Online Science Labs Discussion

On Friday, April 24 and Thursday, April 30, approximately 130 members of the U of M teaching community convened to discuss conducting instructional science labs in an online or distance-learning setting. Ideas and effective practices generated during those discussions are documented here. Contact cei@umn.edu to suggest an addition to this resource.

Facilitators and experienced instructors:

- Kris Gorman, Center for Educational Innovation
- Neil Anderson, Horticulture, Twin Cities
- Pete Border, Physics, Twin Cities
- Charlotte Romain, Medical Laboratory Sciences, Twin Cities
- Joseph Shostell, Math, Science & Technology, Crookston
- Charles Willis, Biology Teaching and Learning, Twin Cities

Recordings and resources

- April 24 session recording
- April 30 session recording
- Trials & Tribulations of Designing an Online Science Lab (Kalli Binkowski)
- Online Biology with a Lab! Online Best Practices at Work (Kalli Binkowski & Annette McNamara)
- Virtual lab assignment: BIOL1001 - Snapshot Serengeti
- Assignment requiring lab kit: BIOL1001 - Evaluating Claims about Cancer
- Glassware and Pipetting modules (shared by Charlotte Romain)

Google Group Email List

- If you are a member of the UMN community and would like to be part of a Google Group email listserv to ask questions or share resources with others teaching or supporting these courses, please request to join the UMN Online Science Lab Instructors group.

Additional Support

- Email TeachingSupport@umn.edu to connect with academic technologists, teaching specialists and librarians who can assist with designing your online lab.

(Re)Considering Your Learning Objectives

Experienced instructors advocated for considering your learning objectives before deciding how to translate your course to an online format. Some objectives may be expanded (e.g. inquiry learning, experimental design, data analysis) while others may need to be scaled back or reconsidered.

One instructor encouraged thinking about whether some learning objectives that are coupled in your current lab set up can be decoupled. For example, students may practice making measurements using materials readily available at home but then conduct data analysis using measurements of actual specimens provided by the instructor.

Creating Digestible Lab Instructions

Experienced instructors emphasized the importance of lab instructions that are packaged in ways that are digestible in chunks:

- Use short (3-5 min) instructional videos
- Segment instructions with multiple steps so each step is its own video
- Provide written instructions that are easily digestible using bullets, white space, and no big blocks of texts
- Keep instructions proximal to their use (i.e. provide instructions when students need them rather than everything all at once)

Instructors use a variety of software to record instructional videos, including VoiceThread, and Screencast-o-matic. Connect with an academic technologist to determine the appropriate tool for your use by emailing teachingsupport@umn.edu.

Assessing Students

Faculty use different approaches to assessment of online labs.

- Some use assignments in Canvas, along with Speedgrader using rubrics. Some have students submit written work by taking pictures or scanning to PDF with a phone, and others require typed assignments.
- Others use an electronic lab workbook. Michelle Driessen has had success with LabArchives and is happy to share.
- Another recommendation was to use Flipgrid for students to submit short videos, because having students explain their work and their findings really tells you what students know and don't know, better than a written summary which is more easily copied.

Facilitating Groups

Some instructors conduct group labs online. Utilizing effective practices for student teams becomes all the more important in an online space.

Some examples of group activities:

- In one class, student groups work together to decide on an experimental design and how it will be executed by the team (e.g. multiple people doing the same thing, different people doing different things). Then, they come together to talk about what that data means and how much confidence they have given their design and execution.
- In another, students each do a control and several replications of their variation. Then students can share the data, using their control results to judge how valid combining the data is.

There was variation amongst whether instructors required synchronous communication between group members (e.g. Zoom meetings), but most encouraged asynchronous communication (e.g. Canvas discussion board, shared Google doc) with only occasional synchronous check-ins.

Designing Lab Activities

At-home Labs

Neil Anderson (horticulture), Pete Border (physics),and Charles Willis (biology) have all taught courses where students conduct lab activities in their homes. Depending on the course, students either purchase a lab kit from the bookstore or external vendor, or purchase required materials locally or from Amazon. All waived additional lab fees. For fall, some participants were considering creating their own kits that would be shipped to students.

One of the considerations to explore for either self-created kits or vendor-created kits is liability. Participants recommended consulting with the Department of Environmental Health & Safety (DEHS) and considering hazards during the lab activities and from disposal of any supplies.

Vendors

Instructors and staff who've used third party vendors recommended coordinating with vendors at least 2 months in advance of the start of the semester. Vendors mentioned by participants were:

- Carolina Distance Learning, provides lab kits in Biology, Chemistry, Anatomy and Physiology, Microbiology, Physics, Environmental Science, Allied Health, and Geology. Provides the ability to fully customize kits.
- eNasco, a provider of educational supplies which can customize kits to provide to students.
- eScience Labs, a provider of intro lab kits for college courses in the fields of Physics, Physical Science, Biology, Public Health, Anatomy and Physiology, Chemistry, Earth Science, Microbiology, Forensics, and Allied Health. They have both standard lab kits they can ship and custom kits they can make.

