# AS&E task force on laboratory and studio-based courses

## Charter and organization

In late April 2020, Deans Runner and Vamivakas chartered the task force to evaluate best practices for hybrid and/or online education for laboratory, performance, and studio-based courses. "Hybrid" was broadly defined as a mixture of online and face-to-face (f2f) instruction. In this scenario it is assumed that a significant percentage of students will be on campus, available to participate in a face-to-face format, and also that a significant percentage will be remote, able to participate only online. Thus, fall activities require planning for delivery in both f2f and online formats ("dual delivery"). In addition, f2f delivery will likely need to be modified to account for the need for social distancing, as there is a strong likelihood that maximum occupancy of student lab and studio facilities will be limited.

The task force first met on April 28 and met, as a whole, twice weekly thereafter. A preliminary report was submitted on May 29. Membership on the task force has gradually expanded and currently consists of Assistant Professor Maya Abtahian (Linguistics), Associate Professor Matthew BaileyShea (Music Theory), Lauren Caruso (RCCL), Nicholas Hammond (CETL), Associate Professor Stuart Jordan (Political Science), Associate Professor Evelyne Leblanc-Roberge (Art and Art History), Professor Scott Seidman (BME, Neuroscience), Helen Shammas (BME), Professor Elaine Sia (Biology), Chad Stewart (IT), Nicholas Valentino (HSEAS), Imani West-Abdallah (PAS), and Professor Paul Funkenbusch (ME, HSEAS), who is acting as Chair.

The task force has focused on how AS&E can best implement a dual delivery approach in fall 2020.

## Executive summary

- Mission of the Task Force. The task force has worked to provide recommendations and resources to assist instructors across AS&E in the development of laboratory, performance, and studio-based course activities for the fall semester.
- AS&E Policies and Guidelines. Laboratory and studio-based courses are very diverse and dependent on specialized practices, laboratory space, and equipment. Detailed planning for space and equipment utilization will need to be done primarily at the department/program level. AS&E can support this by providing clear policy guidance in key areas and offering expedited review of proposed activities.
- Prioritizing development of online and face-to-face activities. When in-person laboratories/activities are planned, it will still be necessary to have online alternatives, because a significant number of students are expected to be remote. Programs are encouraged to begin preparation for online laboratories/activities as soon as possible. Face-to-face activities should be prioritized based on whether online education can

meet the specified learning objectives, and preparation should begin with those (hopefully rare) cases where no online alternative is judged equivalent.

- Learning Objectives. Instructors should be encouraged to write, and make available to students, clearly defined learning objectives for all laboratory and studio-based activities. In addition to pedagogy, this is important to justify the instructional choices made for both accreditation purposes and student satisfaction.
- Resources for instructors, directors, and chairs. This section includes resources (discussion of issues, suggested approaches, videos/webinars, literature examples, etc.) to help guide development of online and socially-distant f2f laboratories and studio-based activities. These are organized primarily on the basis of learning objective. A compilation of general resources and discussions of some additional topics (at-risk students, use of kits, hierarchy of controls, etc.) are also included.

## Mission of the Task Force

The current situation represents an extraordinary challenge to instructors for several reasons:

1. Many policies and guidelines have yet to be set with regard to physical distancing, classroom management, and equipment.
2. There is still no accurate picture of how many students will be on campus or learning remotely at any given time.
3. Although there are many resources for online learning, and some for "Hy-Flex" teaching, the conditions under COVID-19 are unique. None of the prior models fully capture the specific challenges that instructors will face in the fall.
4. Most discussions of problems and potential solutions are presented in discipline specific forums and framed in discipline specific terms, narrowing the range of information and examples to which instructors are exposed.

The task force's role has been to provide recommendations and resources that support instructors, chairs, and directors across AS&E as they develop their course activities over the summer and fall. In response to the above conditions, a strong emphasis has been placed on recommendations and resources to improve flexibility in the face of the evolving situation and that are applicable across AS&E disciplines. These include:

- Recommendations for AS&E policy and guidelines to speed and support instructor development of laboratory and studio-based activities.
- Recommendations for prioritizing the development of socially-distant face-to-face (f2f) activities relative to online alternatives, including the flexibility to ramp-up or ramp-down f2f components depending on changes in health conditions or government policy.
- Compilation of resources (best-practices, discussion of concerns and options, examples, references) based on learning objectives, applicable across disciplines.

- Encouraging ongoing dialogue among instructors and programs that face related challenges.

