written communications assessment.

Description of project

The Pet Rock Project is a nearly semester-long project in which each student is assigned a sample and then follows most of the steps a petrologist would take to analyze and interpret a rock from a known area (Beartooth Mountains, Montana and Wyoming, USA). After preliminary input from the instructor, each student presents the revised results of this study in a written form comparable to a professional petrology journal and in an oral form comparable to that given at a professional geology meeting.

This project runs in the background of the petrology class during the initial part of the semester while each student acquires the petrologic skills to make more sophisticated interpretations. However, during the semester each student must make continuous progress and follow a series of well-defined steps in order to produce a robust petrologic study. Steps, timelines and logistics for a 15-week semester include:

(1) Week 1. Choosing the sample. Because Louisiana is an “outcrop-challenged” state, students randomly choose a metamorphic or igneous rock sample from the Beartooth Mountains and are given the responsibility (as a ward of the sample) of caring for and processing the sample.

(2) Week 2-3. Hand sample description and preparation. The mineralogy and textures are described and samples are cut and prepared for production of a polished thin section.

(3) Week 5-7. Petrographic description of the thin section and initial background reading. Each student works with the instructor make sure that the petrographic description of the sample is accurate, analytical targets are identified and photomicrographs are taken. Background geological literature reading is started at this point.

(4) Week 8-10. Micro-analytical studies of the sample. Each student has an extended session with the instructor in the SEM/microprobe lab, typically 2-4 hours. During this time, the students take a backscattered electron image(s) of the area(s) of the earlier photomicrograph, verify the identity of the minerals in the BSE image with energy dispersive spectrometry and quantitatively analyze selected minerals using the BSE image as a base map. During this process there is generally time to discuss normalization procedures for individual minerals, and application of the appropriate thermobarometers for their sample. Following the analytical session, a variety of programs are made available to the students to normalize the mineral formulae and calculate conditions of formation.

(5) Week 11-12. Preparation of preliminary 10 page written report and 12 minute oral presentation. The culmination of the Pet Rock Project is a written and oral report of the student’s findings in a geologic and petrologic context. In other words, each student takes their results and puts them together as if the student are submitting their findings to a professional journal and giving their oral presentation at a professional meeting. Guidelines and rubrics of the written and oral presentations are made available to the students (Henry, 2009b). This preliminary submission of materials is meant to allow each

student team to make revisions based on the feedback from the instructor and staff in the BASC-CI lab, and is not graded.

(6) Week 15. Presentation of the revised oral report at a semester-end Igneous and Metamorphic Petrology Symposium Day, together with the completion of the revised written report. Each student gives a 12 minute PowerPoint© presentation with 3 minutes left for questions and answers. This Igneous and Metamorphic Petrology Symposium is conducted as if it were at a professional meeting, with the students dressing and conducting themselves accordingly. The Symposium is moderated by the students. The Symposium is advertised and open to the public. The oral presentations should be revised in accordance to earlier discussions with the instructor and staff of the BASC-CI lab. Each presentation is evaluated by the instructor, TA and each of the other students in class using evaluation forms (rubrics) that consider a variety of aspects of the presentation. Each student will also submit the revised 10 page report to the instructor.

Results and discussion

Research experience and communication skills – assessment of the individual student.

The Pet Rock Project, as an embedded research project, has been used in the Petrology class for 14 years. The limited scope of the embedded research project, a single sample from a geologically restricted area (Archean rocks of the Beartooth Mountains), provides the entire group of students with a similar research experience i.e. common geologic background and imaging/analytical tools. Consequently, this has engendered wide-ranging student-student discussion on many, often open-ended, topics. The acquisition of the data by the students creates an ownership that augments the experience.

Since 2005, when this class was certified as communications intensive, the student experience has been further enhanced. A clear set of guidelines for writing a geology (petrology) paper was generated (see Henry, 2009b). Within the writing guidelines, 15 writing criteria were established and weighted in accordance with their relative importance – roughly half being related to expected components/content and half related to the practice of writing. A similar rubric was established for the oral presentations with16 criteria – about half related to content and half related to presentation skills. With these guidelines and rubrics available to the students there is a clear establishment of expectations. In addition, the well-defined scoring rubrics allowed a clear means to assess the individual student scores on these portions of the course.

Attainment of the programmatic communications learning objective

In 2009 the Pet Rock oral and written communications assignments became the designated means to assess the communication learning outcome for the BS degree in Geology i.e. "*Students will develop the ability to effectively communicate geologic concepts and material in written and oral formats*". This is appropriate because this course is required of all Geology majors, generally capturing the students within a year of graduation.

To repurpose the oral and written communications rubrics, each of the 15 written criteria and 16 oral criteria were renormalized to a common 5-point scale. An average, standard deviation and a histogram of the class as a whole (and not individual students) could be readily generated. Initially, a threshold value of 3.0 was chosen as the level for successful attainment of each criterion. The first use of this approach showed that the averages of each of the written criteria were above 3.0, except criteria related to discussions/conclusions and to tables. The averages of the oral criteria were all above 3.0. Additional information of potential issues was more obvious when histograms of each criterion were examined.

When an individual faculty member is responsible for assessment of a programmatic learning outcome, the rater reliability should be considered. In 2009, there was an opportunity to test rater reliability. For 9 of the 23 students in Geology 3041 (Igneous and Metamorphic Petrology), the same Pet Rock writing project was also used as the semester-long research assignment for Geology 4002 (Petrologic Mineralogy). The instructor of Geology 4002 used the same writing rubric as was used for Geology 3041. However, there was a slightly different emphasis and interpretation of some of the criteria used in the writing rubric. Despite these minor differences, the strong correlation (R^2 = 0.89) between the two independent raters is very encouraging and suggests a strong inter-rater reliability (Fig. 1). Deviations from the 1:1 line appear to be largely a function of the different emphases and interpretations of some of the criteria between the instructors. This inter-rater reliability provides additional support for using these types of projects to assess communication skills in undergraduate programs.

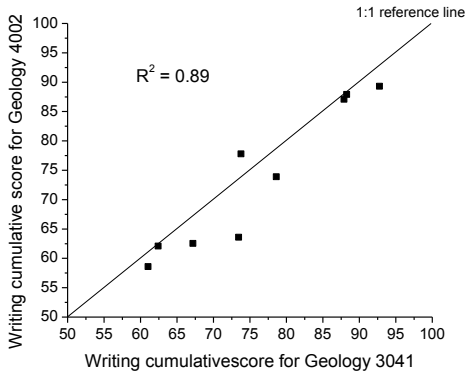

Figure 1. Comparison of scores obtained on the same writing assignment from two different raters

An important purpose of programmatic assessment is to obtain data and use it to improve learning outcomes. The data obtained from the 2009 rubrics and feedback from other faculty suggests that there be some actions taken to improve attainment of the communications objective. The following represent a few things that were learned from this process: (1) there should be a better explanation of the material that is most appropriate in the abstract, results and discussion section; (2) early feedback for revision of the oral and written drafts would help student and instructor; (3) video recording of the oral presentation would allow additional review possibilities by the instructor; (4) the threshold values appropriate for successfully attaining a given criterion in the rubrics should be examined further; and (5) modification of portions of the rubrics after additional feedback from faculty and students will likely strengthen the process.

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