Transformation of the Cell Physiology Laboratories in Integrative Physiology
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Integrative Physiology

Aims

The purpose of the proposed research project is to transform the existing Cell Physiology Laboratories in Integrative Physiology (IPHY) to an inquiry-based approach of instruction that better aligns with the lecture material. We are requesting summer salary support for Instructor Molly Welsh to help develop the Cell Physiology Laboratory materials, including learning goals, assessments, inquiry-based labs, and surveys. Mrs. Welsh has been involved with the Cell Physiology course for the past 5 years and she has extensive expertise in the laboratory protocols, ordering new instruments, maintaining inventory, staff support, and quality control.

Background

Cell Physiology (IPHY 3060) is a 4-credit hour, combined lecture-lab course that serves as one of the six core courses offered to IPHY majors. This upper-division course is fundamental to the training of IPHY majors, many of who are interested in future careers in research or healthcare. The purpose of the course is to understand the structure and function of molecules and cells as they pertain to systems level physiology, and to explore how cellular function and dysfunction affect human health and disease.

In 2006, the Science Education Initiative (SEI) in IPHY helped revise the lecture portion of Cell Physiology, while the laboratory portion of the course remained unchanged and outdated. Although unintentional, this created a major disconnect between the material covered in lecture and the content covered within the labs. Furthermore, the Cell Physiology Laboratories continued use an expository, or “cookbook” style of instruction where the students follow a predetermined set of instructions with a predictable outcome. Although easy to administer, the “cookbook” style of laboratory instruction is typically viewed by students as uninteresting, boring, and tedious [1-4].

To assess student attitudes toward the existing Cell Physiology course, an online survey was administered to students in Fall 2012. Three major problems with the curriculum were consistently cited by the students: 1) the lecture and lab alignment was poor, 2) the experiments were redundant from high school and other undergraduate labs, and 3) the lab did not teach them about important aspects of the scientific method. Specifically, the majority of the survey respondents felt “neutral” when asked if the course taught them different aspects of the scientific method. Specifically, the majority of the survey respondents felt “neutral” when asked if the course taught them different aspects of the scientific method. Specifically, the majority of the survey respondents felt “neutral” when asked if the course taught them different aspects of the scientific method. Specifically, the majority of the survey respondents felt “neutral” when asked if the course taught them different aspects of the scientific method. Specifically, the majority of the survey respondents felt “neutral” when asked if the course taught them different aspects of the scientific method. Specifically, the majority of the survey respondents felt “neutral” when asked if the course taught them different aspects of the scientific method. Specifically, the majority of the survey respondents felt “neutral” when asked if the course taught them different aspects of the scientific method. Specifically, the majority of the survey respondents felt “neutral” when asked if the course taught them different aspects of the scientific method.

“The labs seemed out of sync with the lecture which made it hard to reinforce the lecture material. Now that we are all done, I can see that it has helped but at times, it seemed like they were two separate classes.”
-IPHY student

“We did labs I have done in high school... not exactly riveting.”
-IPHY student

“Maybe more communication with the lecture professor at the beginning of the semester to help line of the content of the lab with the content of the lecture.”
-IPHY student

A Cell Physiology lab provides the perfect platform for addressing these issues.
Given the misalignment of the labs with lecture, the redundancy of some of the activities, and the lack of student confidence in using the scientific method, it was clear that the Cell Physiology Laboratories needed immediate attention. In Spring 2013, a Cell Physiology Revision Committee was formed to revamp the existing Cell Physiology Laboratories. The committee includes Dr. Christopher Link (Associate Professor), Dr. Teresa Foley (Instructor; IPHY Science Teaching Fellow), and Molly Welsh (Instructor; Lab Coordinator). In Fall 2013, Dr. Link will teach the lecture portion of the course, while Mrs. Welsh will coordinate the laboratories. The participation of both of these faculty members in this project allows for the simultaneous development of the entire Cell Physiology course.

The goals of the transformation of the Cell Physiology Laboratories are:
1. To better align the laboratory activities with the lecture material.
2. To remove laboratories overlapping with previous lower-division courses or high school experiences.
3. To transition the labs from a “cookbook” style to an inquiry-based approach of instruction.
4. To document the outcomes of the transformation and share the results with the Science, Technology, Engineering, and Math (STEM) community at CU-Boulder.

