CURQ Vignettes Summer 2013

Introductory Biology Course Involves Every Student in Authentic Research

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For many years our general approach to building research experiences into the biology curriculum involved sprinkling pieces of the scientific process throughout our courses. For example, we added exercises that exposed students to the scientific literature and mini-research projects that taught students some of the rudiments of scientific inquiry.

Although we were generally pleased with the value of these activities, several factors led us to consider a more radical approach. First, since most of these activities were only feasible in the laboratory sections of our courses, because labs hold fewer students and are scheduled for longer blocks of time, students often failed to connect their inquiry-based activities with the other pedagogical goals of the course. Second, the time required to include these inquiry-based elements crowded out a curriculum already packed with mountains of facts and concepts.

The resulting need to expand our core introductory sequence to four courses created scheduling challenges for our students, especially students who did not intend to major in biology but needed or wanted a biology course for other academic goals, such as a biological chemistry major, a neuroscience concentration, or general education requirements. Finally, the introduction of more research activities into our curriculum, where our students experienced the thrill of authentic research, whetted our appetites to do more. We became intrigued with the prospect of taking this approach to the next level.

Thus, after running some pilot courses, we introduced an entirely new biology curriculum in the fall of 2000, which began with a course called Bio 150: Introduction to Biology Inquiry. Unlike our previous efforts, Bio 150 did not simply include bits of research-like activities; rather, the course was designed to fully immerse students in biological research.

Following the ancient Chinese proverb, "Tell me and I will forget, show me and I will remember, involve me and I will understand," we tell our students very little in this first course in biology. Instead, we show them the scientific literature, an organism or groups of organisms, some experimental techniques and methods for analyzing and presenting scientific data, and then, most importantly, we involve each student in a novel research project for the duration of the semester.

All students who wish to study biology at Grinnell College, both prospective majors and non-majors, must first take Bio 150. To meet the demands of approximately 200 students, we offer eight or nine sections of Bio 150 each year, with enrollment limited to 24 students per section. Each section is taught by a member of the biology department who has created a unique course centered on a topic that is typically related to the faculty member's primary research interest. This leads to a rich and diverse selection of courses from which students may choose, including "Animal Locomotion," "Prairie Restoration," "Biological Responses to Stress," "The Effects of Climate Change on Organisms," "Survivor," "Sexy Beast," "The Language of Neurons," "The Sex Life of Plants," "Plant Genetics and the Environment," and "Cell Fate: Calvin or Hobbes."

By limiting student enrollment to 24, each section can fit into one of our teaching laboratories, which allows considerable flexibility in scheduling class times. Sections are usually offered in either two three-hour or three two-hour blocks of time per week. This permits laboratory work to be seamlessly mixed with more formal didactic methods, hopefully mitigating the disconnect students often experience between lab and lecture. In every section of Bio 150, students spend most of the class time at the lab bench or field station trying to answer a "real" question (that is, a question to which no one, not even the instructor, knows the answer). Each semester culminates with a joint poster session in which students present their research findings to the entire college community.

The initial years of the course were accompanied by an assessment plan that included both diagnostic quizzes and student surveys. The diagnostic quizzes assessed students' proficiency with factual information, data interpretation, and research design. Pre- to post-test comparisons showed reliable gains on all three proficiencies across course sections. The student surveys characterized student learning styles and their relation to learning gains. The results indicated that learning gains occurred across a variety of learning styles. Students who had indicated an interest in biology at the beginning of their college career did not fare better in learning gains than other students. In addition, a follow-up study showed that a sizeable proportion (21 percent) of students who had not initially indicated an interest in biology went on to enroll for a second-level biology course.

In recent years, the department has participated in the Classroom Undergraduate Research Experience (CURE) survey, which was developed by one of the authors for assessing the impact of authentic research experiences embedded in coursework. When compared with a national database across a spectrum of courses, the sections of Bio 150 yielded student data indicating learning gains consistent with an authentic research experience.

