Introducing University Students to Authentic, Hands-On Undergraduate Geoscience Research in Entry-Level Coursework

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1 Introduction

The Council on Undergraduate Research (CUR) is a nonprofit educational organization that mentors university faculty in developing and sustaining undergraduate student research investigations (for the purposes of this chapter, the term "undergraduate" refers to students in the equivalent of grades 13 through 16 in the American higher education system). CUR defines undergraduate research as "an inquiry or investigation conducted by an undergraduate student that makes an original intellectual or creative contribution to the discipline" (Wenzel 1997). The first part of the definition states that research is original work and is, therefore, aimed at creating new knowledge. The second part of the definition states that the work is intended as a contribution to the discipline, implying that the results should be disseminated to the professional community through acceptable media, such as conference presentations and scholarly publications. Halstead's (1997) definition is in agreement, that undergraduate research "must be an original investigation that the student engages in for a significant period of time… a student collaborates with a faculty member on an ongoing long-term project, usually initiated by the faculty member. The project is expected to be funded… and to result in publication in a peer-reviewed scientific journal."

These descriptions of undergraduate research imply that undergraduate research is for students in advanced standing with a long enough period of time and mastery of content to be able to create new knowledge that is then published through a respected journal. There is no disagreement that undergraduate research offers many benefits to students, including advanced cognitive and intellectual growth, professional growth and advancement, and personal growth (Osborn and Karukstis 2009).

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However, there is no reason undergraduate research experiences have to be so rigorous in their structure and execution.

Beckman and Hensel (2009) have published an excellent article that assists faculty in understanding a range of dimensions to undergraduate research. Their working definition asks faculty to think of undergraduate research as several categories that fall along a continuum. For example, research experiences can range from student initiated to faculty initiated, interdisciplinary to disciplinary, and original to the student to original to the discipline. I would add to their model the continuum of introductory level to advanced level, and course based to outside of a course.

It should not be a surprise that undergraduate research projects already exist embedded in courses offered for students in their first 2 years at a university. In fact, Cejda (2009) reports that at 2-year colleges in the United States, undergraduate research is typically found on campus as a component of the curriculum rather than a component of a faculty research agenda. I share my insights and experiences with conducting undergraduate research in my introductory-level geoscience courses and the importance of making those research experiences as authentic and applicable as possible.

2 Trends

In the approximately 15 years I have been teaching geoscience and geography courses in higher education, I have not seen a change in how to categorize the students enrolled in my courses – the students are primarily first- and second-year university-level students, nonscience majors, looking to enroll in the course to satisfy a curriculum requirement (at my university, no matter what major a student is pursuing, he/she must take three science courses for graduation). However, I have seen a notable shift in student expectations, attitudes, and levels of engagement in and out of the classroom. Students are still drawn to geoscience courses for the hands-on exercises carried out during the laboratory periods, especially the times we are outdoors doing our work, whether it is on campus or at sites in the region. Both my colleagues and I have moved away from the "cookbook" laboratory exercises provided with textbooks and laboratory manuals. These prefabricated data and exercises are typically designed in a linear fashion for students to reach a solution to a proposed set of prompts. These exercises do not effectively engage students nor do they provide students with an authentic research-based experience driven by inquiry (Rissing and Cogan 2009).

I have seen my students grow increasingly interested and concerned with the intersections of science and society, especially with reference to natural disasters and hazards and natural economic resources. I know there are faculty in all disciplines who have heard from students, "so how does this apply to me?" Fortunately, the faculty are also hearing the follow-up question, "so what can I do about this?" Students are looking for ways to see the applicability of what they are learning and how they can take action to contribute solutions to today's global challenges.

