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Developing Online Training Materials in Molecular Biology: Enhancing Hands-on Lab Skills.

Rachel Boulay
University of Hawaii at Manoa, rachel.boulay@hawaii.edu

Cynthia Anderson
University of Hawaii at Manoa, canders@hawaii.edu

Alex Parisky
University of Hawaii at Manoa, parisky@hawaii.edu

Chris Campbell
University of Notre Dame Australia, ccampbell1@nd.edu.au

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Developing online training materials in molecular biology: Enhancing hands-on lab skills

Rachel Boulay, Cynthia Anderson and Alex Parisky
Center for Cardiovascular Research, John A Burns School of Medicine
University of Hawaii
Chris Campbell
School of Education
The University of Notre Dame Australia, Sydney Campus

A well-accepted form of educational training offered in molecular biology is participation in active research laboratories. However, this approach to learning severely restricts access. Addressing this need, the University of Hawaii launched a project to expand this model to include newly developed online training materials in addition to a hands-on laboratory experience. This paper explores the process of material development and assessment plans. A pilot case study of a science teacher who embarks on learning molecular biology over a four-month period through online training materials and working side-by-side with medical researchers in a laboratory is described. Feedback suggested that the initial online materials over-emphasized abstract concepts and laboratory techniques and did not adequately connect to the active research problems and local context of most interest to teachers and students. The implications for improving blended learning experiences from this specific case are suggested.

Keywords: blended learning, learning objects, molecular biology, online lab training

Introduction

Advances to internet technologies have allowed the World Wide Web to become an alternate source for learning specialized content and the skills necessary to compete in the global job market. As online resources are being used in a variety of contexts to supplement instruction and training in medical schools, we are constantly looking for opportunities to provide educational initiatives that appropriately prepare students and science teachers with an introduction of skills, techniques, and applications for conducting medical research in a laboratory setting. The objective of this educational project is to develop an effective blended learning instructional program that will develop a familiarity for laboratory techniques for prospective individuals prior to conducting molecular biology research in an authentic laboratory setting. The long-term objective of this project is to increase the number and quality of individuals available to conduct research in medically relevant areas of interest to the multi-ethnic population of the Hawaiian Islands. The University of Hawaii's John A. Burns School of Medicine (JABSOM) is well positioned to encourage and support interested individuals, early in the career pipeline, to participate in modern, advanced medical research. However, the potential pool of high school students and their teachers, often lack the basic research skills that would allow them to efficiently integrate into laboratory experiences at JABSOM. The present project proposes to bridge this gap and develop the infrastructure to offer initial training in modern laboratory techniques in an efficient manner. Materials will be displayed online allowing interested parties from multiple areas across the state to gain access to educational opportunities traditionally offered in locations on one island exclusively. Further, these web-based instructional materials will aim to be self-paced and offered freely to interested parties. This project provides the crucial infrastructure to disseminate basic molecular biology training to a wide audience, and enrich the pool of biomedical researchers in the State of Hawaii. This study will address a critical factor limiting interested parties from effectively integrating into laboratories at JABSOM - their limited research experience and previous training. Students have had limited exposure to modern research techniques and need direct initiatives to efficiently supplement their previous training. The plan is to provide online access to professionally developed and packaged training materials that will increase

knowledge critical to participating in a medical research laboratory. To achieve the development and evaluation of the instructional modules, three areas of concentration are planned and in place: 1) access to appropriate content, 2) web-delivery and instructional design expertise, and 3) evaluation and revision of proposed instructional modules. This paper explores the first pilot of these materials in a blended learning approach with a high school teacher learning molecular biology through these online materials and participating full-time in a research laboratory for four months, August – December, 2009.

Literature

A well-accepted form of educational training offered in molecular biology is participation in active research laboratories. Participation in lab internships showed an increase in interest amongst participants in continuing their life science/biology graduate school and careers while also increasing the student's biology laboratory self efficacy (Berkes, 2007). Research laboratory experiences provide students with practical knowledge and resources that allow them to develop their skills as they master the laboratory procedures (Foundation, 2003). The National Science Foundation (NSF) supports undergraduate learning experiences in the area of biology research through a program called Research Experiences for Undergraduates (REU) that provides laboratory practice through summer enrichment courses and supplemental coursework during the school year. In addition universities such as Massachusetts Institute of Technology (MIT) and California Institute of Technology (Caltech) have implemented research based opportunities to increase students' exposure to laboratory work. The MIT model is called the Undergraduate Research Opportunities Program (UROP) and Caltech's model is called the Summer Undergraduate Research Fellowship (SURF) and both models emphasize research laboratory experience over traditional lecturing. These high school or undergraduate training programs are well established within science communities in the USA. However, they are exclusive programs in that they admit a limited number of students and utilize criteria that limit student diversity. While an accepted practice, they fall short of educating a large body of students and meeting the needs of students at large. Building upon the well-accepted practice of laboratory internships, a new blended learning approach is proposed, combining learning objects (digital and web-based), including virtual laboratories, to augment laboratory training. This approach could vastly improve access to high quality instruction and address the needs of more than a few select students a year.