More than 2,500 students have now been "introduced" to biology in this brazen manner. Has it been worth it? We have certainly observed many positive changes over the years, including increasing enrollment in our courses and a large growth in the number of students desiring advanced research experiences. Some of these advances might have occurred despite our curricular changes, since we had a strong undergraduate research program and were quite successful in launching our students into research careers even before implementing Bio 150. However, there is one benefit that is not in dispute. We, the faculty who teach Bio 150, love the course! It continues to be one of our most challenging and also our most rewarding class to teach. We all chose to become scientists because we were drawn to the mysteries of the natural world. Teaching a course that similarly celebrates the unknown more than established facts has rekindled our excitement in teaching biology. Hopefully, this excitement is contagious.

Engaging First-Year Students in the Earth Sciences Through Dune Research: The FYRES Experience

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Students who participate in the First-Year Research in Earth Sciences (FYRES) course at Calvin College in Grand Rapids, Michigan, gain both an undergraduate research experience and core-curriculum science credit by the end of their first college semester.

A research focus on the nearby Lake Michigan coastal dunes provides the setting, purpose, and motivation for students' learning. Students begin by learning skills in research, field methods, and the practices of science through semi-guided, inquiry-based experiences at dune sites. Students finish the semester with a substantive team research project focused on an original research question of interest to local dune managers or to the scientific community. Each research team presents its research results in two formats: a conference-style research poster presented at a campus poster session and a conference-style oral presentation to an audience that includes classmates, as well as local dune managers and other faculty and students.

Throughout the course, laboratory experiences provide the foundation for students to learn about coastal dunes and the practices of science. The weekly five-hour lab period creates a block of research time that can be used for travel to dune sites and data collection or for deep, on-campus engagement in research design, data analysis, or scientific communication. In addition, three regular class periods each week engage students in acquiring knowledge about dunes, the nature of science, and the practices of research.

The first-year student experience is supported by a team of faculty and upper-level students who model and teach the practices of science and dune research. The FYRES project is led by a physical geographer (Deanna van Dijk) who has experience in teaching Earth science core courses, expertise in dune research, and experience working with undergraduate researchers. The first-year students are mentored throughout their experiences by upper-level geoscience majors who hold paid positions as FYRES Research Mentors. The mentors work with students during the skill-building activities early in the semester and lead research teams later in the semester. Mentors are critical to successfully building community and providing technical assistance when student teams are at various coastal locations.

After the semester ends, the FYRES mentors continue each research project in order to complete a presentation at a regional conference, as well as completing a written report. The first-year students have co-authorship on these results of their team research, and they are invited to attend the regional conference to see their results presented. By the end of the academic year, both the first-year and upper-level research students have several research accomplishments to list on their resumés, along with the benefits, knowledge, and skills gained through the research experience.

The FYRES project was first implemented in fall 2011 with 13 first-year students and five upper-level mentors participating. By the second year (fall 2012), participation was near capacity with 23 first-year students and six upper-level mentors. The project evaluator (Crystal Bruxvoort) assessed the program's effectiveness at the beginning and end of each semester using a pre/post-test design. Research questions guiding the evaluation process focus on examining students' and mentors' views of the FYRES program, and specifically target participants' opinions of the gains made and challenges faced during their involvement in the program. Data collection consisted of semi-structured interviews (30 to 45 minutes per interview) and administration of the Classroom Undergraduate Research Experience (CURE) survey (www.grinnell.edu/academic/csla/assessment/cure). Students also completed weekly journal entries as a course assignment in which they reflected on their understanding of and reactions toward the investigative activities assigned during the lab periods.

One might think that the type of students drawn to participate in the FYRES course would be mainly freshmen who are science-focused upon entry into college and perhaps already involved in geo-related activities (e.g., rock collecting, environmental stewardship). However, student feedback during evaluation revealed that science and non-science students alike were attracted to the course. Students who intended to be Earth science majors were present, but the course also attracted students who were exploring the possibility of majoring in a science-related discipline, and students who intended to major in non-science areas of study (e.g., Spanish, business, English) and sought the course to fulfill a general education requirement.

