Online Science Laboratories

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What is an Online Science Laboratory?

An online science laboratory is just what it sounds, a laboratory that takes place remotely at home, online via computerized robotics, or virtually through simulations or software. They have the same learning outcomes as the traditional laboratory, but the focus and the structure of the online laboratory may make more use of and implement greater reliance on online content, at-home or local materials and learning centers, or online peer-to-peer collaboration. For example, a student in geology may be tasked with observing and identifying specimens of fossils at home by viewing and rotating 3D photographic replicas, a student in physics may need to complete her exercise on wave vibration using a computer-controlled robot via the internet, or a geography student may apply principles of mapping through Google Earth® software.

The increasing abundance of scholarly studies (see Chapters 6 & 8 in Kennepohl, 2016) aimed at evaluating the efficacy of online science laboratories shows that online learning of specific learning outcomes, for example, through a computer-based laboratory, can be just as effective, and in some cases, more effective than traditional instruction. As instructional technology continues to improve and new methods of communication and collaboration are created, students and instructors are finding the online laboratory to be an exciting and desirable means to introduce, demonstrate, or solve complex problems in science disciplines.

Introduction

An online science laboratory may be offered in response to the increasing interest students have in pursuing their education in an online environment, or because of programmatic or institutional goals or guidelines. Although offering a science laboratory course online may seem like an unachievable task, many schools, such as University of Oregon and Arizona State University, have successfully implemented online science laboratories into their curriculum. Here at Kent State University, for example, introductory physical science laboratories are offered online in geography, geology, and physics. Each of these departments has chosen a particular method of pedagogy by which to engage and teach the student, but each has shown that online laboratories can be done successfully, as measured by end-of-semester surveys and academic performance.

The key to a successful online science laboratory is its design. Using backward design and focusing on the learning objectives of the course, the instructor and/or course designer should avoid automatically adapting their traditional laboratory exercises directly to the online environment, but rather should be very critical of the feasibility and accessibility of the required materials, current content knowledge of the students and the time needed to complete the laboratory exercises. For example, if students are to master the ability to identify parts of a plant, it would be rather easy for them to gain access to a plant nearby their residences to identify and even dissect the plant. In contrast, it would be

much more difficult for students to gain access to specific plants that may not be available where they live. Instead of requiring students to observe the more specific, but less accessible plants, the instructor could consider equally instructive specimens that are more readily available.

Not all laboratories are best for the online environment. The development of your online laboratory may require you to rethink the laboratory based on tools available and limitations of software. You may find that certain laboratory exercises are best left to a face-to-face environment. Educational laboratories do exist (see Other Resources below) which can offer a robot or simulation-based exercise that allows students to perform the same skill they would do if they were present in a laboratory classroom. Please note, if the online laboratory is not developed in-house, a major drawback to the third-party laboratory is the rise in cost as students or institutions must pay a fee for this service. Many specialized tools are operated remotely through computer software even in the face-to-face environment, so controlling it remotely does not change the experience drastically. If actually doing the manipulation is not be a crucial component of a student's experience, the online environment is sufficient. Most online science laboratories are intended for an introductory course in the discipline, thus any deficits in tactile learning are reduced through more advanced laboratory courses in the major of choice.

Follow the implementation steps below to begin developing your online laboratory. The focus of this teaching tool is to get you started; this is not an exhaustive list of all you can or must do but rather a guide to help you jumpstart online laboratory instruction. Additional tools and references are provided below for support beyond this introduction.

