CHAPTER 5
CHOOSING LABORATORY ACTIVITIES

5.1 Labs or No Labs?

Not every science course requires a lab component, and some majors do not require students to take the lab portion of science courses. The Texas Core Curriculum no longer requires the lab component of science electives; it now only requires six hours of science rather than eight (Texas Core Curriculum). Some college majors still require the lab portion of science courses, though, and perhaps for good reason. Lab activities allow students to experience science rather than simply reading and discussing scientific information. This levels the field for students with diverse backgrounds and supports learning for all students, regardless of prior knowledge (Eisenkraft, 2013).

Teaching a lab course online is challenging, but with innovative technology and resources, that challenge is manageable. There are several issues to consider, including how students will obtain access to necessary chemicals and equipment, how instructors can ensure students know how to properly complete experiments, how instructors can reduce their liability in case of accidents or negligence by the student, and perhaps most importantly, student safety. At Blinn College, we considered separating credit for lecture and lab to overcome this issue. By separating the courses, students could take the lecture portion of lab online, and attend once a week for lab. Ultimately, we decided against this option, since not all students who enroll in the online course would be able to attend labs on campus.

Assuming you (or your college) want to include labs in your online course, there are generally four options available. You could have students purchase a lab kit from a supply company, write labs that can be completed at home with everyday items, use virtual

simulations, utilize a remote laboratory like NANSLO, or a combination of these options. You should carefully consider your choice, as it could affect your and/or your college's liability in the case of accident or injury.

5.2 Lab Kit Companies

A popular option is to utilize a lab kit supply company. There are several, and your college may already have a contract with one or more of them. Check with your department head to determine if there is already a contract in place. When working with a lab kit company, decide which experiments you would like to use in your course. Pick and choose which experiments you would like students to complete for your course, and the company packages kits specifically for your students. Students then order the kits directly from the company.

There are several advantages to this option. First, students conduct hands-on experiments as they would in a face-to-face class, so they gain experience in using laboratory equipment. Second, the company includes a lab manual with all instructions and safety information. Finally, and perhaps most importantly, is the issue of liability. You can't watch over your online students as they complete a lab activity, so you cannot ensure their safety as well as in a face-to-face class. However, since students purchase lab kits directly from a separate company instead of the instructor or the college, this could mitigate the liability of the college and instructor. For example, in an article of InsideHigherEd.com posted in 2009, Linda Jeschofnig, president and chief executive of HandsOn Labs, writes that, "The liability is ours, and we're happy to accept it because we believe we have a safe product" (Moltz, 2009).

There are three popular companies that offer lab kits for a variety of college science courses. Contact them for sample lab kits to determine which would best meet your needs.

Hands-On Labs
Phone: 866-206-0773
info@holscience.com

eScience Labs
Call us: (888) ESL-KITS
info@esciencelabs.com

Carolina Biological
Phone: (800) 334-5551
www.carolina.com

5.3 Instructor-Written Labs Using Household Materials

Writing your own labs for students to complete at home is difficult. You must consider what chemicals are available to students and safety concerns with instructor-written labs are more of an issue, depending on your subject area. Designing labs will require more time on your part as well, since you would have to write the labs according to what chemicals and supplies are readily available in multiple locations. This would limit your selection of materials and equipment drastically.

Your college could also build its own kit, although the logistics of this could become a nightmare depending on chemicals and equipment used. Your college (you) would have to compile the chemicals, materials and equipment into a kit, and ensure that there are enough kits for all students. Then, the college would have to calculate the costs of the kits so that those costs could be added as fees for students to pay, including shipping. Then the kits would have to be shipped to the students. At Blinn College, it was decided not to develop our own kit for students to purchase.

Instead, we developed our own lab manuals for introductory biology. One goal in developing an online course was to make the online course as similar in content to the face-to-face course as possible. For us, this meant replicating experiments from that lab manual in a format that cost as little extra as possible for students. While the course was successful (see data from chapter 3), I don't recommend this option. An at home lab with materials purchased from local stores could not replicate everything we did in the college laboratory, and some students struggled to find appropriate materials for certain labs. This meant we had to supplement these kitchen labs with online simulations. I used free, open source simulations, which meant that over time, links would break, and I would be forced to rewrite labs and/or find alternative resources, sometimes during the semester.

I was also concerned about my students completing the labs safely. While I had no reports of student accidents, the potential was there. Students could have purchased incorrect materials, mixed incorrect amounts, or made any number of other errors. Since the labs used materials purchased over the counter at local stores, the college felt that risk was low. As the instructor of the course, however, I felt more exposed to liability. Considering the issues of time to write and modify labs to use everyday materials, availability of materials, how well labs using everyday materials can replicate lab experiments, and student safety, having students purchase a lab kit or access to high quality virtual labs seems a more efficient and effective alternative.