Regardless of students' professed interest in science at the onset, FYRES students reported similar reasons for choosing to enroll in the course. First, students reported a general enjoyment of the outdoors and looked forward to experiencing Lake Michigan's coastal dune system. Second, they expressed a keen interest in a science class that they felt was quite unlike any other. Students deemed other science courses as involving "mostly lecture and taking notes" with "very little hands-on" and "you always knew the answer going in." They were drawn to participate in FYRES because of its instructional approach allowing them to do authentic research in the field. Consider the following representative comments:

"I am exploring science options as a major of study and I felt like this course was a great way to explore being a scientist" (Kate, pseudonym, 9/2011).

"I am a science major and so doing what scientists do and being in the natural world and doing hands-on work is what it should be" (Lew 9/2011).

"I am taking this course to fulfill a gen[eral] ed[ucation] requirement. I struggled to 'get it' in previous science courses in high school. I'm excited though that this course involves being outside of a regular classroom where I feel I am more likely to be at ease and be myself and ask questions and so forth" (Hope 9/2011).

Those quotations illustrate how students of all types were drawn to the course because of its instructional approach, which they deemed as atypical and inviting. In post-course interviews, students were asked to describe the extent to which FYRES met their early expectations, and they resoundingly reported that it did. Even better, when asked if they would recommend this course to other students, they responded affirmatively.

For more information on the FYRES project,
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Undergraduate Research in a Japanese Culture Class: A Pedagogical Narrative

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In the spring of 2010, I introduced a 300-level course called Japanese Culture in a Global World at George Mason University, and it has since become a course regularly offered every spring semester. It is one of the university's general education courses that fulfill the global understanding requirement, one of the six core requirements that help students become better able to synthesize new knowledge, respond to various challenges, and meet the demands of a complex world. The course has been a popular choice, reaching the enrollment capacity of 25 as soon as the spring semester's course registration begins in November.

Most present-day undergraduates in the U.S. have grown up exposed to Japanese popular culture via anime, manga, video games, J-pop, Hello Kitty, and so on. They constitute a majority of the course enrollees. The coursework includes collaborative narrative inquiry, which entails the students' constructing, sharing, analyzing, interpreting, and reflecting on their personal experiences with Japanese culture. Their childhood experiences make this inquiry process personally meaningful. The inquiry activity is linked to an empirical research project, which the students are to carry out individually, about any globalizing or globalized aspect of Japanese culture.

Through engaging in research, the students learn to make sense of what they have found about their chosen topic by reviewing relevant literature and collecting empirical data through surveys and interviews. In the process, they learn to make an argument by pulling everything together into a self-supporting whole or a thesis that has meaning and coherence. Research work is an important component, enabling the course to address the university's general education requirements for global understanding—that is, students' acquisition of cognitive and intellectual skills and knowledge needed for success in an increasingly globalized world.

All other aspects of the coursework are designed to facilitate the students' research work, which begins with the students' small-group discussions in English with Japanese students who are visiting from Japan to learn English and experience American culture. In this discussion my students test their preliminary ideas for their research projects by asking questions of the visiting Japanese students and observing their reactions. The finished products of their research—typically an academic paper but occasionally a short documentary film or other creative work—are evaluated for such aspects as quality of argument, depth of analysis, integration of sources and data, organization, mechanics, and style. Some of these products can go beyond a classroom milieu because they can be included in an application package for the Japan Studies Award contest, sponsored by a nonprofit organization near the university, or they can be submitted for publication in the university's undergraduate journal.

Megan Pfeifle took this class when she was a junior in the spring of 2011. She decided to conduct research on visual kei [visual style], "a brand of Japanese rock music characterized by bands performing in intricately designed costumes with strong androgynous flair" (cited from her forthcoming article, "Exposing the Underground: The Japanese Subculture of Visual Kei" in The George Mason Review, Volume 21). Pfeifle had been a big fan of visual kei for many years when people outside Japan were just beginning to get to know about this Japanese musical style. She was enthusiastic and very knowledgeable about it, but she had been puzzled by one thing. She writes, "When I visited Japan for the first time eight years ago, I was like many jaded fans and believed visual kei to be mainstream and beloved by all Japanese people. I was very surprised to find the reality of visual kei: tiny venues, the same fans at a variety of shows, and very few true resources to purchase the music. Over time, both within Japan and in the United States, I saw the scene grow, but it never made it to the mainstream music market; the scene stalled out and while it has fluctuated in public interest, visual kei has remained an underground scene" (ibid.).