The decision to transition the Cell Physiology Laboratories from a “cookbook” style to an inquiry-based approach of instruction was made for several reasons. First, because our students lacked confidence with the scientific method, we wanted to implement a style of laboratory
instruction that would closely model how scientists actually engage in research. Compared to the “cookbook” style, inquiry-based methods: a) provide little direction to the students, b) have an undetermined outcome, and c) require students to develop their own hypothesis and procedures [5-7]. Moreover, this type of laboratory instruction has been shown improve student learning and enhance understanding of lecture concepts and the scientific method [8-13].

Second, because of the overlap of Cell Physiology Laboratories with previous lower-division courses or high school experiences, we wanted to employ a style of instruction that would challenge the students to a higher level of thinking. Numerous of studies have demonstrated that inquiry-based labs help students develop their independent, critical and analytical thinking, and scientific reasoning abilities [14-16].

Third, it has been shown that inquiry-based labs increase retention of undergraduates in STEM disciplines [17-20] and improve overall attitudes and motivation toward learning and science [16, 21-24]. Because Cell Physiology is one of the first core courses students take as an IPHY major, we wanted to use style of laboratory instruction that would keep students engaged and interested in Physiology.

Finally, this will be the 2nd laboratory course in IPHY to transform to an inquiry-based approach of instruction. Both Dr. Teresa Foley and Molly Welsh were involved in the transformation of the Physiology Laboratories (IPHY 3435) from a “cookbook” style to the inquiry-based approach, and Dr. Teresa Foley received the Chancellor’s Award for Excellence in STEM Education in 2011 for her work on that project. The participation of Dr. Foley and Mrs. Welsh in the current project will ensure successful implementation of the new method of instruction in the Cell Physiology Laboratories.

Methods

The revised Cell Physiology Laboratories will be incorporated into the curriculum beginning Fall 2013. The lab revision will follow the SEI model of course transformation (http://www.colorado.edu/sei/) that involves establishing what students should learn, what students are learning, and which instructional approaches improve student learning [25]. The transformation will involve an iterative cycle of development and refinement of the following materials:

A. Learning goals
The first task of the Cell Physiology Revision Committee will be to establish a set of learning goals that define what students should be able to do upon completion of the lab course. The learning goals will emphasize: A) concepts in cell physiology, B) basic laboratory skills (e.g., pipetting, using a microscope, maintaining a lab notebook), C) the scientific method (e.g., developing a research question and hypothesis, designing an experiment, analyzing/interpreting data), and D) critical thinking skills. Dr. Teresa Foley has extensive experience in learning goal development and will take the lead on this aspect of the project.

B. Assessments
Three types of assessment tools will be used to identify what students are actually learning in
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Cell Physiology: lab exams, weekly quizzes, and the Student Assessment of their Learning Gains (SALG) online survey tool ([http://www.salgsite.org](http://www.salgsite.org)). The SALG online survey tool allows students to assess their own learning gains towards the course learning goals [26], and can be used in a lecture [21, 27-29] or laboratory setting [30]. All of the assessments will be aligned with the learning goals and will focus on A) **concepts in cell physiology**, B) the **scientific method**, and C) **critical thinking skills**.

**C. Inquiry-based labs**
The third task will be to develop a set of 10 inquiry-based labs that align with the concepts presented in lecture. The labs will start out with more guided approach to help students develop the necessary skills, and then will progressively become less guided and more-student directed. By the end of the semester, students will design their own experiments from start to finish. The Lab Coordinator Molly Welsh was involved in the transformation of the Physiology Labs (IPHY 3435) into the inquiry-based approach of instruction, and will take the lead on this aspect of the project. Drs. Chris Link and Teresa Foley will provide assistance with development of the labs and alignment with the lecture as needed. To guarantee successful implementation of the new format, Dr. Teresa Foley and Molly Welsh will directly train and mentor the Cell Physiology Laboratory Teaching Assistants.

**D. Surveys**
The final task of the Cell Physiology Revision Committee will be to develop a survey that assesses the effectiveness of the lab transformation. An online survey will be administered via Survey Monkey ([http://www.surveymonkey.com/](http://www.surveymonkey.com/)) at the beginning and end of the semester and will measure: A) **student attitudes towards the lab**, B) **the effectiveness of lab activities in promoting student learning**, C) **whether the labs aligned with the concepts presented in lecture**, and D) **the level of confidence in critical thinking skills and the scientific method**. Dr. Teresa Foley will take the lead on this aspect of the project.