- [Hands on Labs](), provides lab kits and lab curricula in Anatomy/Physiology, Biology, Chemistry, Environmental Science, Forensics, Geology, Microbiology, Physical Science, and Physics.

Instructor provided supply lists

- Pete Border prefers building a list of supplies that students purchase directly from Amazon. If something becomes unavailable, he can quickly alter the list and students can buy only the items they don't have on hand.
- Neil Anderson has typically provided a supply list to students in his class which primarily involves botanicals that are easily acquired in stores during normal times with no safety concerns.
- It is possible to direct students to design the particular execution of their lab activities from materials they have on hand at home (e.g. figuring out how to build a ramp to get a car up to a reasonable speed). One has to be clever about doing this, giving students options and latitude, but a surprising amount can be done in this way. Pete Border describes his students enjoying "having to wing it" and designing creative solutions to meet the objectives.

Pedagogical Considerations

- **Support project planning -** Set expectations with students that they need to be proactive to ask for help and get started early on labs. Be forgiving at the beginning and establish the instructor/TA as a person who can be helpful. Reorient your expectations to allow time for difficulty and coach project management for planning and execution.
- **Plan for mistakes** - Because students will be setting up and executing all aspects of a lag, expect and plan for failure and frustration.
- **Adjust goals from correct implementation to understanding what happened** - For home labs, success may look different – it's less about correctly implementing a procedure given to the students, and more about understanding what they've done and why they failed if they did. Part of the exercise is dividing the labor and components of an experiment, and in the end deciding how much confidence they can have in their results.
- **Consider experiment design as a goal of the lab.** Panelists reported that students can be very creative in devising at-home methods of exploring various scientific principles (e.g., using 130-proof rum instead of isopropyl alcohol for DNA extraction).
- **Create a backup plan** - For data interpretation, consider what you will do if/when students fail to collect data. One option is to have a data set for them to use in case of experimental failures. Another is to ask students to create a figure of what the data would look like if they support or don't support the student's hypothesis.
- **Expect richness in discussion sections** - Instructors all indicated an increased richness in students' responses to "What could you change about this experimental set up to make it better?" These are often proforma questions in in-person labs, but with at home labs, students often have more nuanced responses.

- **Provide realistic data -** If you are providing data sets to students for analysis, make sure you provide realistic data that includes situations where the controls didn't work or samples that were outside of expected values so that students can learn to identify and manage errors.
- **Collect video/photos of experimental set-ups** - As a way to make sure students are setting up and completing labs, have them visually document the experimental set-up.

Virtual Labs/Simulations

Virtual labs or simulations are another option for conducting online labs. Michael Seery (not-affiliated with UMN) has advice for using simulations or recorded labs. Those at the U had the following experiences to share:

- Joseph Shostell (physics) has used Labster with success for labs requiring apparatus like a voltmeter. Joe reported that simulation labs allow students to easily perform the lab multiple times with changed parameters, and many actually do this. (Labster is under review for integration with Canvas.)
- Charles Willis (biology) has a lab in one of his classes that is 100% virtual (BIOL1001 - Snapshot Serengeti).
- For anatomy, physiology, and dissection, it can be difficult to make videos that are of high enough quality for students to learn effectively. The "visible body" is software/simulation that is pretty good in this regard.
- For images of human tissue samples, Bob Sorenson at the UMN digitized hundreds of slides to create a virtual microscope. There is an atlas for sale in the bookstore.
- JoVE has videos that were reported to be high quality, at least in chemistry; they include biochemistry.

If you are looking for virtual labs and simulations for your field, three lists are being kept current:

- Options for Virtual Labs and Simulations for Laboratory-Based Courses, Washington State University
- Open Educational Resources: Simulations and Virtual Labs, Colorado School of Mines
- Online Resources for Science Laboratories - Remote Teaching, POD

Remember to test any simulations for your lab activities as some are higher quality and more accurate/reliable than others for various activities.

3D Models

Online 3D Models

For some labs, access to 3D models of specimens will be crucial to successful implementation of an online or remote lab. One option is to leverage online repositories of high quality 3D models:

- Some 3D models are listed by discipline in the Online Resources for Science Laboratories - Remote Teaching.
- For neuroanatomy, 3D Neuroanatomy Models and Brain Facts may have what you need.
- The Twin Cities College of Liberal Arts also has 3D imaging capability and Elevator which stores the data. Elevator is integrated with Canvas to deliver the data in ways that allow the 3D images to be turned, manipulated and zoomed in. Samantha Porter is happy to help instructors find relevant 3D models.

DIY models

It may also be possible to create at-home models to understand some of the relationships students identify in a typical dissection. For example, instructors for anatomy and physiology could have students create their own clay models that show the origins and insertions. Beverly Smith-Keiling has experience doing this and is willing to share.