Pfeifle wanted to know why visual kei had never achieved the status of mainstream music. She titled her course project "Visual kei: Universal subculture" and carried out an extensive study to gather information from fans, media, event organizers, and the general public concerning what they thought about the present and future of visual kei. Analyzing the responses to the surveys and interviews, Pfeifle came to the following conclusion:

As a part of Japan's post-war modern pop culture, visual kei's future depends on its ability to survive in competition not only with other music styles of Japan, but in its marketability to worldwide music fans. Despite its future challenges and consistent small stature, it remains beloved by its fans and still today maintains its Western roots while keeping its succinct Japanese style. (ibid.)

Pfeifle submitted the course paper to the Japan Studies Award contest and won the award, giving her an internship in Tokyo in the summer of 2011. She then revised the paper extensively to submit it to The George Mason Review, a cross-disciplinary undergraduate journal, which accepted it.

Very few students in the class have trouble coming up with a research topic. In other words, most of the students are already content experts in one way or another. Having had personal and intimate experiences with their topics since childhood, they typically are enthusiastic about turning their interest into empirical research and taking an objective or analytical look at the familiar topic.

First-Year Experience: Think Like a Nurse

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To integrate evidence-based research into clinical practice, baccalaureate students must attain the knowledge and skills necessary to assess, participate in, and communicate research (Taylor 1999, 35). Although students preparing to become registered nurses learn research skills during their introductory research course, students benefit most when they enter a nursing program already armed with information literacy, critical thinking capability, and writing skills. However, students do not always possess these foundational skills when they enter college (Troxler, Jacobson, and Oermann 2011, 280; Van de Vord 2010, 170). Consequently, we pursued methods for assisting students in attaining these skills prior to their acceptance into the baccalaureate nursing program, and we developed a unique approach using the First-Year Experience (FYE) at Georgia Southern University.

The FYE program facilitates first-year students' acclimatization into university life through purposeful initiatives designed to encourage academic engagement and to assist students in developing the academic and life skills crucial for success (Georgia Southern University 2012). FYE Think Like a Nurse is a first semester, two-credit hybrid (classroom and online) course that utilizes evidenced-based methodologies to introduce pre-nursing students to information literacy, critical thinking, and writing skills. This model is well suited for educators seeking to help baccalaureate students succeed in evaluating research information and clearly communicating their findings.

The hallmark of this model is its incorporation of evidence-based pedagogical strategies to introduce freshmen to the concept of research. For example, the pedagogy of peer-to-peer learning (Hussain, Anwar, and Majoka 2011, 940) typically is employed to "(bring) researchers and students together in new forms of engagement" (Boud and Lee 2005, 515). In the course, peer-to-peer learning pairs freshmen with upper-level nursing students who serve as mentors to the freshmen. The senior nursing students attend course sessions, engage the freshmen personally, and answer their questions about college, the research process, and the nursing program. Additionally, the freshmen attend the Minority Health International Research Training (MHIRT) Research Day, funded by the National Institutes of Health, at Georgia Southern University. There, undergraduate nursing students present the results of their research conducted with research mentors abroad. The freshmen attendees have the opportunity to ask questions about the seniors' research experiences abroad.

Providing the opportunity for freshmen pre-nursing students to network with senior nursing students at the MHIRT event is an effective peer role-modeling approach (Christenson and Bell 2010, 804; Fried and MacCleave 2009, 482; Sims-Giddens, Helton, and Hope 2010, 24). It not only provides for early student engagement with research, but also impacts freshmen's understanding of the role that nurses can play as researchers (Hentz and Gilmore 2008, 28). When freshmen meet upper-level nursing students who have participated in research and used research to inform their nursing practice, a generative phenomenon occurs. The senior nursing students make lasting impressions that positively impact first-semester students and their attitudes toward future engagement with nursing research. A third strategy, to help students develop their writing skills, becomes tangible when freshmen introduce their own research-based course projects near the end of the semester. Freshmen participants report a positive change in attitudes toward research.

