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Designing and Developing Open Education Resources in Higher Education: A Molecular Biology Project

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Abstract

Recent advances in internet technology have transformed how we gather and share information in today's world and have provided us with a platform to access educational resources and related information on the Internet. Every day, new technologies are developed that are changing the when and where we access that information. The capabilities of new technologies have allowed society to access information and learn virtually anywhere. As technical ingenuity continues to generate new technologies and paths of communication, we must look for opportunities to collaborate, share and extend our educational resources in higher education. Distributing Open Educational Resources (OER) in the form of freely licensed materials is necessary in order to laterally influence current advances in learning technologies. Online resources are being used in a variety of contexts to supplement instruction and training at higher education institutions. The aim of this Open Educational Resource project was to design and develop a blended learning instructional program to assist online users in developing familiarity with laboratory techniques prior to conducting molecular biology research in an authentic laboratory setting. This paper will look at the background of OER, describe the online materials that the Center for Cardiovascular Research (CCR) developed for open use, and discuss the outcomes and implications for use.

Keywords

Open Source; Science; Online Learning; Blended Learning

Introduction

Recent advances in internet technology has transformed how we gather and share information in today's world and provided us with a platform to access educational resources and related information on the Internet. Additionally new technologies are changing the where we access that information. The capabilities of new technologies have allowed society to access information and learn virtually anywhere. As technical ingenuity continues to generate new technologies and paths of communication, we must look for opportunities to collaborate, share and extend our educational resources in higher education. Through the use of information and communication technologies, college-aged students appear to be expanding the variety of physical locations where the pursuit of learning is being accomplished.¹ The Center for Cardiovascular Research (CCR) is actively searching for

opportunities to provide educational initiatives in the State of Hawaii that appropriately prepare scientists, and the science educators who teach them with a knowledge base of skills, techniques, and applications for conducting medical research in a laboratory setting.² As the internet is being utilized in a variety of ways to help facilitate instruction and training in higher education, educators are constantly searching for opportunities to provide educational resources more effectively. In the end our goal is to adequately prepare science students and their instructors with an introduction of skills, techniques, and applications for conducting medical research in a laboratory.

The project was initiated in early 2009 as part of a joint collaboration between Dr. Wendy Hutchins of the University of Calgary School of Medicine and the Center for Cardiovascular Research at the John A. Burns School of Medicine at the University of Hawaii to provide molecular biology content materials online. Dr. Hutchins had developed a comprehensive molecular biology curriculum that would provide an excellent foundation for the project. The project was developed over the next year with the intent of being piloted by a group of high school biology teachers as part of a professional development program at the Center for Cardiovascular Research. It was our aim to develop an effective blended learning instructional program to assist users in developing familiarity with laboratory techniques prior to conducting molecular biology research in an authentic laboratory setting.³ Initial feedback from the teachers indicated the materials supported the learning that was taking place in the laboratory. The project was undertaken by the Center for Cardiovascular Research at the John A. Burns School of Medicine (JABSOM), University of Hawaii – Manoa. Molecular Biology materials are shared through the internet and available worldwide so any interested parties with a browser can freely gain access to these educational resources that are typically offered only in limited locations. Furthermore, these online instructional resources allow the interaction between user and the materials to be self-paced. This project provides the initial foundation to disseminate basic molecular biology training to a vast audience, and enrich the pool of scientists worldwide.

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Framework

Open education has followed the same path of development that we have seen in other open systems including open source software, open access, and open archiving. Open education as a movement sits within the broader framework of the history of openness that brings together a number of disciplines and fields that have a direct effect on knowledge and

¹Ellen Wagner, “Enabling Mobile Learning,” *Educause Review* 40, no. 3 (2005).

²R. Boulay, A. Parisky, and C. Campbell, “Developing teachers' understanding of molecular biology: Building a foundation for students,” *ASCILITE Annu Conf* (2010).