5.4 Virtual Labs

There are several advantages of using virtual labs (computer simulations) in your online course, but research suggests that once again, the success in terms of student engagement and learning depends on how the simulations are used in the course. Perhaps most importantly, students can perform experiments in computer simulations that would otherwise be too dangerous to complete outside a supervised classroom laboratory. Computer simulations can also transcend time and space, allowing students to complete simulations of experiments that in real life would be impractical due

to time, expense, or lack of equipment. Simulations allows students to experience real-world applications that would otherwise not be available to them (Sahin, 2006).

For example, there are several virtual lab activities from Howard Hughes Medical Institute's Biointeractive (http://www.hhmi.org/biointeractive) website that I have used in my courses. One analyzes the data collected on anole lizards in the Caribbean to determine why there are so many distinct species and how they evolved (http://www.hhmi.org/biointeractive/lizard-evolution-virtual-lab). I could not take students there to study lizards in person (though I would have loved to go), but students could analyze data collected from real scientists in the field. My students learned about evolution, and how different selective pressures affect evolution of species from this lab. Another of their virtual labs allows students to analyze pelvic structures of stickleback fish to learn how data collection and analysis can be used to study evolutionary processes (http://www.hhmi.org/biointeractive/stickleback-evolution-virtual-lab). My students really like the labs, since they deal with real-world data from actual scientists studying these processes.

There are other free resources for simulations as well, but no free resource I have found has a comprehensive set of virtual labs for my course. If you want a comprehensive set of virtual labs from one source, you'll probably need to review virtual lab systems that charge a fee paid by the student. Late Nite Labs has created a set of online laboratory investigations that students access through the Internet after purchasing an access code. They compare the labs to flight simulators, a place in which students can learn and perform experiments without risk of harm to themselves, other students, or property. In a survey of Late Nite Labs users, almost 90% of those surveyed indicated that they liked not having to worry about making mistakes, wasting materials, or causing a potentially dangerous situation. Late Nite Labs notes that students can even make enough mistakes to cause an explosion in their virtual lab (Schwab, 2012-2013), something we all hope would never happen in real life.

The instructor's side of Late Nite Labs allows you to see information students' have saved, including each student's experiment

log and assignment. The instructor can then post a grade for the student to view, or re-assign the lab if the instructor feels like the student should go through it again (Schwab, 2012-2013). One thing you should investigate is whether the grading system of Late Nite Labs or other online lab company will integrate well into your learning management system. I have seen some outside resources that link with the LMS and automatically populate grades, and others that do not. For resources that do not link directly, you would have to manually enter grades for those assignments.

You may find that your textbook publisher offers virtual simulations to accompany their textbook. Call your textbook sales representative for more information. The lab kit companies mentioned above might also have some online simulations to accompany their kits. For example, a microscope would be too expensive to include in a lab kit, so an online simulation would be a suitable alternative. You should also contact Late-Nite Labs for trial access to their simulations.

Late-Nite Labs
800-262-0518
mlls@macmillan.com

5.5 North American Network of Science Labs Online (NANSLO)

One resource bears special attention: the North American Network of Science Labs Online (NANSLO - http://www.wiche.edu/nanslo). NANSLO offers complete lab manuals for biology and chemistry, and a few lab activities for physics that are openly licensed and customizable, and students can complete experiments by remotely controlling equipment in the NANSLO lab. When I first heard about this resource, I thought it sounded amazing. The more I learned about it, the more excited I became. I felt like Gollum with the One Ring, "My Precious," except, of course, that I am willing to share. Remotely operated labs are the future of online science education!

Here's how the process works. You, the instructor, reserve a block of time through NANSLO's scheduling system for students to complete a NANSLO laboratory activity. The reservation generates a PIN and URL for students to use to schedule a day and time (within the block you reserved) to complete the activity. During their scheduled time, students connect to the NANSLO lab via the Internet and access real laboratory equipment to collect real data, conduct experiments, generate graphs and data tables, capture images, and collaborate with classmates and NANSLO lab personnel. Rather than simple simulations, students are controlling actual laboratory equipment, often too expensive to be included in a lab kit, by remote control via the Internet. And, they are working with actual lab personnel at NANSLO, not a tutorial on a computer screen. This brings the online student as close as possible to the real-life, in-person laboratory as possible in a remote setting (Western Interstate Commission for Higher Education, 2015).

Considering that more and more scientists are using remote technology and robots in their work, and the growth of remote laboratories around the world, students using NANSLO resources are arguably better prepared for advanced science laboratory courses. Technavio estimates that the market for virtual and remote laboratories in the United States will increase by 36 percent, and in Europe by 37% by 2020. The market's growth is influenced by cooperation between educational and other institutions, allowing students and staff of one institution to access remote laboratories of others, thereby supporting more distance education and online courses (Technavio, 2016).