Implementation

1. Determine your learning objectives for the science laboratory. Seek to fulfill the 3E model proposed by Mary Mawn (*in* Kennepohl, 2016): Expectations, Experimentation, and Engagement.
    A. Expectations: Be sure the learning outcomes are explicit, measurable and align with the guidelines/protocols for your discipline, institution or state board of education.
    B. Experimentation: Laboratories should actively engage students in scientific investigations. Allow students to perform tests, build models, or challenge theories to find answers to questions and validate observations.
    C. Engagement: Use tools to engage learners such as relevant topics, providing opportunities to link theory with practice, thereby challenging and strengthening students' understanding.
2. Identify tools, techniques and skills students will be using or developing. Explore options by seeking and testing various pedagogical approaches, such as 3D models, computer simulations, specialized software, etc.
    A. Locate and utilize available resources to create learning materials and manage your course (e.g., through a learning management system, such as KSU's Blackboard Learn).
    B. Locate sources of physical materials for laboratory exercises. You may consider putting together your own "kit" to ship to students, or you may have students purchase their materials, e.g. from scientific supply companies, their local hardware store, etc. Many educational companies offer standard kits for sale and can tailor them to your needs.
    C. Select, design or use preexisting laboratory exercises the students will execute.
    D. Determine whether the student requires specialized software or hardware (e.g., smartphone, camera, etc.).

*If you have determined that there are applicable tools and resources that help the student achieve the learning objective without compromising integrity, then proceed with the development.

3. Discuss your plan with other faculty and with instructional designers/educational technologists at your institution. Here at Kent State University, seek input from the Office of Continuing and Distance Education (OCDE), The Center for Teaching and Learning (CTL), and your assigned educational technologist. Consider also getting involved in a community of practice. For example, the KSU Stark campus hosts a Distance Learning Community of Practice which holds regular practical workshops and brown-bag lunches to help facilitate improvements in online learning.
4. Do a test run of the laboratory yourself and ask other faculty or student volunteers to evaluate the laboratory experience.
5. Make plans for how you will assess both students' learning as well as the students' experiences in the online lab. This recommendation may require some consultation with others already involved in the scholarship of teaching and learning (SoTL). Here at Kent State University, many faculty are actively engaged in SoTL and these resources are available through the CTL and FlashPort, a resource available through your Flashline account. In addition, a Blackboard page, SoTL Central, has been created to help faculty connect with other faculty and provide access to various resources related to SoTL. Other institutions have similar professional development and SoTL resources.

Frequently Asked Questions

a) *Who can offer an online science laboratory?* The answer to this question depends on the discipline. Speak first with your department chair or college dean to inquire about Ohio Board of Education mandates and other guidelines adopted by KSU and other Ohio public institutions.
b) *What laboratories can be offered online?* It is recommended that teachers first determine their primary learning objectives. You will know best what required skills or techniques of mastery are needed. Just because you can offer something online, does not mean that you should. If there are methods available at home or through a fee-for-service educational online laboratory that help students learn the same skill or principle as a traditional laboratory, then an online laboratory may be possible. If the learned skill requires expensive and potentially unsafe equipment or chemicals, then it may be best to stick with a traditional laboratory.
c) *How long does it take to develop an online science laboratory?* It may take some time to develop an online laboratory complete with several exercises so start early, at least 6 months to design, test and implement the exercises.
d) *What teaching resources are available to help me design and manage the course?* Speak with the OCDE, CTL or their equivalent at your own institution. It is also beneficial to consult with current faculty who teach online science laboratories already. You can also visit various national or international websites devoted to the development of online courses, such as the Open Science Laboratory.
e) *What are the most common mistakes in developing an online laboratory*? A common mistake is to assume that what a student does face-to-face is what they must do online. This is usually related to having poorly developed or absent learning objectives. Another mistake is to assume that only sophisticated technology or software is needed for a successful learning experience. Put the emphasis on the learning objective rather than the technology or software.

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Other Resources

At Kent State University
KSU Office of Continuing and Distance Education; https://www.kent.edu/cde
KSU Center for Teaching and Learning; https://www.kent.edu/ctl

Other online resources
North American Network of Science Labs Online (NANSLO); https://www.wiche.edu/nanslo
The Open Science Laboratory; http://www.open.ac.uk/researchprojects/open-science/

Materials
Ward's Scientific; https://www.wardsci.com/store/
Hands-On Labs; https://holscience.com/
eScience Labs; http://www.esciencelabs.com/

References

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