³Ibid.

learning.⁴ In 2002, UNESCO invited a group of academics, to assess a new development – the OpenCourseWare initiative of the Massachusetts Institute of Technology (MIT). The Forum on the Impact of Open Courseware for Higher Education Institutions in Developing Countries coined the term ‘OER’, which was defined as: The open provision of educational resources, enabled by information and communication technologies, for consultation, use and adaptation by a community of users for noncommercial purposes.⁵ The William and Flora Hewlett Foundation, the principal financiers of the Open Educational Resource movement defines OER as: teaching, learning, and research resources that reside in the public domain or have been released under an intellectual property license that permits their free use and re-purposing by others.⁶ Other terms such as open content, open educational content, open learning resources, open educational technologies, open academic resources, open source, and open courseware are variously used in the literature and in online and face-to-face discussions; but it is the term OER adopted at a UNESCO meeting in 2002 that is most commonly used. OER include full courses, course materials, modules, textbooks, streaming videos, tests, software, and any other tools, materials, or techniques used to support access to knowledge. Open source is a particular way of giving access to materials and processes in that the source material is available alongside the finished artifact, thereby allowing subsequent adaptation and redevelopment by anyone wishing to undertake the work.⁷

Education has always been dependent to some degree on changing information and communication technologies. The Open Education movement has expanded the development of curricula and educational materials as the Internet has changed the way existing content resources are shared and distributed. OER are teaching and learning resources that are accessible to the public and sometimes licensed for reuse in alternate settings and they are typically organized into cohesive educational units, or courses, that frequently utilize videos, simulations, tutorials, and a variety of learning tools that help facilitate an online learning experience.⁸ When considering the impact of OER on medical, healthcare education, it is important to recognize that it is only one component of health sciences education. In practice, medical education requires a complex blend of educational materials, experiential learning, and human interaction within a school structure.⁹

Description of Practical Application

The OER Site

The OER (www.ccrhawaii.org) are divided into four sections or modules, each consisting of several topics. Each topic is then divided into subtopics that contain the content material and additional learning resources such as technique videos, animations, and activities. There are

⁴M.A. Peters and R.G. Britez, eds., *Open Education and Education for Openness* (Rotterdam: Sense Publishers, 2008).

⁵UNESCO, “Forum on the impact of open courseware for higher education in developing countries: Final report,” UNESCO, unesdoc.unesco.org/images/0012/001285/128515e.pdf.

⁶Hewlett-Foundation, “Open educational resources (OER) – making high quality educational content and tools freely available on the web,” <http://www.hewlett.org/programs/education-program/open-educational-resources>.

⁷Rachel Ellaway and Ross D. Martin, “What’s mine is yours—open source as a new paradigm for sustainable healthcare education,” *Medical Teacher* 30, no. 2 (2008).

⁸David Wiley and Seth Gurrell, “A decade of development,” *Open Learning* 24, no. 1 (2009).

⁹Mary Y. Lee et al., “Expanding the reach of health sciences education and empowering others: the OpenCourseWare initiative at Tufts University,” *Medical Teacher* 30, no. 2 (2008).

a variety of videos demonstrating Molecular Biology laboratory techniques located in several topics where the particular techniques are explained in the content area. In addition, each section contains video explanations for each topic. The molecular biology materials takes anywhere from 10 to 30 hours to review depending on the users' background knowledge in this particular area of biological sciences. The content of the instructional modules was assembled through three steps: 1) permission to use materials from Dr. Wendy Hutchins at the University of Calgary was obtained, 2) links to publicly available, well-known and highly regarded online resources, such as those of MIT OpenCourseWare or Howard Hughes Medical Institute were reviewed and hyperlinked, and 3) a web design was generated based on recommendations from reviewers and the addition of various learning objects.¹⁰

The University Of Calgary Faculty Of Medicine had previously developed a series of molecular biology tutorials to support the instruction of medical students. Dr. Hutchins allowed the Center for Cardiovascular Research to modify the curriculum for its own project within the State of Hawaii. These modules were redesigned and redeveloped for web-based delivery to better accommodate the needs of online learners. Table 1 lists the modules and subsets developed.

The development of the instructional modules incorporated an extensive review of webbased content materials available to the public from various distinguished sources¹¹. The materials were initially developed to be used at the advanced high school to university level. The modules integrated various animations, simulations, tutorials, virtual labs, videos, and additional web-based content from the sources described following. There were 14 technique videos that were developed by the research staff at CCR. The site provides links to over 200 unique online resources and has included materials developed by a total of 12 institutions, including 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 79 two-dimensional and three-dimensional guided animations, 44 video segments, 60 interactive tutorials, and 21 problem-sets/laboratory protocols/virtual laboratory investigations. These up-to-date, technology-enhanced virtual learning resources 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.

Implementation

This section describes the implementation of OER developed to augment traditional laboratory internships. The online materials first used to supplement a CCR professional

¹⁰Alex Parisky, Paul McKimmy, and Rachel Boulay, "Sharing an Open Resource in Medical Education," in *World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education 2011* (Honolulu, Hawaii, USA: AACE, 2011).