Students require critical thinking skills to appropriately critique and utilize research (Wangensteen, Johansson, Björkström, and Nordström 2011, 2436). Since first-semester students often lack confidence in their ability to be successful at the college level and are outspoken regarding their need to understand the rationale for curriculum approaches (van der Meer 2012, 83; Goldfinch and Moira 2007, 262; Kuh 2008, 28), pedagogical efforts that encourage students to make connections between required core and discipline-specific coursework help promote students' critical thinking skills (Coker, Scott, and Johnson, 2008, 13).

One example occurs when students are provided with core nursing knowledge about diabetes through an interactive lecture format that includes the basic pathophysiology of diabetes, the concepts of hypoglycemia (low blood glucose levels) and hyperglycemia (high blood glucose levels), the use of glucose monitoring equipment, and consideration of hospital policy and procedure. With guided learning, students are encouraged to connect the nursing knowledge about diabetes with appropriate choices for patient care in case study examples. After studying scenarios of diabetic patient dilemmas, students are asked to discover scholarly literature that will support potential nursing actions based on the information provided. Students access scholarly databases and utilize evaluation methods previously introduced in the course to choose literature to support possible solutions to the scenarios presented.

Questions about the use of glucose monitoring, the treatment of patients with hypoglycemia or hyperglycemia, and appropriate nursing actions are deliberated, based on the research literature students bring to the discussion. The concept of evidence-based practice, its development, and its use in the nursing profession are discussed as part of this learning strategy. Finally, through the use of Socratic questioning (Paul and Elder 2009), students are asked how anatomy and physiology, microbiology, chemistry, nutrition, math, and writing coursework might aid nursing students in learning how to care for a diabetic patient (Mann 2012, 26). A lively discussion ensues surrounding the connections among core coursework, nursing research, and upper-level coursework, and the underlying reasons for their use in the curriculum.

The Think Like a Nurse model invites freshmen to critically think about their program of study, the knowledge that core course work provides, and the connections between core and upper-level coursework. More importantly, it allows students to understand their future roles in basing their nursing practice on research and clinical evidence, and in participating in the advancement of nursing knowledge through research (Kirkpatrick, Tweedell, and Semogas 2011, 595; Polkinghorne and Wilton 2010, 457). The FYE Think Like a Nurse pedagogical model is an innovative approach for educators seeking to prepare students to assess, perform, and communicate research through development of information literacy, critical thinking capability, and writing skills. Students' evaluations of the three components of the model will be sought.

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The Practical Value of Undergraduate Participation in Descriptive Science Research

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Although there is much published literature detailing the exposure of students to science, most of it pertains to experimental, rather than descriptive, science. Descriptive science focuses more on producing a detailed narrative with highly specialized terminology, unlike experimental science, which is more process-oriented. Exposure to descriptive science, however, allows students to develop organizational, analytical, and technical skills that will be useful for future graduate careers. The following discusses how students can be guided through the descriptive science process, what they learn, and how they benefit throughout the process.

Initial exposure to descriptive science occurs in the core (freshman/sophomore) biology curriculum, where students are exposed to dissections, whole mounted specimens, and live specimens for examination. At this stage students learn the importance of a detailed narrative, a literature review, and consistency in both nomenclature and well-drawn and labeled figures (Rehorek 2004). As they proceed through the biology major, they have the option of conducting research with faculty. By continuing the research process in an upper-division course, students are exposed to more rigorous expectations and results.

In a descriptive project, there are numerous parallels to an experimental project. At the start of both types of projects, project preparation and proposal requires students to write a proposal and conduct a literature review. And after the completion of the laboratory phase, students must interpret data, determine the significance of this data, and, finally, explain the data.