## ASE Policies and Guidelines

Laboratory, performance, and studio-based courses are very diverse and strongly discipline/program specific. In most cases they are dependent on specialized laboratory space and equipment. Laboratory space (unlike classroom space used for lectures, recitations, and workshops) is not interchangeable among programs, thus, detailed planning for space and equipment utilization must be done primarily at the department/program level. AS&E can support this activity by providing clear policy and guidance in key areas and offering expedited review of proposed activities:

1) Interactions with the wider community. AS&E policy is a key issue for courses that involve interactions with the wider community. What requirements for social distancing, sanitation, and use of PPE will apply to course activities held off campus and that include f2f interaction among students, faculty and members of the community? Conversely, what rules will apply when members of the community visit campus to participate f2f in community-engaged course activities? What protocols need to be followed in organizing/scheduling?
2) Field activities. Similarly, policy guidance is needed with respect to off-campus activities that do not involve interactions with the community but may involve shared transportation of students to off-site locations.
3) Social distancing in laboratories, performance spaces, and studios. Will the same guidelines that apply to lecture/recitation spaces also apply in teaching laboratories and studios? For example: Will masks be required for singing? What distancing requirements will there be for singing?
4) Expedited assessment of proposed activities. Most instructors have no training in medical, legal, or public health issues and may find it difficult to apply policy guidelines to the special circumstance in their courses. The task force recommends that AS&E establish a clear mechanism by which they can obtain a quick, definitive assessment on whether a proposed approach to social distancing meets university policy (and, ideally, to suggest possible fixes if it does not). This might be a recognized point-person or, more plausibly, a team available to meet with the program/instructor on short notice.
5) Expedited evaluation and processing of hardware, software, and installations. Given the short timeline, and likely bottlenecks, Instructors need to be able to obtain highly expedited evaluation of (and approval for) proposed hardware or software items and installations. As a simple example, consider installation of plexiglass sheets to separate an interviewer from a community interviewee. Can these be obtained and installed by the start of classes, by September 1st, by October 1st? The task force recommends that AS&E establish an expedited process for assessment and approval of hardware, software and installations.

6) Minimum technology requirements for students. What are the minimum requirements (computer, internet) for students to take courses (and participate in labs/studio-based activities) online? When will students be told?
7) Policy on sanitation and distribution of shared hardware. In many teaching labs and studios students share, and often check-out, equipment. Examples include musical instruments, pipettes, cameras, and yoga-mats. What will be the AS&E policy on this for fall semester? Will this be permitted? If so at what level (AS&E? Department?) will approval and management be handled?
8) Staffing. Overhaul of courses for dual delivery will be very time consuming for faculty. F2f lab and studio sections with social distancing will require increased instructional time in these courses, at a time when TA budgets are being dramatically reduced. This issue is particularly acute for students joining UR from under-resourced secondary schools, who may need higher levels of support for laboratories and studio-based activities. It is unclear how these sections will be staffed. Reduced staffing also makes it more important that support roles/services be clearly defined - for example that students understand where to go for help with laboratory issues (TAs) as opposed to study skills (CETL).
9) Training. It's important that instructors be provided with opportunities for simple, practical training to support their use of best pedagogical practices - for example, writing effective learning objectives, application of backward design, and UDL (Universal Design for Learning) principles.
10) Academic honesty. Will there be a consistent university policy on how to best handle this for online instruction? The types of honesty policy infractions we have seen during the Spring 2020 semester, with students working remotely, indicates that instructors should clearly communicate with students their course-specific interpretation of the policy, In particular clarity is needed regarding posting or otherwise distributing instructor-created materials and proper use of online sources. (For lab and studio-based courses, project journals or lab reports are a recommended option for assessment when these are appropriate for your learning objectives. Short answer and essay questions can also work well.)
11) Policy on additional materials provided to, or purchased by, students. The task force recommends that existing procedures for approval of laboratory materials (for example departmental approval and/or EHS check-off) be extended to cover this case. Policies also need to be established covering their purchase and return. Can students be required to purchase them? If supplied by the university, do they need to be returned? Is their return an academic honesty issue? What resources are available for students for whom the added cost would be a financial burden?
12) Dialogue among instructors and programs. Programs share similar challenges in developing online and socially-distanced laboratory/studio-based activities for the fall. At the same time, social distancing may reduce normal interchanges among faculty. AS&E should set up and actively promote channels for dialogue among faculty on relevant issues. The task force experimented with a set of divisionally based Zoom forums with

some success. These could be restarted/continued. CETL is setting up a Microsoft Teams groups to bring together instructor groups with shared interests for discussion. This could also provide space for formation of lab/studio-based groups. Additional options include discussion boards, Blackboard, and other online collaborative spaces (Slack or Discord for example).

## Prioritizing development of online and face-to-face activities

For planning purposes programs should be encouraged to classify their laboratory and studio-based activities into three broad categories as follows:

**Category 1**: Labs/activities for which online delivery provides good to excellent ability to meet the required objectives. Given time limitations and continuing uncertainty with respect to social distancing requirements, we recommend that programs commit to, and begin preparation for, online delivery of this content as soon as possible.

**Category 2**: Labs/activities for which there is an acceptable online delivery option, but f2f is considered markedly superior (for either pedagogical purposes or student satisfaction). Ability to offer these courses in a socially distanced f2f format should be prioritized (presumably within the program) based on impact, time, and resources. Additional complications with f2f delivery are the need to simultaneously offer the same material in an online format and to ensure that online students fulfill the same learning objectives as f2f students. For accreditation purposes, this makes it essential that the ability of the alternative (online) format to adequately meet the learning objectives be described/documented. There is also a potential issue with perception among students receiving online delivery, who may feel they are not receiving the same (shared) learning experience as the f2f students.