**Timeline**

*Summer 2013*: Development of learning goals, assessments, 10 inquiry-based labs, and surveys.
*Fall 2013*: Implementation of inquiry-based labs, Teaching Assistant training, and administration of assessment tools and surveys.
*Spring 2014*: Data analysis, write-up and presentation of results at the weekly Discipline-Based Education Research (DBER) seminar series and the annual SEI/CSL End-of-Year Event, and refinement of laboratory materials as needed.

**Expected Outcomes**

In addition to the established benefits of inquiry-based laboratory instruction for students (see pages 2-3), IPHY faculty will also benefit from the outcomes of this project. Since 2006, the Department of Integrative Physiology has committed to improving undergraduate science education, and its curriculum has been nationally recognized as a model for successful course reform [31]. A major reason for the success of science education in IPHY has been participation by faculty in the development and implementation of effective instructional techniques. To continue the forward momentum of course reform, the Cell Physiology course will be the 2nd lab
course in IPHY to transition to the inquiry-based approach of instruction and will involve a new faculty member, Dr. Christopher Link. Participation in this project will enhance the professional development of Dr. Link by introducing him to research-based curriculum development, a new style of instruction, and science education research.

Outcomes from this project will also facilitate the transformation of other laboratory courses in IPHY, including the Exercise Physiology (IPHY 4650) and Neurophysiology (IPHY 4720). These two upper-division courses serve up to 400+ IPHY majors each year and employ the “cookbook,” style of laboratory instruction. Students often take these two courses concurrently or subsequently to Cell Physiology. By training students to design his/her own experiments in the lower division labs, the upper-division faculty could “push” students to a higher level of critical and analytical thinking (i.e., students could develop their own inventions to answer a particular research question). Moreover, transition of the upper-division labs into an inquiry-based approach of instruction would involve IPHY faculty who actively promote science education research and are willing to make the transformation, including Dr. Roger Enoka (Chair), Dr. William Byrnes (former Director of the IPHY SEI), and Dr. Janet Casagrand (Instructor).

The STEM community at CU-Boulder will also benefit from the outcomes of this project. The Physics Department has already transitioned their Advanced Physics Lab Course using a model promoted by the SEI [30]. A major difference between our project and the work of Physics is that the Advanced Physics Lab course is not directly associated with a lecture component. Outcomes from this project would add to the work done by the Physics Department by demonstrating how a laboratory could be directly aligned with the lecture course. To reach the STEM community, outcomes of this project will be presented at the weekly DBER seminar series and at the annual SEI/CSL End-of-Year Event in Spring 2014. Many of the top Education Researchers at CU-Boulder attend the SEI/CSL End-of-Year Event, and this will provide an excellent opportunity for the members of the Cell Physiology Revision Committee to share his/her experiences regarding the transition to an inquiry-based approach of laboratory instruction.
**Budget Justification**

Funds from the Chancellor’s Award for Excellence in STEM Education will be used for summer salary for Molly Welsh, beginning 5/13/2013 and ending 8/16/2013. As the Lab Coordinator, Mrs. Welsh is *critical* for the revision of the Cell Physiology Labs into an inquiry-based approach of instruction. She has extensive expertise in the laboratory protocols, ordering new instruments, maintaining inventory, staff support, and quality control. Her participation in this project over the summer is essential for the development of the laboratory materials by Fall 2013. The Department of Integrative Physiology will resume salary support for Mrs. Welsh beginning 8/19/2013. The budget does not include any overhead or indirect costs.

Salaries and wages for Molly Welsh, Lab Coordinator at 100% time; 5/13/2013 to 8/16/2013  
**Total budget: $10,000**

**Current and pending funding**

We have recently submitted a proposal for CU’s ASSETT Development Award towards the acquisition of five Motic Moticam digital camera systems for the Cell Physiology Laboratories. The total amount requested was $4,665.00. Salary support was not requested from the ASSETT Development Award.

CU’s Science Education Initiative will fund Dr. Teresa Foley’s work on this project during the summer.
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