Course-embedded research and scientific communications in undergraduate geology majors courses: Examples from the Mineralogy – Igneous/Metamorphic Petrology sequence at LSU
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INTRODUCTION
The opportunity for all undergraduate geoscience students to obtain authentic research experiences and to learn effective communication of this research is a powerful means to establish deeper understanding of geoscience topics as well as to engage all students in the culture and practice of research. The purpose of this contribution is to provide an example of an integrated approach that provides a research and communications experience for all geoscience majors within a geoscience curriculum. This undergraduate research and communications experience, realized in the Mineralogy – Igneous/Metamorphic Petrology sequence at LSU, builds on opportunities and resources of the On the Cutting Edge program.

The legacy of “On the Cutting Edge”
Cutting Edge workshops have been and continue to be critical for expanding boundaries of the possible. In addition, Cutting-Edge online resources have been particularly useful both for faculty development and student learning.

MINERALOGY
In the required sophomore-level Mineralogy course, crystallographic and physical properties, chemical systematics and 3-D visualization of mineral frameworks are studied. Students are introduced to optical microscopy and optical cathodoluminescence (CL) as tools to discover unique and diagnostic properties of minerals. As a way for these students to explore concepts, to improve spatial mapping from different images, and to put theory into practice, the LSU electron microprobe (EMP) is used to provide a research experience in Mineralogy.

IGNEOUS AND METAMORPHIC PETROLOGY
In the full embedded research, the Pet Rock Project, students follow the steps of a practicing petrologist going from megascopic to microscopic descriptions, EMP imaging and quantitative analyses of selected minerals and interpreting data to provide evidence for a coherent story for development of the selected rock. Next, students write a professional petrology-type paper and give a talk to the class.

The limited scope of the embedded research project, a single sample from a geologically restricted area, is important because it:
- Provides the entire group of students with a similar research experience i.e. common geologic background and imaging/analytical tools.
- Engenders wide-ranging student-student discussion on many, often open-ended, topics.
- Creates ownership of data by personal acquisition of data and this augments the experience.

Certification of the class as communications intensive enhances the student experience because:
- A clear set of guidelines for writing a geology (petrology) paper was generated (e.g. Henry, 2009b)
- 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 – about half related to content and half related to presentation skills.
- Guidelines and rubrics are given to students so that there is a clear establishment of expectations.

LESSONS LEARNED
Experience with course-embedded has provided several lessons:
- Have well-formulated rubrics.
- Adjust expectations if equipment fails.
- With larger class size, group projects will likely be necessary. Group projects have their own challenges e.g. dynamics, group scoring, etc.
- Be ready for a transformation in the students.

MEASURABLE OUTCOMES
A measurable outcome of the course embedded research opportunities is the enhanced engagement of undergraduate students in subsequent research, measured by enrollment in research specific undergraduate courses, with geoscience faculty i.e. beginning with 16 in 2002-2004 and expanding to 145 in 2015-2017.

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RESOURCES