**Category 3**: Labs/activities for which f2f delivery is considered essential. (No acceptable online option.) Departments and instructors need to consider the impact of this on remote students, who are unable to participate f2f. Some options: defer the course to spring semester, offer the course in both fall and spring semesters, offer the lab/activity portion of the course as a separate course (available spring and fall semesters), or use a modified "incomplete" option that would defer granting credit until completion of the specified f2f content in spring. Finally, consideration needs to be taken of online students who are planning to complete their degrees in the fall semester. Clearly they should be advised not to take elective courses with labs/activities that fall in this category. It is unclear how to deal with this situation if the course is required for graduation.

Under the "hybrid" scenario (significant percentage of the student population learning remotely), online versions of all labs/activities in categories 1 and 2 need to be offered regardless of other developments. These online versions also serve as a fallback in the event of tightening of social distance requirements or onset of a second wave of COVID-19. The earlier this guidance can be provided to the faculty the better.

Development of socially distanced f2f courses should initially focus on category 3, progressing thru category 2 as time and resources permit. This also provides flexibility to expand f2f offerings (moving further down category 2, or even into 1) if social distance requirements are relaxed as summer progresses.

When dual delivery is an option (category 2), consideration needs to be given to ways to best integrate the online students into the activity and to foster the course's learning community.

## Learning objectives

Instructors should be encouraged to write, and make available to students, clearly defined learning objectives for all laboratory and studio-based activities. Use of specific, well-defined learning objectives is recognized as a best-practice in education. Moreover, in spite of the programmatic diversity, laboratory and studio-based courses do share many commonalities in terms of learning objectives. This should be exploited to improve pedagogy and student satisfaction, identify and share best practices, and help determine the most appropriate delivery format (online vs. f2f). The process will also help instructors prioritize the most important learning objectives for the laboratory and studio components of their courses, and perhaps triage less important objectives in exchange for enhancing the more important. Indeed, instructors will need to carefully budget their efforts and resources to maximize the student experience.

A repeated concern in discussions with faculty and staff about the fall semester, is that this will be an additional one-time effort, similar to spring semester. In other words, that the efforts they make for fall will not have a lasting impact on instruction at UR. Efforts should be made to address this by building long-term improvement in pedagogy into the College's efforts for the fall. Broader introduction of learning objectives is one potential pedagogical gain. Attention should be given to identifying other, permanent, improvements that can be made as part of the current efforts.

As a starting point, the task force has developed a list of 14 core learning objectives broadly applicable to laboratory and studio-based courses. This is based on a similar list proposed for engineering laboratories paper by Feisel and Rosa (J. Eng. Ed., 2005, 121 – 130), with some addition and modification to generalize them beyond the original (engineering) context. It is hoped these will be useful to instructors in recognizing the core learning objectives applicable to their course. The list is provided as part of the Resources section of this report.

Having identified the core learning objectives, instructors will need to customize these to fit the goals for their course. The exercise of developing specific, detailed learning objectives will be unfamiliar to many faculty. However, there are AS&E faculty with degrees in education and these have been augmented by the training some faculty have received in online course development (which includes learning objectives) during spring and summer. Many additional resources are available. A very short, but useful, discussion of how to write learning objectives may be found (pages 53-57) in a book by Ko and Rosen (Teaching Online, Susan Ko and Steve Rosen, Routledge pub., 2004), which is available online through the UR library. Additional resources are provided in the resources section of this report.

Learning objectives may also be useful in addressing the concern that students will perceive online (and possibly even socially-distanced f2f) laboratories and studio-based activities as inferior substitutes for the more conventional activities. For this to be effective, it is key that the objectives be specific, detailed, and presented transparently to students, so that they can clearly see that they have achieved each objective. Similarly, the ability to demonstrate that students have achieved well-defined learning objectives will be important for accreditation purposes. This is especially true when new delivery methods (online or socially-distanced f2f) are being introduced and if, as proposed, some students are learning via a different method than others.

Finally, instructors need to be prepared to deal with changes in student status due, for example, to illness or international students reaching campus mid-term. Having clearly defined learning objectives will allow students to be judged fairly and consistently even if they need to change delivery mode during the semester.

# Resources for instructors, directors, and chairs

## Forward

The following sections contain a variety of resources to aid in developing both online and socially-distanced face-to-face laboratory and studio-based activities for fall 2020 courses. The task force strongly recommends that the process begin by identifying, and recording, clear learning objectives for each activity: What are students expected to know and be able to do upon completing the activity? This is important both pedagogically and as an aid in choosing and designing activities. Moreover, since different students may be receiving instruction in different and unfamiliar formats (or even switching between delivery modes as a result of illness), demonstrating achievement of concrete learning goals is important for student acceptance/satisfaction and accreditation purposes.

The following sections provide resources (discussion of issues, suggested approaches, videos/webinars, literature examples, etc.) organized primarily on the basis of learning objective. The task force began with a list originally developed for engineering laboratories by Feisel and Rosa (Journal of Engineering Education, 2005, 121 – 130) and modified it to account for the broader range of activities under consideration here. These learning objectives were then organized into six broader groupings, based on similarities in the instructional challenges and approaches they present.