¹¹Ibid.

development training program for local high school advanced biology teachers. The professional development program was facilitated using a combination of online training materials supplemented by seven in-class laboratory demonstration days, over a period of four months between February and May 2010. Participants were given access to the online training materials once they had completed their pre-program survey and prior to hands-on laboratory training. Therefore, the teachers were given access to the online instructional modules prior to working in an actual laboratory. After completing online-guided activities, the participants performed work in a laboratory that covered the material they studied online. Usage statistics were monitored during this period, and subsequently, to determine the extent to which the site was accessed as a publicly available open educational resource. In the first year of use the site saw an average of 400 unique visitors and in the next year that grew to about 2000 unique visitors. The site is currently attracting an average of 5600 unique users per month. The highest percentages of those users are accessing the site approximately 30 minutes to 1 hour per visit. The most accessed pages are the tutorials on Tissue Culture and Nucleic Acid Amplification.

Twenty advanced biology teachers piloted the molecular biology content and online resources during this program's initial four month period. The average biology teaching experience for the participants was approximately thirteen years. The participants were selected from a pool of secondary biology teachers from the State of Hawaii, including the islands of Maui, Kauai, Oahu, and the Big Island. The Center for Cardiovascular Research chose individuals that had significant experience teaching advanced courses in biology, as they would be exposed to students who were most likely to follow a path leading into biomedical research careers. Additional screening for participants who had demonstrated leadership experience at their respective school sites was important to our study as we were looking for input from the leadership of the science teacher community in the State of Hawaii.¹² Since 2010, an additional 20 teachers have been trained using the online materials in conjunction with hands-on training. At the end of the training teachers responded to a survey about their experience and a final statement was provided. Although there was no formal assessment, teachers were prompted to provide feedback on the use of the online materials.

In addition to the teachers in our programs, there has been huge spike of interest in the web materials outside of our local population, as site use profiling through IP addresses has indicated that users from all parts of the world are accessing our online molecular biology materials.¹³

Outcomes

The use of OER has demonstrated its effectiveness for educational contributions in recent years. When considering the concept of unlimited and unfettered sharing of such material resources online has gained attention in all facets of higher education. As the OER movement continues to grow, its presence in the academic arena will flourish. As the site

¹²Ibid.

¹³Parisky, McKimmy, and Boulay, "Sharing an Open Resource in Medical Education."

currently is meeting the needs of approximately 5600 unique visitors a month, we can make the assumption that the online materials are being viewed by majority of users that are outside our original intended population of science teachers in Hawaii. With this in mind we believe our project is making an impact in the realm of OER.

By compiling such resources, both from original contributions and from existing OER, the ccrhawaii.org site proved an easily accessed resource that attracted an ever expanding number of users - far greater than the initially intended audience. OER have been around for over 10 years now but even now only a very small proportion of higher education institutions are involved with publishing OER although the momentum is increasing as OER are adopted into national and/or institutional policies.

Strengths of OER

There are numerous benefits to be gained from adopting OER to promote equity for students in educational contexts, especially in distance education. OER have been increasingly introduced into the recent dialogue in education, mostly in relation to their potential to increase access to education, improve quality, and reduce the cost of education mainly in developing countries.¹⁴ Sharing knowledge is congruent with the academic tradition; and sharing is considered an academic value. The cost of content development can be reduced and quality may be improved, and materials may be reused, redeveloped, and redistributed. The public image of the institution may be enhanced and new students attracted and gaining publicity or reaching the market more quickly may result in an economic advantage.¹⁵

Educators worldwide can also take advantage of OER. They can access a broad range of learning resources that in many cases are peer reviewed, which they can use for their own personal learning, incorporate into their existing units, and adapt and include in new units. All the above can assist educators to reduce teaching preparation time, avoid duplication, and concentrate their efforts on making students' learning a greater experience. In other words, instead of focusing on information conveyed in a course, academics can finally focus on the process of learning.

Weaknesses of OER

One of the biggest drawbacks is the lack of proper internet communication technologies, such as lack of broadband access. Many countries have limited financial resources to invest in infrastructure, software and hardware. Also many potential users may be discouraged as they may lack the skills needed to use a particular technology and often easy access to training is not available. The language of instruction can be problematic in the creation of OER.¹⁶ English is considered an international language due to its usage in knowledge dissemination, publications, international business, technology, and aviation, each being major drivers of globalization. However, the majority of learners worldwide come from non-English-speaking backgrounds. Even though the number of OER translated into different

¹⁴Asha Kanwar, Balasubramanian Kodhandaraman, and Abdurrahman Umar, "Toward Sustainable Open Education Resources: A Perspective From the Global South," *American Journal of Distance Education* 24, no. 2 (2010).

