Enhancing Learning Through Research in Biology 225

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There is something fundamentally wrong with a curriculum when scientific subjects are completely interdependent in real life but remain mutually exclusive in the classroom. Since the emergence of the document *Vision and Change in Undergraduate Biology Education* published by the National Science Foundation (NSF) which called for reformation of undergraduate biology programs, professors and students alike have worked to solve this issue in Calvin College’s own biology courses. Biology is dynamic. It uses simulations, quantitative reasoning, and extended knowledge of other scientific disciplines—chemistry, statistics, and even psychology—to unravel mysteries of greater society. Guided by the *Vision and Change* core concepts and competencies, the Biology department seeks to accentuate this multi-faceted nature of biology as an interdisciplinary science so that students are prepared to solve real-world problems in an applicable way.

In order to meet these standards of the NSF *Vision and Change* document, Calvin College has been continually updating its biology curriculum. During the summer of 2012, project mentors Dr. David Koetje and Dr. Herb Fynnewever worked with two students on a complete overhaul of Biology 224 Lab: Cellular and Genetic Systems. Similarly, this summer we are working with the same two professors as a follow-up, remaking Biology 225 Lab: Ecological and Evolutionary Systems. In the case of Biology 225 Lab, there has not been a published lab manual for several years—the daily course activities have been presented as a series of worksheets and one-week projects that have changed from year to year. Our goal for this summer is to have a complete, functional lab manual that adequately guides interdisciplinary, hands-on learning—which follows the *Vision and Change* core competencies—by the beginning of the 2013 fall semester.

The process of creating a lab manual began by meeting with multiple professors from the Biology Department, including both the current instructors and potential future instructors. After deciding on three-module format, each module was given a main topic—aster hybridization, phylogenetics using local fish species, and hominid evolution—presented as an encompassing question, such as, “how do humans fit the evolutionary model?” We worked as a pair to develop the details of the curriculum, consulting professors individually as needed. Typical lesson planning utilizes a backward approach, where teachers begin by outlining the specific goals of the course and then develop methodologies to reach these goals (activities, assignments, and assessments). Researchers use the “forward method” when a scientific question prompts an experimental procedure through which a specific goal or outcome emerges. We used what might be called the “lab hybrid method,” which utilizes both the traditional “backward” approach to lesson planning and the “forward” method by optimizing data and procedures and creating specific research-based objectives for the students.

To put this concept into perspective, Module Two (Fish Phylogenetics) began with two goals: the core competency of societal connections in biology, and the core skill of using simulation tools. We then decided to fulfill the core competency by using articles that addressed fraudulent behavior in the identification and selling of whales and seafood, so that students
could understand the importance of the Module Two procedures in a global context. Throughout the four weeks of the module, students are asked to make multiple phylogenetic trees (a map of species that shows ancestry and relatedness) both manually and with computer software to fulfill the core skill of simulation. This brought about our hybrid goal to identify unknown species of fish using molecular (DNA) and morphological (physical) evidence.

After using the hybridized approach to develop goals for each module, we proceeded to design learning activities for students to complete these goals. Some of these activities include a tree identification scavenger hunt to employ the skill of using a dichotomous key and GPS navigation systems, phylogeny construction using the morphological and genetic characteristics of fish, an activity where students can take measurements to compare skull replicas of extinct hominid species, and many more. Each lab activity focuses on particular core concepts, skills, and competencies. Typically, one module will strongly reflect two or three of the competencies outlined in the NSF Vision and Change document, and all competencies are addressed at least once during the 11-week course.

Although, the main product of our work will be the final, completed lab manual to be used this coming fall semester, we also worked to include materials that allow the class to run smoothly. By working through each activity ourselves, we were able to optimize the procedures for students. For each set of procedures, we included notes where students might have trouble, places where students will be able to use replication in order to get better results, and time management steps (such as DNA extraction, which was completed this summer to be used during the lab rather than having students extract DNA themselves—a skill learned in Biology 224). We also designed notes and documents for professors, such as introductory PowerPoint presentations for new topics or procedures. Currently, in our ninth week of the project, we have completed rough drafts of all three modules, over 51 pages. We are still incorporating the results of our optimization tests into the lab by adding further instructions and notes to better student comprehension, deleting sections that are irrelevant, and altering portions that will fit better at different stages of the course.

This project, besides being a paid position, has already provided direct benefits to us. Designing the course has been a hands-on introduction to lesson planning, which is appropriate to both of our future goals. One of us is majoring in Secondary Education in Biology (Paige Stephens), while the other is majoring in Biology with a Psychology minor (Jon Knott), tentatively planning to teach as a professor after attending graduate school. In addition to preparation and insight for future teaching experiences, designing the course has also benefitted us as biology undergraduates. We have gained an understanding of scientific concepts and procedures more deeply and extensively than we had previously encountered in a class setting. Additionally, although this is not “traditional” research with the goal of publishing a scientific paper, it does give both of us the opportunity to publish lasting materials for the Biology department at Calvin College. We have been privileged with the opportunity to engage in open discussion with professors, as well as use our own student voice to directly impact the way biology will be taught in the future at Calvin College.