## Sections

- General resources: A list of broadly applicable resources for teaching laboratory and studio-based activities.
- Learning objectives and groupings: A description of fourteen core learning objectives, organized into broader groupings. This section may be useful in identifying and categorizing the learning objectives for programs/courses.
    - Resources for Teamwork, Communication, and Learning-from-failure: These objectives are centered around 'learning to take risks in the learning environment', which requires that students feel safe and that their experience is structured and purposeful.
    - Resources for Sensory awareness, Psychomotor skills, and Instrumentation: These objectives are generally linked in that they all involve situations where students develop a physical connection with the material under study.
    - Resources for Creativity and critical thinking, Data analysis, and Modeling: These objectives involve situations where students are encouraged to develop independent thoughts and ideas, whether by reacting to prior concepts and information or developing something new on their own.
    - Resources for Experimentation and Design: These objectives focus on planning and iterative problem solving.
    - Resources for Community engagement: This objective focuses on building partnerships with the broader community in the public and private sectors.
- At-risk students: Discussion of potential issues and approaches/resources for at-risk student groups in laboratory, studio, and performance environments.
- Course Kits and Software: Discussion, recommendations, and tips on use of kits and software in a Hyflex environment.

- Case study:  A hypothetical case study illustrating the role of learning objectives, use of kits, etc. in moving a laboratory course online.
- Hierarchy of Controls: The task force recommends use of a modified "hierarchy of controls" approach to help design socially-distant laboratory and studio-based activities.  This section describes the approach with examples.
- Recorded sessions.  Working with online students in a Hyflex environment will very likely require making use of recorded sessions.  For reference, a list of current policies/best-practices is provided here.

## General resources[1]

- ### Learning objectives
  - **One-page guide** to writing learning objectives.
  - Ko and Rossen (Teaching Online A Practical Guide, Routledge pub., 2004). Brief, practical introduction to online teaching. There is a short, helpful discussion of learning objectives on pages 53-57.
  - **In depth guide** to learning objectives/outcomes (what, why, how) from the University of Toronto.
  - Feisel and Rosa (Journal of Engineering Education, 2005, 121 – 130). This paper discusses the role played by laboratories in undergraduate education. It includes a discussion of the importance of learning objectives and some discussion of online teaching.

- ### UR tools
  - Blackboard/Discussion Forums [https://tech.rochester.edu/services/blackboard-discussion-boards/]
  - Blackboard/Wikis [https://help.blackboard.com/Learn/Instructor/Interact/Wikis]
  - Zoom/Breakouts/Annotations of shared docs [https://tech.rochester.edu/zoom-tutorials/]
  - Panopto for recording, sharing video instructions or to bring remote learners 'into' the lab/class space [https://tech.rochester.edu/services/panopto/] (Note: the Panopto tool should always be used when uploading video to Blackboard, as loading recordings directly into Blackboard itself can tax the system. Panopto also automatically captions recordings for accessibility.)
  - Solidworks CAD software
  - VSDC video editor (free, not UR supported)

- ### Resources for virtual labs
  - **ASEE Resource Central**
  - MERLOT virtual labs
  - VLab virtual labs
  - JoVE (Journal of Virtual Education) Faculty Resource Center. (Note: Access to full videos requires a subscription.)
  - Biology, Chemistry, Biochem resources and labs: [https://www.asbmb.org/education/online-teaching/online-lab-work]
  - HHMI Biointeractive virtual labs [https://www.biointeractive.org/]
  - PHET Interactive Simulations, for natural sciences: [https://phet.colorado.edu/]
  - Vernier online labs, physics heavy. [https://www.vernier.com/remote-learning/] (pay service)
  - Slack group for Physics instructors: [https://physicsprofessors.slack.com/#/]
  - AIChE Concept Warehouse [https://jimi.cbee.oregonstate.edu/concept_warehouse/CW.php]
  - CircuitLab [https://www.circuitlab.com/]
  - LabsLand [https://labsland.com/en]

[1] This list was developed from a list originally posted by NYU: https://docs.google.com/document/d/1x0gNpU96Mb1O0f8w8jEjLl0JbbsG-GX0SQ5zLqgaUDU/edit

- PICsim (online PIC and arduino emulator): [https://sourceforge.net/projects/picsim/]
- Electrical engineering/CompSci labs: [https://learn.ni.com/teach]
- Biology/Physics/Chemistry [https://www.labxchange.org/library]
- Computational Modeling of Biological Systems https://cellcollective.org/

## Studio and performance

- Event Safety Alliance Reopening guide.
- Rapidly Transitioning Campus Courses (Shanks, Christine J.: 2020), Art focused online guide. Also includes a Student Guide for Learning Online
- Performing in a Pandemic (webinar)
- A collective sharing project platform for reimagining and sharing what is possible in art and design education: [https://www.whatdowedonow.art]
- Facebook group: Online Art & Design Studio Instruction in the Age of "Social Distancing" [https://www.facebook.com/groups/onlineartanddesigninstruction]

## Example of lab videos

- Making videos for online labs (UW)
- Tensile test
- Heat transfer measurement
- Temperature control kit

## Webinars related to virtual laboratories

- KEEN
    1. How to Create Virtual Engineering Labs.
    2. How to Move Engineering Classes Online & Preserve 'Hands-on' Learning.
    3. How to Plan & Manage Virtual Engineering Capstone Classes.
    4. How to Maintain Academic Integrity in a Virtual Setting.
    5. Chat logs for the above webinars.