¹⁵David Wiley, ed. *On the Sustainability of Open Educational Resource Initiatives in Higher Education* (Paris: OECD-CERI, 2007).

¹⁶Leilani Silver, "Pure potential: The impact of open educational resources," *Open and Libraries Class Journal* 1, no. 2 (2009).

languages has grown substantially in recent years, and consequently this has increased access to OER repositories that provide resources in other languages, the majority of OER available are still in English.

Implications

Today's technologically rich digital environment provides both challenges and opportunities for educators. For example, mobile and Web-based learning offers the opportunity to take learning outside the classroom, allowing educators to explore ways in which learning can be organized across formal and informal educational contexts.¹⁷ Such an expansion in online use could be utilized in many ways. Institutions might seek to convert open courseware consumers into registered students. Visitors to open education resource sites could generate advertising dollars for the institutions investing in such endeavors. Teachers and students utilizing open distance learning could take advantage of OER, where teachers could disseminate content materials in lieu of textbooks and workbooks to a greater population of students, significantly reducing material costs. Distributing OER in the form of freely licensed materials is necessary in order to laterally influence current advances in learning technologies. And perhaps most importantly, as quality OER are shared and re-mixed by other institutions with similar open ideals; all those involved can mutually leverage the results of the projects – achieving lower development costs for all. It will take a community of educators working in collaboration to take this movement to the next level. OERs are already being utilized to educate populations about healthcare issues. Large scale institutions such as the Howard Hughes Medical Institute and MIT's OpenCourseWare project are two examples of OER that serve the medical and healthcare populations.

In the future technological infrastructure will grow, and access to OER will increase.¹⁸ This will enable contributors from other nations to add cultural significant materials. As OER becomes more widely available, accessible, and accepted, it will become an important part of closing the educational gaps, especially for those who need it most.

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¹⁷Andy Lane and Patrick McAndrew, “Are open educational resources systematic or systemic change agents for teaching practice?,” *British Journal of Educational Technology* 41, no. 6 (2010).

¹⁸Silver, “Pure potential: The impact of open educational resources.”

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Biographies

Alex Parisky: I am currently a Doctoral Student in Educational Technology. I am Instructional Designer for the Center for Cardiovascular Research at the John A. Burns, University of Hawaii. I am doing my dissertation research on how Medical School uses distance learning systems to supplement traditional medical education.

Dr. Rachel Boulay: Rachel Boulay is the Director of Education for the Center for Cardiovascular Research. She is committed to building the bridges between science teachers and scientists to collaboratively spark students' interest in science. She recently launched a statewide initiative to upgrade the content knowledge of biology teachers teaching in public high schools throughout the Hawaiian islands and the Pacific. She has a broad background in research and evaluation as well as in curriculum development, technology integration and organizational change in education. Research areas include the development and structure of online open access content for teaching science, professional development for K-12 teachers and higher education faculty, and the instructional design of curriculum materials for use in blended learning environments.

Figure 1. Introductory Page for CCR OER

Source: www.ccrhawaii.org

Figure 2. Cell Culture Techniques Module

Source: www.ccrhawaii.org

Figure 3. Introduction to Cell Culture Video

Source: www.ccrhawaii.org

Figure 4. Tissue Culture and Preparation of Lysates Technique Demonstration Video

Source: www.ccrhawaii.org

Table 1

Molecular Biology Online Training Materials.

Introduction to Molecular Biology Includes: 24 animations 4 videos 8 interactive tutorials 8 virtual labs	a. Laboratory Safety b. Molecular Biology Laboratory Equipment c. Measurements, Solutions, & Calculations d. Content Overview/Review
Nucleic Acid Techniques Includes: 34 animations 7 videos 12 interactive tutorials 26 virtual labs	a. DNA Restriction & Nucleic Acid Analysis b. Nucleic Acid Amplification & Sequencing c. Nucleic Acid Hybridization & Expression Analysis d. Molecular Cloning e. Preparation, Purification, Quantitation of DNA & RNA
Protein Techniques Includes: 24 animations 6 videos 23 interactive tutorials 7 virtual labs	a. Protein Expressions & Proteomics b. Protein Detection & Analysis c. Protein Purification
Cell Culture Techniques Includes: 4 animations 6 videos 11 interactive tutorials	a. Intro to Cell Culture & Aseptic Technique b. Maintaining Cells c. Transfection Methods d. Expression Analysis