I am also seeing a change in who is sitting in my classroom. I am seeing a decrease in the traditional-aged college student and an increase in the nontraditional student – the parent that dropped out of school to raise a family now coming back, the serviceman returning from military service overseas (Brown and Gross 2011), etc. My nontraditional students have strong ties to the local community, as do the traditional-aged college students who have decided to continue living at home instead of in on-campus dormitory housing to save money. Overall, there is an increase in the culture among my students to be connected to their local communities, and students are looking for additional ways to give back to local organizations beyond volunteering outside the classroom.

The Project Kaleidoscope (2006) report *Recommendations for Urgent Action* further supports what I am seeing in student expectations, stating that each undergraduate student should be (1) challenged with inquiry-based learning for a deep understanding of science, mathematics, and technological tools and (2) have research opportunities beyond the classroom and campus to connect student learning of content and skills in STEM (science, technology, engineering, math) fields to the world, so students appreciate the relevance of their studies and consider STEM careers. Undergraduate research provides the opportunity to address the demands and expectations of the changes in my classroom. By providing authentic experiences that allow students to learn the geoscience content while developing essential skills, I am avoiding the non-engaging "cookbook" exercises where students can find little relevance and applicability to their local community.

3 Challenges to Overcome

Introductory-level geoscience courses are filled with students receiving their first formal introduction to the content of the discipline. For many students, it may be their first and last opportunity to be instructed in the geosciences. This creates a challenge for faculty, as without a strong foundation and understanding of geoscience, students lack the preparation necessary to complete a research project in this discipline. However, I have found that beginning undergraduate research in introductory-level courses allows for students to develop several valuable research-based skill sets. These research skills provide a solid foundation where the skills they learn can be applied and further developed in upper-division courses, which will then prove useful in future careers. Some of the fundamental undergraduate research skills students can be introduced to and develop may include learning how to complete a literature review, how to process and graphically represent data, how to work as a team, and how to see research through to completion (Guertin and Esparragoza 2009).

Many geoscience and geography courses take advantage of the natural, outdoor environment. I have seen that bringing students outside, even if they are still doing laboratory work on campus, gets them excited and engaged to learn.

Certainly, much geoscience-based research is grounded in data that can be collected from outdoor locations, which then provides a natural environment for undergraduate research projects. However, not all university campuses, especially those located in urban areas, have access to geologic outcrops, rivers and streams, etc. The initial hands-on geoscience experience that has served as the foundation for so many geologists to pursue this career field may not be accessible to students during the early years when they are deciding upon a degree program. Not getting outdoors can limit the opportunity to provide the authentic research experiences students are looking for.

For some faculty, there is the concern of having enough time during a semester to complete all the course objectives and to cover all the course content. Embedding inquiry-based activities into the introductory-level geoscience classroom requires in-class time, from introducing the activity to students to carrying out the exercise to completing the analysis and dissemination. For example, when I take the students in my oceanography course to the Atlantic coast to complete a temporal and spatial investigation of beach profiles, we utilize handheld technology as a data collection tool (Guertin 2006). This requires that I take time to train students on how to use the handheld technology to enter and download the data, before I then train the students on how to work with and plot data in Microsoft Excel. Faculty such as myself quickly learn we have to sacrifice covering course content to make room for research-based experiences during the term.

4 Recommendations for Good Practices

As stated previously, faculty should not feel obligated to follow the strict definition of undergraduate research when integrating research experiences into introductory-level courses but instead revisit Beckman and Hensel's (2009) range of dimensions to undergraduate research. A review of these various components and practices of undergraduate research can remind us that we can design opportunities for students to receive an early and effective student-centered, inquiry-based experience.

One practice for developing student participation in discipline-based projects would be to engage introductory-level students in local-to-international "citizen science" programs. Citizen science programs are led by professional scientists but allow, even encourage, amateur and nonprofessional scientists in the process of collecting and entering data online for projects that may be too large in size and scope for the primary investigators. I have had students contribute to citizen science programs, such as EarthTrek's Gravestone Project (http://www.goearthtrek.com/Gravestones/Gravestones.html), a project that aims to map the location of graveyards around the globe and then use marble gravestones in those graveyards to measure the weathering rate of marble at that location. My students have also contributed to the World Water Monitoring Challenge (http://www.worldwatermonitoringday.org/), an effort that engages global citizens to conduct basic monitoring of their local water bodies. With both of these projects, my students practice data collection and analysis and have the opportunity to access the data already entered into these databases for a global comparison. This scales up the project in its rigor and expectations for synthesis and evaluation of data.