- ASEE
    1. Emerging Insights on Navigating Remote Labs.
        a. Recording (email sign-in required)
        b. Slides
        c. Community Insights on Remote Labs (from chat pod)
    2. Upcoming webinars.
    3. ASEE Resource Central

- Mentor Collective and UT Dallas Roundtable (focused primarily on students)
    1. Recording
    2. STEM Roundtable Thought Leadership Brief

- ## Examples from the STEM literature

Instrumentation. LabView used to do remote and online. Process control lab (2010) "Developing the TriLab, a Triple Access Mode (Hands-On, Virtual, Remote) Laboratory, of a Process Control Rig Using LabVIEW and Joomla", Abdulwahed and Nagy:

Instrumentation and Experiments. Labview used for remote. Power engineering (2004) "Embedding Remote Experimentation in Power Engineering Education", Albu and Hobert

Data analysis. Virtual microscope (slide library). Pathology. (2008) "Improved Learning Efficiency and Increased Student Collaboration Through Use of Virtual Microscopy in the Teaching of Human Pathology", Braun, Mark W.; Kearns, Katherine D. ANATOMICAL SCIENCES EDUCATION Volume: 1 Issue: 6 Pages: 240-246 Published: NOV-DEC 2008 (available online thru UR library website)

Instrumentation and Psychomotor. Electronics measurement lab. (2004) "Remotely accessible laboratory for electronic measurement teaching", Canfora, G; Daponte, P; Rapuano, S, COMPUTER STANDARDS & INTERFACES Volume: 26 Issue: 6 Pages: 489-499 Published: OCT 2004 (available online thru UR library website)

Instrumentation and Psychomotor. Computer tutorials/simulations. Electrical eng. (1997) "Advantages and disadvantages of using various computer tools in electrical engineering courses", Canizares, CA; Faur, ZT, IEEE TRANSACTIONS ON EDUCATION Volume: 40 Issue: 3 Pages: 166-171 Published: AUG 1997 (available online thru UR library website)

Psychomotor and Data analysis. Computer simulation. Physics (pulleys). (2012) "Exploration of factors that affect the comparative effectiveness of physical and virtual manipulatives in an undergraduate laboratory", Chini, Madsen, et al

Psychomotor, data analysis, teamwork. Remote and online. Mechanical testing. (2011) "Process and learning outcomes from remotely-operated, simulated, and hands-on student laboratories", Corter, Esche, et al

Learn from failure, data analysis. Online simulated experiment. Food science (very simple). (2015)
"A Comparison of the Degree of Student Satisfaction using a Simulation or a Traditional Wet Lab to Teach Physical Properties of Ice ", Crandall, O'Bryan et al.

Instrumentation, experiment, data analysis. Online virtual experiment. Physics labs. (2014) "Are Virtual Labs as Effective as Hands-on Labs for Undergraduate Physics? A Comparative Study at Two Major Universities", Darrah, Humbert, et al

Instrumentation, experiment, data analysis. Physiology. (2009) "Evaluation of the Virtual Physiology of Exercise Laboratory program", Dobson

Sensory awareness, psychomotor. Virtual reality catheter insertion. (2003) "Intravenous catheter training system: Computer-based education versus traditional learning methods",

Psychomotor, instrumentation. Comparison of online and physical. DC circuits. (2010)
"A study on the impact of real, virtual and comprehensive experimenting on students' conceptual understanding of DC electric circuits and their skills in undergraduate electricity laboratory", Farrokhnia and Esmailpour

At risk students. Use of remote laboratory to improve access for students with disabilities. (2015)
"Supporting Access to STEM Subjects in Higher Education for Students with Disabilities using Remote Laboratories ", Grout

Experiments, models. Comparison of remote and f2f teaching. Electrochemistry. (2013)
"Virtual laboratory vs. traditional laboratory: which is more effective for teaching electrochemistry?", Hawkins, Ian; Phelps, Amy J., CHEMISTRY EDUCATION RESEARCH AND PRACTICE, Volume: 14 Issue: 4 Pages: 516-523 Published: 2013 (available online thru UR library website)

Creativity, Learn from failure, Instrumentation, Experiment, Design. (2020)
"Creating Distance Design Courses, A Guide for Educators" Jones, Derek

Data analysis, instrumentation. Inorganic chemistry. (2006)
"Simulation of laboratory assignments to support students' learning of introductory inorganic chemistry", Josephsen

Data analysis, sensory awareness. Virtual microscope (slide library), Histology. (2005)
"Complete and rapid switch from light microscopy to virtual microscopy for teaching medical histology", Krippendorf and Lough

Chemistry. (2011)
"Argument-Driven Inquiry as a way to help students learn how to participate in scientific argumentation and craft written arguments: An exploratory study", Sampson, V., Grooms, J., & Walker, J. P.(2011). Science Education, 95(2), 217-257.