5.6 Effectiveness of Online and At-Home Laboratory Activities

Despite the expansion of online science courses across the world, some faculty and administrators still question how well students can learn science in fully online classes. Most debate centers around the laboratory portion. Can students learn the information and techniques needed to progress into upper level science courses in four-year universities? There is not a wealth of research since fully online science courses are not as widespread as face-to-face courses,

but a study shows no significant difference in student learning and preparation for upper level science courses between online courses and face-to-face courses. Since 2001, the Colorado Community College System (CCCS) has offered fully online science courses with the lab portion of the course delivered through commercially available lab kits purchased by students (Epper, 2012). Even though grades received by students in face-to-face science classes were generally higher than those in online science courses, the online students had higher GPAs overall, and more cumulative credit hours completed at the community college.

The Colorado study didn't stop there. Students who transferred from CCCS schools to the University of Colorado (CU) Boulder, CU Colorado Springs, CU Denver, and Colorado State University at Fort Collins were tracked, and were compared based on overall GPA and science major GPA. There was no statistical difference in the GPAs of students who had taken online science courses versus face-to-face courses at community colleges, suggesting that online science courses can prepare students for upper level courses just as well as face-to-face courses (Epper, 2012).

Clearly, commercially available lab kits used in online science courses are effective for student learning, but online simulations can be effective as well. For students who have grown up in a video-game and Internet culture, well-developed, interactive online simulations can stimulate highly effective and engaging learning (Wieman and Perkins, 2006). However, design features of online simulations vary, and can affect results. Critical components of effective online simulations include interactive animations that provide direct responses to users, inviting environment and graphics, simple controls, and real-world connections (Wieman and Perkins, 2006). If used skillfully by the instructor, simulations can push students beyond simply memorizing facts, and encourage using data to support explanations and provide evidence for conclusions (Laxman and Chin, 2011). Research into efficacy of non-traditional labs (online simulations and remote labs) demonstrates that, in at least some regards, non-traditional labs are equally or more effective than traditional hands-on labs. Of 49 studies, 44 showed equal or more

effectiveness of non-traditional labs in generating knowledge and understanding (Brinson and Brinson, 2014).

NANSLO began operations in 2011, but there is already some data that supports its effectiveness in online science learning. Students who engaged in NANSLO lab activities while taking online Biology 101 courses through the Colorado Community College System raised their final grade by 10% (Edwards, Mattoon and McKay, 2015). Instructors are strongly encouraged to complete activities themselves before assigning tasks to students, and NANSLO offers guidance to faculty on how best to prepare their students for the lab activities. Advance preparation by faculty is essential to anticipate student problems and questions and leads to increased student engagement. Students in classes that required advance preparation for NANSLO labs reported increased enjoyment and learning from the lab activities (Edwards, Mattoon and McKay, 2015). As with any instructional practice, the pedagogical/andragogical skill and preparation by the instructor affects the success of implementation of NANSLO labs.

5.7 Faculty Liability

Faculty and institutional liability in any science course is of utmost concern. Although most information and research related to liability and science teachers is geared toward K-12 teachers and institutions, applications to college science teaching can be argued. Multiple science teachers have been sued in the past because of student injuries from experiments that did not go as planned, even because of the student misusing equipment (Nigro, 1988). Without the ability to supervise students completing laboratory investigations in an online class, how can we, as instructors, reduce the risk of student injury? How can we reduce the risk of being sued by students who are completing experiments off campus, without supervision?

Mitigating liability is all about managing risk, whether the class is face-to-face or online. Nothing can eliminate all risk (Nigro, 1988), but there are actions that can reduce the risk. Instructors should always stress lab safety, even though students are using lesser

amounts of chemicals and/or household chemicals. You should train students in laboratory safety, and keep a record of that training to create a record that can be used in court to demonstrate that you took precautions to promote safe learning (Love, 2013). You should carefully go through and perform each experiment to look for potential hazards, regardless of whether you wrote the experiment to be completed at home with everyday materials, or a company wrote and supplied lab materials. Consider what mistakes a student might make while performing the experiment and take steps to reduce the chance that students will make that mistake. Teachers should also give instruction to the students over any laboratory activity before asking students to perform that activity. In an online course, this could mean a pre-lab activity, video demonstration, and/or a discussion of potential risks.

Choosing to use a lab kit company could transfer risk liability from the college and instructor to the lab kit company, depending on the company and the contract between the company and the college. However, risk transfer is not a defense in 100% of cases (Love, 2013), and does not eliminate the need for the instructor to go through and perform every lab to ensure student safety and give instruction about the lab and safety issues.

Obviously, the safest option for online courses is using virtual or remote laboratory activities, since they avoid risk inherent in performing laboratory activities at home. However, you must decide if there is an online platform for experiment simulations that fully meets the needs of your course and your students. Even if using all virtual laboratory activities, instructors must still include safety information in their courses, so that students understand risks involved in performing real experiments and learn proper procedures for the future.

Finally, check with your college to determine what type of liability insurance it has and what it covers. Consider purchasing liability insurance through an educator's association; it could help you in the event of criminal charges or civil litigation. The cost of insurance is low when compared to legal fees and other costs associated with a lawsuit (Love, 2013).