Learning objects utilized in distance learning provide educators with resources that are re-useable, cost effective, and available to a virtually unlimited amount of learners via the internet. The use of learning objects in conjunction with traditional instructional strategies in a blended learning approach supports distance learning by allowing the user to take control of their online experience and employ the learning style that suits their needs (Ruiz, Mintzer, & Issenberg, 2006). Blended learning has been a successful strategy for online education as learning objects tend to be dynamic and are geared toward a student-centered approach that allow learners to interact with the resources at their own pace. Blended learning is based on a combination of traditional instructional strategies, online education, and learning that is supported by other technologies, the result is a learning environment that is tailored to the learner's needs (Hoic-Bozic, Mornar, & Boticki, 2009).

Problem

With the surge of televised programming featuring crime scene investigations or other forensic sciences, interest among teachers and students in "science" and "science research" has increased in the United States. In the State of Hawaii, this resulted in a new challenge for its one medical school, the John A. Burns School of Medicine (JABSOM), the home of any research even tangentially related to forensic science training. Medical schools, including their high-end equipment and specialized scientists, are not typically available to school-aged children and their teachers. However, in a state isolated from any other state or country by thousands of miles of ocean, the medical community felt a certain amount of duty to provide a strong educational base for the youth in its community. This was particularly valued as 60% of the local medical practitioners receive their medical training within Hawaii. JABSOM decided to augment the early educational experiences of children as this was hoped to foster interest in medical research and strengthen the qualifications of the pool of future medical practitioners in the Hawaii. However, major practical questions emerged. How could a medical school and its medical researchers begin to address the need of its local student population and their teachers, without overburdening the medical school's limited resources? How could educational programs be offered that did not exclude specific schools and their students, if the school was located on a different island than the medical school? The tentative answer was an experiment with a blended learning approach.

Methodology

The methodology of this study examines the new "online instructional modules" developed to augment traditional laboratory internships. First, the process for developing the online instructional materials will be discussed. Second, the pilot of these materials in training a local science teacher of children aged 14-18 years old will be explained.

Content of online instructional modules

The content of the instructional modules was assembled through three steps: 1) permission to use materials from a well-developed in-person training at the University of Calgary, 2) links to publically-available and highly regarded online resources, such as those of Cold Spring Harbor Laboratory or Howard Hughes Medical Institute, and 3) new embedded supplemental materials to relate content to specific active research projects and researchers in Hawaii, predominantly at JABSOM.

Step 1. In collaboration with Dr. Hutchins, Director of the Biotechnology Training Centre at the University of Calgary, a well-developed modular curriculum was modified to efficiently address the lack of access to rigorous training available in Hawaii. The Faculty of Medicine at the University of Calgary developed a series of curricular modules to efficiently increase the technical skills and scientific capabilities of its students. Their modules included the following topics: Nucleic acids, Proteins, Web-based Informatics, Cell Culture and Microscopy basics, Genomics/Proteomics, Integrated Cell Biology, and Genetics and Biochemistry. Dr. Hutchins allowed JABSOM to modify the developed curricular materials for Hawaii's target learner cohorts. The modules were repackaged for web-based delivery to better fit the issues of access to training of Hawaii's particular audiences. Figure 1 describes the modules and subsets developed.

I. Molecular Biology Lab Intro	II. Nucleic Acid (NA) Techniques	III. Protein Techniques	IV. Cell Culture Techniques
a. Laboratory Safety b. Laboratory Equipment c. Measurements, Solutions & Calculations d. Molecular Biology Model Organisms e. Content Overview: DNA → RNA → Proteins	a. DNA Restriction & Analysis b. NA Amplification & Sequencing c. NA Hybridization & Expression Analysis d. Molecular Cloning e. DNA Prep, Purification & Quantitation	a. Protein Expression Systems & Vectors b. Protein Detection & Analysis c. Protein Purification	a. Sterile Technique b. Maintaining Cells c. Passaging Cells d. Transfection Methods e. Harvesting Cells f. Expression Analysis

Figure 1: **Molecular biology laboratory techniques**

The opportunity to take advantage of successful, award-winning modular curricula greatly enhances this project's potential effectiveness. The timeframe needed to design and trial web-based materials was further reduced by drawing upon this collaboration and presented a unique potential benefit to the educational opportunities afforded at JABSOM, available to the surrounding community.

Step 2. The development of the instructional modules incorporated an extensive review of web-based content materials available to the public from various distinguished sources. The modules integrated various animations, simulations, tutorials, virtual labs, videos, and additional web-based content from the sources described below. The reviewed sources included materials developed by the Howard Hughes Medical Institute, the Cold Spring Harbor Laboratory and Dolan DNA Learning Center, the Massachusetts Institute of Technology, The National Human Genome Institute, the National Center for Biotechnology Information, the University of Calgary Biotechnology Training Centre, the Arizona Biology Project, and the University of Maryland Baltimore County's Applied Molecular Biology Program. These sources provided an array of content materials presented in various formats that include two-dimensional and three-dimensional guided animations, video segments, interactive tutorials and problem-sets, laboratory protocols, and virtual laboratory investigations. These learning objects enriched the curriculum materials provided through the collaboration with Dr. Hutchins at the University of Calgary. The developed module subsets contained specific learning objectives, content, and learning activities.