Chemistry labs. (2020)
"Moving early undergraduate chemistry labs online" (blogpost), Seery, Michael

Experiment. Remote, virtual, face to face. Lab view. Fluid tank experiment. (2013)
"An Assessment of Distance Learning Laboratory Objectives for Control Engineering Education", Stefanovic, Miladin; Tadic, Danijela; Nestic, Snezana; et al., COMPUTER APPLICATIONS IN ENGINEERING EDUCATION Volume: 23 Issue: 2 Pages: 191-202 Published: MAR 2015 (available online thru UR library website)

Learn from failure, psychomotor. Remote, virtual, f2f. Robot arm manipulation. (2006)
"Virtual and remote robotic laboratory: Comparative experimental evaluation", Tzafestas, Costas S.; Palaiologou, Nektaria; Alifragis, Manthos. IEEE TRANSACTIONS OF EDUCATION Volume: 4, Issue: 3 Pages: 360-369 Published: AUG 2006 (available online thru UR library website)

Chemistry.
"Argument-driven inquiry: An introduction to a new instructional model for use in undergraduate chemistry labs" Walker, J. P., Sampson, V., & Zimmerman, C. O. (2011).. Journal of Chemical Education, 88(8), 1048-1056.

Instrumentation. Comparison of simulation and face to face oceanography experience. (2006) "Learning Oceanography from a Computer Simulation Compared with Direct Experience at Sea", Winn et al.

At risk students. Effect of gender, ethnicity, non-traditional status in online STEM. (2015) "The Online STEM Classroom—Who Succeeds? An Exploration of the Impact of Ethnicity, Gender, and Non-traditional Student Characteristics in the Community College Context ", Wladis et al.

## Learning Objectives (Groupings)

The task force developed a list of 14 core learning objectives broadly applicable to laboratory and studio-based courses. This is based on a similar list proposed for engineering laboratories paper by Feisel and Rosa (J. Eng. Ed., 2005, 121 – 130), with some addition and modification to generalize them beyond the original (engineering) context. (Resources to help instructors write detailed learning objectives specific to their course may be found at the top of the general resources page)

The core learning objectives were then organized into six broader groupings, based on similarities in the instructional challenges and approaches they present. [The following sections provide resources (discussion of issues, suggested approaches, videos/webinars, literature examples, etc.) organized primarily on the basis of these groupings.]

- Objectives centered around 'learning to take risks in the learning environment', which requires that students feel safe and that their experience is structured and purposeful.
    - **Teamwork**: the ability to collaboratively decide on and execute efficiently assigned group project(s).
    - **Communication**: the ability to communicate effectively with their professor, their fellow students, and the wider community.
    - **Learn-from-failure**: the ability to systematically analyze what went wrong in a procedure or project and develop new strategies to improve.

- Objectives that involve students development of a physical connection with the material under study.
    - **Sensory awareness**: the ability to use the senses to gather information and make sound judgments.
    - **Psychomotor**: the ability to select, modify, and operate instruments, tools and other resources.
    - **Instrumentation**: the ability to apply appropriate sensors, instrumentation, and/or software to measure physical quantities.

- Objectives that involve situations where students are encouraged to develop independent thoughts and ideas, whether by reacting to prior concepts and information or developing something new on their own.
    - **Creativity and critical thinking**: the ability to exercise appropriate levels of independent thought, creativity, and capability.
    - **Data analysis**: the ability to form and support conclusions by collecting, analyzing, and interpreting data.
    - **Models**; the ability to identify the strengths and limitations of theoretical models as predictors of real-world behavior.

- Objectives that focus on planning and iterative problem solving in open-ended situations.
    - **Experimentation**: the ability to make a discovery, test a hypothesis or demonstrate a certain fact.
    - **Design**: the ability to create a plan, an outline, or a sketch for the execution or construction of a machine, system or object.

- Objectives that involve collaboration between the University of Rochester and our larger communities (local, regional/state, national, global).
    - **Community engagement**: the ability to build partnerships with the broader community and public and private sectors to prepare educated, engaged citizens; strengthen democratic values and civic responsibility; address critical societal issues; and contribute to the public good.

- Objectives that deal with accountability for behavior and actions. (Note: We have not provided a separate listing of resources for this grouping.)
    - **Safety**: the ability to Identify health, safety, and environmental issues and deal with them responsibly.
    - **Ethics**: the ability to recognize and behave with high ethical standards.

# Resources for Teamwork, Communication, and Learn-from-failure

## Learning Objectives:

This covers three primary learning objectives: (1) teamwork, where students develop the ability to collaboratively decide on and execute efficiently assigned group project(s); (2) communication, where students develop the ability to communicate effectively with their professor, their fellow students, and the wider community; and (3) learn-from-failure, or developing a student's ability to systematically analyze what went wrong in a procedure or project, and develop new strategies to improve.

## Rationale:

A common theme of these three learning objectives is 'learning to take risks in the learning environment', which requires that students feel safe and that their experience is structured and purposeful.