The laboratory phase of descriptive science is different from that of experimental science, however, in that students are involved in preparing specimens for examination, not conducting experiments. Below we refer to specific faculty-student research projects involving three-dimensional imaging in the laboratory phase of examining a specimen from a primate. There are three steps in this phase: the first two steps are purely structural in nature (procedural), with little room for student-faculty mentoring. The third step provides an opportunity for the faculty mentor to work with the student and show how the images may be interpreted, how to best show features of interest, and how both the content and orientation of the three-dimensional image can alter the ultimate understanding of the features being examined. In the following, we describe one descriptive science project involving a tissue specimen from the facial region of a non-human primate.

Step 1: Serial paraffin sectioning. In this step, the paraffin-embedded specimen must be sectioned at specified increments and all sections must be accounted for (though sections may be occasionally lost, their absence needs to precisely noted). In this process, students have to learn to stay organized and understand the importance of consistency (in this case, consistent arrangement of sections on a slide). Sections are stained using appropriate protocols to identify structures of interest.

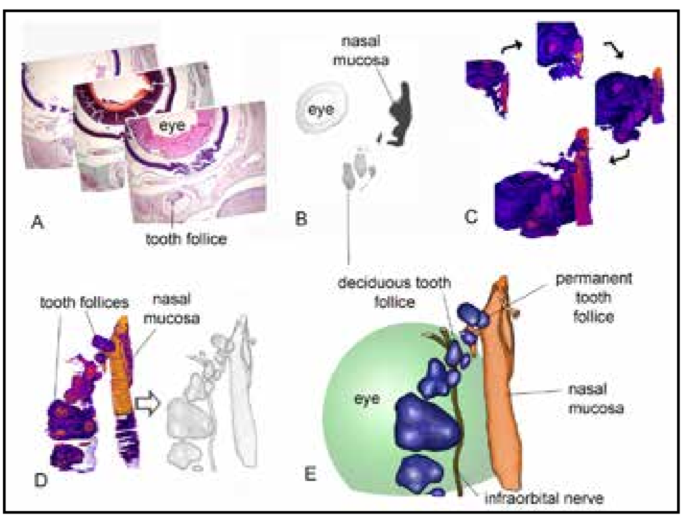
Step 2: Data collection and analysis. Digital micrographs of serial sections of the specimen are taken. These are then aligned into image stacks and prepared for a three-dimensional reconstruction (see Rehorek and Smith 2007 for technique details). In this step, students learn how an old technique (paraffin histology) can be combined with newer techniques (digital image manipulation) and the importance of fidelity of the digital image (as a unit of data).

Step 3: Image construction for publication (see Figure 1). In this step, the three-dimensional reconstruction is used as a template for an anatomical figure. First, several 3-D stacked images (each showing different components) are prepared by the students (figure 1A). Second, features of interest are identified (by both the student and the faculty member), and the faculty member trains the student to digitally dissect the combined images (figure 1B) and produces an outline (figure 1C). Third, the illustration is produced (by a faculty member: figures 1D and 1E). Undergraduate science students may not have the artistic training to prepare the final illustration; their contribution lies in the production of the 3-D images and identification of the appropriate features. Thus, students learn how accurate anatomical diagrams are prepared and gain an appreciation for the effort and talent involved in their production. Their efforts can culminate in a professional experience, such as a poster presentation at national science societies (Bruening et al. 2010) or a peer-reviewed publication (e.g.: Rehorek et al. 2011)

Figure 1: An overview image showing serial digital images of histological sections of the facial region of a non-human primate, which have been aligned (A), digitally dissected (B), and then reconstructed as a "stacked" 3-D image, which can be rotated along X or Y axes (C). Selected views are redrawn by hand (D), and then color-coded to highlight salient anatomy. This resulting illustration (D) shows the soft tissue structure in an inferior view (E). The "digital dissection" removed the bones and other connective tissues, allowing major structures to be seen in their spatial relationship to each other (teeth in blue, nasal mucosa in orange, a major facial nerve in brown, and the eye ghosted).

Exposing students to research, whether experimental or descriptive, must begin in the core biology curriculum, with subsequent student projects following a distinct series of steps with clearly outlined actions and outcomes.

Figure 1.