Step 3. The next important step for the project will be to provide direct connections between the content knowledge in steps 1 and 2 above and real-life research laboratories in Hawaii. The instructional modules will be expanded to provide information specific to the current research investigations taking place in different JABSOM laboratories through videos of researchers, recorded research presentations (webinars), and providing scientific journal articles. The development and integration of new video segments unique to JABSOM will provide a virtual insight into the laboratory facility and allow for demonstrations of specific techniques utilizing authentic JABSOM research equipment. The video demonstrations will further incorporate an important audio and visual component into the instructional modules to enhance the web-based learning environment. In addition, providing access to published journal articles written by biomedical researchers working at the JABSOM will describe the investigations that have taken place at the JABSOM as well as the future directions of these real-life research projects. Furthermore, an underlying goal of creating these specific connections is to establish a stronger awareness among Hawaii's student population of the biomedical research areas that are of specific focus and need of future investigation in Hawaii.

Evaluation and revision of online instructional modules

A pilot case study of a local science teacher is underway to provide insights into the utility of the developed online materials and also to understand the unique issues in approaching learning of molecular biology through a blended approach. Teacher A, whose named has been changed to protect her confidentiality, is a science teacher in a local high school in Hawaii. Her school is located in a location that is isolated from JABSOM. Teacher A has been teaching for over 10 years and has received National Board Certification in the US, the highest professional designation for quality teaching. She began a four-month long study of molecular biology in which she is released from her teaching load through a sabbatical and participates full-time in an active research laboratory. To augment her training, she was provided with the newly created online materials. This approach to evaluation and revision of the online instructional materials is part of a larger evaluative initiative.

An overall plan for the assessment of the online materials was submitted January 2009. The Committee for Human Subjects granted a certificate of exemption (CHS# 16844). A three-staged approach to revision of the online instructional modules was proposed, using content reviewers, individuals as test cases, and a small pilot group.

Content Reviewers. An initial team of well-funded medical researchers are providing overall insight, feedback, and accuracy check of the content disseminated in the modules. Dr. Daniel Bernstein, Stanford University, and Dr. Ralph Shohet, Director of the Center for Cardiovascular Research at JABSOM, are the most active volunteers to review the content of the online materials. They provided feedback on the module, assessment tools, participated in semi-structured interviews to collect suggestions and ideas to improve the instructional modules.

Individual test cases. A few cases from the target audience will be selected to trial materials and provide feedback on their utility and appropriateness for their learning goals and experience. Continued revisions will be made. Currently, Teacher A is using and assessing the materials, as the first test case.

Small Pilot Group. A small group of participants of approximately 15 individuals will pilot materials. All participants will complete a pre-test assessment of their knowledge and skills in conducting molecular biology techniques. Then they will be given access to the instructional modules for a period of time. On their own schedule, individuals will complete online guided activities, such as those explained above in the content development section of this application. Participants will arrange for a post-test assessment after they have completed the materials. In addition to the objective performance assessment results, participants will complete surveys asking for their general feedback and suggestions on the materials, delivery format, and utility of the materials.

Initial results

The program was first implemented in the summer 2009. While in its preliminary stages of development, the modules will eventually undergo a thorough review process from university faculty, molecular biology researchers, medical doctors, as well as local teachers and students. Professionals reviewing the content and organization of the modules will be presented with several versions of the materials to build the final program. The initial results already gathered through Brenda's personal case of learning, emphasize the need to provide direct connections between the content and real-life research laboratories at the JABSOM. In other words, abstract information, such as that commonly found in textbooks, is now

available online, but while this content is rich with engaging animations and interactive tasks, the information is still perceived as "abstract." The connection to everyday life or the active research underway is not clear enough. We plan to revise the materials to facilitate these connections within the modules by including specific information on current research projects taking place in the different medical laboratories. This information will be structured to fit the online format by creating instructional videos of technique demonstrations and interviews with researchers in the laboratories in addition to including electronic versions of scientific journal articles published by JABSOM researchers. The JABSOM-focused videos and journal articles will be important instructional tools to provide implications for creating an authentic learning experience for Hawaii's students and secondary level teachers. Furthermore, we believe that these specific connections will establish a stronger awareness among Hawaii's science students and teachers of the biomedical research areas that are currently being studied and are of need of future investigation in Hawaii.

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Authors: Cynthia Anderson, Center for Cardiovascular Research, John A Burns School of Medicine, University of Hawaii. Email: canders@hawaii.edu
Dr Rachel Boulay, Center for Cardiovascular Research, John A Burns School of Medicine, University of Hawaii. Email: rachel.boulay@hawaii.edu
Dr Chris Campbell, School of Education, The University of Notre Dame Australia, Sydney Campus. Email: ccampbell1@nd.edu.au
Alex Parisky, Center for Cardiovascular Research, John A Burns School of Medicine, University of Hawaii. Email: parisky@hawaii.edu

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