FY13 Funded Proposal: Engaging undergraduates in STEM laboratories using emerging technologies for teaching and learning

FY13 Innovations in Teaching with Technology Awards

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<th>Proposal Title:</th>
<th>Engaging undergraduates in STEM laboratories using emerging technologies for teaching &amp; learning</th>
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<tr>
<td>Investigators:</td>
<td>Adam Ward, Art Bettis, Anthony Castronovo</td>
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<td>Org Unit:</td>
<td>College of Liberal Arts</td>
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<tr>
<td>Department(s):</td>
<td>Geoscience, Art &amp; Art History</td>
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<td>Funding Awarded:</td>
<td>$36,827</td>
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Undergraduate students are required to take general education courses that include a laboratory experience, but are commonly hesitant to engage with STEM discipline materials. This problem is exacerbated in Introduction to Environmental Science (ENVS:1080; offered fall, spring and summer with annual enrollment of 400-450), a General Education course that draws students with a wide range of backgrounds and interests given a broad interest in environmental issues related to a breadth of undergraduate majors. Current laboratory exercises are organized in a traditional format (introductory lecture, hypothesis, experiment, conclusions) emphasizing results as an end-product rather than helping students engage with the material. There is, therefore, a critical need to facilitate student's engagement with STEM content in this course. A positive experience in a general education course in the STEM disciplines is a critical step in recruiting and retaining STEM majors. Additionally, this course provides an opportunity for non-STEM majors to engage with science in their daily lives and to see linkages among STEM disciplines and the arts and humanities. We also aim to help STEM majors engage with the fine arts as a result of the this project.

Our long-term objective is to reformulate the existing lecture and laboratory content of Introduction to Environmental Science to better engage students from a wide range of disciplines and backgrounds, and to recruit and retain STEM majors on campus. The central objective of this proposal is to overhaul the laboratory component of the course, establishing a more modern curriculum and increasing the opportunities for students to engage with environmental science in both their disciplinary majors and their daily lives. We are well positioned to conduct this activity given PI Ward's past experience developing virtual laboratory experiences, and PI Bettis experience developing the current laboratory curriculum and serving as the Academic Coordinator for the
Environmental Sciences program. PI Castronovo will help forge linkages between the arts and sciences in this project.

**Specific tasks and details:**

1. Develop an eBook to replace the existing laboratory manual, accessible on mobile devices and including virtual lectures to supplement written content.
2. Develop a series of virtual laboratory experiments for self-guided learning, including video content scaffolding to assist students. These exercises will emphasize student access to online resources, simulations, and supplemental content.
3. Develop a series of examples linking the content of the laboratory with the arts and humanities, promoting interdisciplinary engagement with course content.
4. Refine or replace existing laboratory modules to emphasize active learning and experiential education, including building upon the virtual laboratory experiments completed before class. Each eBook chapter and assignment will include ICON-based feedback to the TA, such that the laboratory discussion can be customized to emphasize points of confusion self-identified by students, and examples from student responses.
5. Establish an honors laboratory section of Introduction to Environmental Science to beta test the revised laboratory content.

**Work plan**

The laboratory curriculum will be jointly developed by the PIs, a graduate research assistant, and an undergraduate who will conduct preliminary tests of the curriculum. Our general schedule is:

- **Spring 2013.** Assess existing laboratory strengths and weaknesses through student feedback and focus groups. Video tape lectures to provide an initial database of lecture material for the current laboratory exercises.
- **Summer - Fall 2013.** Develop and revise curriculum and eBook
- **Spring 2014.** Implement the beta-test of the refined laboratory, and refine each chapter based on student feedback collected.
- **Summer 2014.** Conduct training session with all Teaching Assistants for the laboratories to familiarize them with the content and implement the revised laboratory in the course.
- **Fall 2014.** Implement.

The proposed work will transform the Introduction to Environmental Science laboratory from what is perceived as a burdensome, unengaging experience into an experience that is focused on active learning in the classroom, and emphasizes individual engagement with class materials. Specific advances include:
1. Video lectures to accompany written content, addressing multiple learning styles in a single document.

2. Integration of multimedia examples from the fine arts to help make Environmental Science accessible to non-STEM majors. For example, integration of a video of the kinetic sculptures of Theo Jansen would highlight the use of harnessed wind energy, providing a link to class discussion of sustainable energy use and management. This example may be more motivating for some students than plots of energy use or CO2 emissions.

3. Virtual laboratory experiments or experiences leveraging web-based resources (e.g., the Iowa Flood Information System) and emphasizing self-guided learning.

4. Video scaffolding to accompany virtual laboratories and assignments. Each task will have a I need help link to a video demonstrating best practices or guiding students through completion of the exercise.

5. Prompts for students to upload their own examples to ICON as part of each laboratory assignment. For example, students might be asked to find an example relevant to the lab in the popular media and share this on the lab ICON site, for discussion in the in-person lab each week.

6. Prompts for students to report specific questions anonymously on ICON before lab so TAs can focus their instruction during lab periods.

7. Accessibility of the eBook as a free download on mobile devices (tablets, smart phones) and personal computers (both PC and Mac). This will save $65 for each student (the cost of the current laboratory manual). This represents a total savings of $26,000 to undergraduate students during the first year of implementation (400 students) alone, and a total savings to students of nearly $130,000 if the book is used for 5 years.

One major strength of an eBook is the adaptability for future iterations. In future years, honors section students will be required to develop a video module highlighting one of the course topics in an area of their choosing (and all students will have this option for extra credit). This content can be integrated with the eBook in future iterations as supplemental material. In this way, our eBook will evolve and will build a large database of supplemental content for use by future students (a form of virtual peer-to-peer instruction). We also hope to engage a fellow from the Writer’s Workshop and one from a performance art (e.g., dance, music) to develop complimentary content in future years.

Assessment
We will work with Jean Florman (Director, Center for Teaching) to develop the assessment instruments for the course, and Melissa Ward (Research Associate, IIHR-Hydroscience and Engineering specializing in assessment and engagement related to STEM education) to conduct focus groups with students. We intend to obtain IRB approval for the assessment activities such that they will be publishable results that can benefit the educational research community. We will conduct lab exit interviews pre- and post-change, and establish an honors section of Introduction to Environmental Science to beta-test our new curriculum. Part of this honors section will entail surveys about perceptions of eBooks and interactive learning (before and after the course).

Because this project is focused at a relatively large general education course the active learning concepts and methodology we incorporate into the eBook and other laboratory exercises should be useful in other general education courses with laboratories. The project is therefore likely to produce benefits to undergraduate education far beyond those realized in the course we are targeting in this proposal.

**What resources will you need?**

Curriculum development support. The primary limitation in implementing these changes is the time associated with development and refinement of the eBook and its features. The primary use of funds requested will be to support a graduate research assistant. This student will be primarily responsible for development of curriculum under the supervision of the PIs.

Technology infrastructure. We request funds to purchase a digital video camera for the recording of eBook multimedia content, and an iPad to test content on mobile devices. Software and hardware resources to edit video and produce the eBook are already available in the Department of Geoscience.

**Rough estimate of costs**

We propose to support a half-time research assistant in the Department of Geoscience, with the primary responsibility of developing eBook content and adapting the existing laboratory exercises, including tuition scholarship and fringe benefits. $30,195.65.

We propose to support 80 hours of support for a student supervised by PI Castronovo at $10/hr plus fringe. $6,132.00.

We propose to purchase an iPad to test eBook content on iOS devices. Computers owned by the PIs will be used to test desktop and laptop access on both Mac and Windows operating systems. $499.00