Chapter 7

Online Laboratory Education: Principles and Practices of the Integrated Laboratory Network

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ABSTRACT

The Integrated Laboratory Network (ILN) is an initiative to provide anytime, anyplace access to advanced scientific instrumentation and online laboratories for science education. To date, the ILN has been used successfully in high schools, community colleges, and universities, both nationally and internationally, and has provided new learning opportunities that incorporate instrumentation into the broader curriculum. The ILN uses open source software to facilitate remote access to instrumentation and curricular materials and to support video conferencing during online laboratory sessions. This chapter describes the principles and best practices of the ILN. Specifically, the history of the ILN, the technologies used by the ILN, and the pedagogical issues and strategies related to the design, implementation, delivery, and evaluation of online ILN labs will be discussed. Current activities toward the development of laboratory science kits enhanced with remote instrumentation and the formation of an international consortium of online laboratory developers will also be presented.

INTRODUCTION

It is no secret that we are living in a time of incredible technological change. With the advent of more robust and stable international networks, the Internet and World Wide Web (Web) have dramatically changed the way we think about and engage in science. From “live” remote surgeries (Anvari, McKinley, & Stein, 2005) to “real-time” experiments in ocean floor labs (Victoria Experimental Network Under the Sea, 2001) to mini-blogs from Mars (Havenstein, 2008), Internet applications and Web-based tools are providing unprecedented opportunities for scientific collaboration,
problem-solving, and research. Projects such as pharmaceutical giant Eli Lilly’s InnoCentive (InnoCentive, 2001) and the emergence of Science 2.0 (Waldrop, 2008) typify the innovative ways that Web technologies are being used to harness the collective intelligence and creativity of scientists to address pressing societal problems, improve research productivity, and challenge traditional views of “doing” science.

Science education has also been impacted dramatically by technological change (Cancilla & Albon, 2010). Everything from online classroom management systems, virtual classrooms in Second Life, and social networking tools such as Twitter, Facebook, and YouTube to the use of remote instrumentation and online labs are providing alternatives to traditional “bricks and mortar” classroom and laboratory learning experiences (Cancilla & Albon, 2010; Chen, 2010). Initiatives such as Western Washington University’s (WWU) Integrated Laboratory Network (ILN) (Cancilla, 2010), the Massachusetts Institute of Technology’s (MIT) iLabs project (Long & DeLong, 2010), Purdue University’s Center for Authentic Science Practice in Education (Center for Authentic Science Practice in Education [CASPiE], 2004), Youngstown State’s Science Teaching and Research Brings Undergraduate Research Strengths Through Technology (STaRBRUSTT) consortium (Hunter et al., 2006), the British Columbia Integrated Laboratory Network (BC-ILN) (Brewer & Cinel, 2010), British Columbia’s (BC) North Island College’s Web-based Associate of Science (WASc) project (Evans & Balbon, 2010), and Iowa State University’s Web-based scanning electron microscope (WebSEM) project (Chumbley & Chumbley, 2010) provide examples of how institutions have embraced Web-based technologies for transforming science education.

While a common feature of these educational initiatives is remote access to modern scientific instrumentation, the underlying pedagogical reasons are varied. For example, the ILN and BC-ILN have focused primarily on providing instrumentation for undergraduate teaching, while the CASPiE initiative provides instrumentation for undergraduate research. MIT’s iLabs, WWU’s ILN, and the BC-ILN make a variety of scientific instrumentation available, while the STaRBRUSTT and WebSEM initiatives have historically focused on single instruments for the analysis of crystals and microscopy applications, respectively. The WASc project in physics and astronomy, which includes remote access to the telescope at the Tatla Lake On-line Observatory, represents BC’s first fully online Web-based science degree program serving communities and populations in northern BC and Canada’s territories, including the country’s First Nations peoples (Evans & Balbon, 2010). The particular focus of each group has also led to the use of different Web-based technologies, from fairly expensive commercially available networking and security tools, to the development and use of sophisticated in-house software applications, to the use of free and open source software. The broad experiences and successes of these groups demonstrate that a number of “best practices” currently exist both pedagogically and technologically for supporting online laboratory education (Cancilla & Albon, 2010).

This chapter describes the “best practices” of the ILN project (Albon & Cancilla, 2004; Cancilla, 2001, 2004; Melious & Cancilla, 2002), an initiative to provide anytime anywhere access to scientific instrumentation for teaching and research. Combining open-source Web-based tools and learning-centered curriculum design principles, the ILN project has focused on creating cost-effective remote, online laboratory activities addressing real-world issues and authentic scientific practices (Albon, Cancilla, & Hubball, 2006; Albon & Hubball, 2004; Cancilla & Albon, 2005; Charuk, 2010). In addition, research on student learning and teaching practice has provided compelling evidence that ILN-based labs help students develop in-depth understanding of
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