## Takeaway strategies for online or hybrid instruction:

Smaller groups than in face-to-face settings for group assignments and a greater degree of 1-on-1 contact, check-ins and peer review sessions.

Several smaller projects that connect together in order to allow students to formatively learn from instructor and peer feedback as the course progresses, in place of large or semester-long projects that have only one assessment point at the end.

## Examples:

-Group design projects in an engineering course
-Partnered students in Biology labs who collaborate on collecting data and writing joint lab reports
-Co-op courses or group projects where students are partnered with a community entity to work toward a deliverable
-Collaborative art projects / productions / presentations
-Peer review / feedback group sessions
-Troubleshooting experimental procedures in a lab project or artwork

## Challenges and potential approaches:

1) What do we do when students must attend remotely?

Challenges may be:

- To coordinate and execute group projects students must find mutually agreeable times, which may be difficult across time zones
- Possible discomfort around some academic topics being discussed when students' family is nearby
- Some students not having appropriate study space or working space at home
- Discussions are slower if they are asynchronous
- Listening and responding to one another (e.g. in music, theater) is very difficult in online spaces
- Building an authentic Learning Community is challenging in an online space with no f2f component

- Ranges of internet access and equipment sometimes make it difficult to find supporting platforms, software, and media that are accessible by all students
- Learning from failure, in the experiential sense, might be difficult if students are not 'doing' the activity (as in some STEM labs, possibly)

Potential approaches:

- Communicate frequently with students. This is a key for success in remote learning. Check-in often, send reminders, grade, and leave feedback in a timely manner. Leaving students in the dark can foster disengagement in the course quickly. Use clear 'signposting' in the class as a whole, and particularly around group work to help ensure groups understand the goals and expectations of assignments.
- Use of breakout rooms in synchronous sessions will allow students who are able to attend to work in smaller, more comfortable groups and have their voices all be heard. Use of headphones and the chat function in Zoom can help mitigate when students feel they are unable to participate in sensitive classroom discussions. Some instructors use a TA to monitor the chat box in larger courses and collect thoughts and questions.
- Use live document links, rather than static documents like PDFs, for course components like syllabi, assignment guidelines, schedules, collaborative projects, etc. This can be helpful for students as you (or they) can update and modify and the changes take place immediately, rather than you having to upload the modified document again. Also saves time and avoids confusion.
- Break assignment information up into digestible sections. Consider breaking assignments up into parts, rather than assigning the entire project at once as you might in a classroom that meets regularly in person.
- Resources that can help instructors develop more authentic Learning Communities are included in the Recommended Tools section.
- An online course, with students attending remotely, can serve to especially focus the content and activities on the communication and teamwork learning objectives. Some lab courses have pivoted to a focus on the communication of results to various audiences, with greater emphasis than was given in prior iterations.
- Students are more open to considering user error and learning from failure when they themselves are not the source of the error. STEM is often focused on making sure the exercises presented in labs are almost certain to be successful for students, and as a result, they do not reflect how research is authentically done in the lab. Learning from failure is an iterative process, with regular feedback required from instructors to help guide students. Analysis of pre-recorded lab experiments, in teams, that critique the performance and outcomes of someone else could be very useful.

2) What do we do when some students attend on site and some remotely?

Challenges may be:

- All the challenges listed under (1) above for students attending remotely, and additionally:
- How to assign groups when groups are a mix of f2f and online students
- How to grade group projects when groups are a mix of f2f and online students
- Ensuring that the experience is normalized across the f2f and online students

- How to retain some of the spontaneity and sharing of ideas that happens in the f2f classroom for the students who are online
- Recording the f2f sessions and providing them to remote students might be difficult if masks decrease the quality and clarity of recordings

Potential approaches:

- Groups might be assigned based on geography, so that they can meet outside of 'class' time to work on projects. Based on time zones, for instance. If the goal is that some students 'do' the physical activity and then the group assesses and analyzes, then a mix is better with one student on campus and some remote.
- Assessing projects can be done in smaller chunks, with small goals established and clear rubrics around expectations. Students can work toward one single grade they all get for the product they turn in and an individual grade based on their respective contribution, which is also handed in. Consider having students assess or review one another's work. (See some useful tools under the *recommended tools for teaching and assessment* heading below.)
- It is important to note that grading projects in blended environments should take into account the potential for implicit bias of the instructor and other students.
- Sharing classroom recordings through the UR-supported channels (the Panopto tool in Blackboard) allows for significantly easier provision of captioning through the Office of Disability Resources. (Note: always use the Panopto tool when uploading video to Blackboard, as loading recordings directly into Blackboard itself can tax the system. Panopto also automatically captions recordings for accessibility.)

3) How will we teach students in person with social distancing protocols?

Challenges may be:

- Spacing guidelines and the use of masks inhibits performing artists and (if the masks are 'windowless') excludes those students who are hard-of-hearing or Deaf.
- Teams and partners will be unable to approach the same equipment or space (whiteboard, piano, studio) at the same time, so communication and teamwork will be more difficult while also being more imperative.