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An Integrated Research and Writing Experience for Freshman Biology Students

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Juniata College has developed a year-long freshman experience in which incoming biology students conduct field research and laboratory analysis in the fall semester, and in the following spring semester analyze a compiled data set and prepare a scientific manuscript based on their fall research.

The fall ecology laboratory is an intensive field and lab research experience for freshmen interested in biology or other natural science degrees. The broad goal of the ecology module is to introduce students to the scientific research process through the following specific activities:

1. Students will participate in hypothesis generation and prepare equipment for field research.

2. Students will conduct terrestrial and aquatic field surveys, collect samples, and record observations.
3. Students will analyze and identify field-collected samples.
4. Students will conduct a preliminary analysis of the data and compare the results to their hypotheses.

The specific case study used for this module is an examination of the effects of acid mine drainage (AMD) on biodiversity. The field research component focuses on two adjacent streams, one greatly impacted by AMD and one seemingly unaffected by it. Students are given the freedom to form their own hypotheses, but are guided toward formulating the following questions:

- Do the streams have different underlying abiotic conditions reflective of AMD contamination?
- Does the AMD-impacted stream have lower biodiversity of aquatic macroinvertebrates?
- Does the AMD-impacted stream have lower biodiversity of terrestrial bryophytes in the riparian corridor?
- Does the presence/absence of any species help to elucidate the impact of AMD (that is, did students observe any bioindicator species)?

To try to answer these questions, students meet in the lab or the field twice a week for three weeks. In addition to preparing for the fieldwork, and executing terrestrial and aquatic ecological sampling protocols, students also get quantitative experience through calculating diversity indices and simple statistics (e.g., arithmetic means). Students summarize their findings in a final report that requires students to:

- Draft a methods section as it would appear in a scientific peer- reviewed journal.
- Create two figures and one table that best summarize important results.
- Find a relevant source and create an annotated bibliography for this source.
- Answer several short-answer questions that help to guide students' thinking about interpreting their results.

All freshman biology majors subsequently enroll in a one-credit biology seminar in the spring semester. Its main focus is to guide students through the writing of a scientific paper that is based on their fall research. The objectives of this writing course are that the freshmen:

1. Will read and discuss the philosophical and quantitative underpinnings of scientific inquiry.
2. Will apply writing skills acquired in their first-semester, general education College Writing Seminar to communicate scientific ideas in the form of a scientific paper.
3. Will receive instruction from their faculty advisor and receive faculty and peer feedback in a small-seminar format.

This seminar meets one hour per week, with each weekly session focusing on a different aspect of preparing a scientific manuscript, using as a guide Writing Papers in the Biological Sciences, 5th edition, by Victoria E. McMillan (published by Bedford/St. Martin's Boston, New York).

For the first session of the seminar, we meet as a large course-wide group to review the hypotheses and methods covered in the fall semester's laboratory work. Students are also introduced to the Minitab® Statistical Software v. 16 (www.minitab.com), which they use to conduct several t-tests and regression analyses on a combined data set. Finally, students are assigned to conduct a literature search and compile an annotated bibliography of three sources that they will use in writing their paper. In subsequent weeks, students meet in smaller sections of 12 to15 students with a faculty member, often their freshman advisor. Each section follows the same syllabus, so that faculty can discuss the progress of the student manuscripts between sessions.

Writing a scientific paper for the first time is a daunting task, and we have found it helpful to provide structured details for each section. Even with a detailed structural guide, however, many students struggle to generate a quality first draft. A rubric outlining appropriate content and style, as well as in-class peer-review of their written work, helps them become more familiar and comfortable with how to approach each section. Learning activities used for teaching each section are shared and discussed in departmental meetings. Using this collaborative model allows us to combine our teaching experience and creativity.

The syllabus lists the due dates for each section of the paper. When students hand in the draft of a section, faculty members have one week to comment on and grade the draft. Students revise each section before compiling a draft of the complete paper, which is then commented on and revised for the final version. Original drafts of each section count for a small percentage of the grade so that emphasis is placed on revising and rewriting.

This first-year experience reaches approximately 200 freshmen and, by virtue of having students work with their advisors in the spring writing seminar, involves the entire biology faculty in a collaborative teaching effort.