Faculty may be able to find local community partners that have an identified need that even an introductory-level student group could assist. In my geoscience and geography courses with an outdoor laboratory component, I have had groups of students complete GPS mapping of trails at a local arboretum (Dufoe and Guertin 2011; Orner et al. 2011) and create an enhanced podcast of environmental information for a walking trail in a state park (Woodruff et al. 2009). Informal science education centers, such as museums, also offer the opportunity for students to conduct research to benefit their outreach efforts. For example, I had two students in a course I was teaching about dinosaurs who decided to pursue a project that allowed them to take their dinosaur content knowledge and combine their communication technology skills to create an online video to present unique dinosaur knowledge to virtual museum visitors (DiLauro et al. 2010).

I encourage faculty to pursue interdisciplinary projects with colleagues across their university, not only to inspire their own "out-of-the-box" thinking and approach toward developing undergraduate research projects but to demonstrate to students the interdisciplinary nature of the geosciences. A year ago, I was at a university function where I was sitting across the table from a faculty member in the department of music education. My colleague was describing one of the challenges her preservice teachers face in the elementary-school classroom, with static maps and world music presented as a set of disjoined facts. I described how Google Earth could be a tool to facilitate the delivery of music, images, landforms, etc., all in one interface. Since our first meeting, we have had graduate students and undergraduate students bridge the disciplines and create music education curricula enhanced with geospatial technology (Clements and Guertin 2011).

5 Conclusions

Introductory-level geoscience courses can be designed to provide undergraduate students the opportunity for early, authentic research experiences. These inquiry-based opportunities can be conducted in conjunction with global citizen science projects, for community partners, or across university disciplines. Even for students not pursuing a career in the geosciences, an undergraduate research experience will provide students content knowledge and skill sets that can be applied to future studies and careers.

Overview

Status Quo and/or Trends

– Geoscience classrooms are moving away from "cookbook" exercises provided in laboratory manuals with prefabricated data designed for students to reach a solution to an experiment. Increasingly, geoscience courses have students engage in authentic research-based experiences, driven by inquiry.
– Students are establishing connections to their local communities and are looking for additional ways to give back to local organizations beyond volunteering outside the classroom, and research can allow students to do so.
– Students are growing increasingly interested and concerned with the intersections of science and society, especially with reference to natural disasters and hazards and economic resources. Students are looking for ways to contribute solutions to today's global challenges.

Challenges to Overcome

– Students enrolled in introductory-level geoscience courses are learning the content knowledge of the discipline for the first time. Without a strong foundation and understanding of geosciences, students may lack the preparation necessary to complete a discipline-based research project.
– Geoscience-based research can be grounded in data collected from outdoor locations. However, not all university campuses, especially those located in urban areas, have access to geologic outcrops, streams, etc. The initial "hands-on" experience that served as the foundation for professional geologists to pursue this career field may not be accessible to students during the early years when they are deciding upon a degree program.
– Embedding inquiry-based activities into the introductory-level geoscience classroom requires in-class time, from introducing the activity to students to carrying out the exercise to completing the analysis and dissemination. Faculty may have to sacrifice covering course content to make room for research projects during the term.

Recommendations for Good Practices

– Inquiry-based course projects can be designed for students to collect data to contribute to a larger, existing ongoing research program. For example, several "citizen science" programs exist to which students can contribute.
– Faculty should seek out local community partners that have an identified need that a student group could help fill.
– Interdisciplinary projects allow faculty to connect across their university as well as demonstrate for students the interdisciplinary nature of the geosciences.

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