Potential approaches:

- Attention can be paid to the needs of Deaf and hard-of-hearing students by having/providing masks with clear windows in them . Guidance on this will come from the Office of Disability Resources. [https://www.rochester.edu/college/disability/]
- Instructions for procedures or activities can be broken down into individual roles and components, while also including a discussion of how each person's duties fit into the day's procedure as a whole. This can be provided to students for a faster start, or they can be tasked with organizing steps and assigning them to individuals on the team for a more in-depth approach for teamwork and communication.

## Recommended tools for teaching and assessment:

- Tuckman's stages of teamwork
    - [https://hr.mit.edu/learning-topics/teams/articles/stages-development
    - [https://www.lfhe.ac.uk/download.cfm/docid/3C6230CF-61E8-4C5E-9A0C1C81DCDEDCA2]
- Parker's team roles [https://psycnet.apa.org/record/1990-98306-000]
- [https://tll.mit.edu/help/teaching-teamwork]
- [https://www.who.int/cancer/modules/Team%20building.pdf?ua=1]
- Use polling software.
    - Piazza [https://tech.rochester.edu/services/piazza/]
    - Plickrs [https://get.plickers.com/]
    - PollEverywhere [https://www.polleverywhere.com/],
- Use collaborative brainstorming tools
    - AWW Boards (A Web Whiteboard) [https://awwapp.com/]
    - Padlet [www.padlet.com]. Getting Started with Padlet - [https://padlet.com/support/begin].
    - SMART Notebook has a Shout It Out interaction that allows users to submit text or graphics to a communal whiteboard.
    - Google Docs, Draw, Slides.
    - Mindmeister [www.mindmeister.com]. The Mindmeister Academy - [https://www.mindmeister.com/training].
    - Discord [https://discord.com]: closed voice and text chat platform
    - Slack [https://slack.com]: to facilitate discussion forums outside of class time
- Group students so that each group has proximity to a shared space on the wall. Students can approach the wall one at a time to add write on poster paper, a white board, or add a Post-It note. One student can take a picture of the completed work and share with everyone in the group.
- Small group discussion, one on one interaction between instructor and student
- Cycles of feedback (instructor or peers) followed by revision.
- Comprehensive Assessment of Team-Member Effectiveness (CATME). There is a licensing fee of $2 per unique student to use the tool suite, but it is fairly well grounded in engineering education research. Helps build and assess teams.
- How can I assess group work? (Carnegie Mellon) [https://www.cmu.edu/teaching/designteach/design/instructionalstrategies/groupprojects/assess.html]
- Evaluating Teamwork (Queen's Univeristy) [https://www.queensu.ca/qloa/sites/webpublish.queensu.ca.qloawww/files/files/TeamQ%202-pager.pdf]
- How to Assess Group Projects (edweek.org) [https://www.edweek.org/ew/articles/2019/02/06/how-to-assess-group-projects-its-about.html]

- Methods for Assessing Group Work (University of Waterloo) [https://uwaterloo.ca/centre-for-teaching-excellence/teaching-resources/teaching-tips/developing-assignments/group-work/methods-assessing-group-work]
- Assessment of Team Performance and Learning (GWU) [https://guides.himmelfarb.gwu.edu/c.php?g=365963&p=2473006]
- Reported use of tools assessing (directly and indirectly) teamwork across Cal State Fullerton [https://www.fullerton.edu/data/_resources/pdfs/presentations/MCBE_AssessConf_XXI_Teamwork_050517.pdf]

# Resources for Sensory awareness, Psychomotor skills, and Instrumentation

This section covers three primary learning objectives: (1) *sensory awareness*, where students use their senses to gather information and make sound judgments; (2) *psychomotor*, where students demonstrate competence in selection, modification, and operation of tools and resources; and (3) *instrumentation*, in which students apply appropriate sensors, instrumentation, and/or software tools to measure physical quantities.

## Rationale

These three objectives are generally linked in that they all involve situations where students develop a physical connection with the material under study.

## Takeaway strategies for online and hybrid instruction

Will need to supplement face-to-face learning with various "virtual" activities and demonstrations

## Examples

- Playing a musical instrument
- Using a camera to capture an image
- Using a microscope to count bacteria
- Using a balance to weigh reagents for chemistry experiments
- Using a gas burner to provide heat to drive a reaction

## Challenges and potential solutions

1) What do we do when students must attend remotely?

Challenges may be:

- Lack of immediate connection to students is obstacle to assessing level understanding and providing immediate feedback. May lead to student frustration and/or safety issues.
- Peer feedback also limited/with delays. Delays would prevent simultaneous use by multiple users and make it difficult to work in groups.
- Socratic approach is more difficult to implement.
- Lack of direct access to equipment for students and/or lack of direct observation of student effort with equipment. In addition, disappointment/dissatisfaction of students over the lack of access to equipment to manipulate may prove demotivating to students resulting in poor performance.
- Software licensing issues
- In situations where supervision of a trained individual is a safety requirement, online delivery involving distance learners directly using the equipment may not be possible. Similar consideration is given for situations where misuse might damage expensive equipment.
- Instructors might be placed in undesirable positions where they must serve as support staff for equipment or computer hardware.

Possible approaches:

- Teach to understand/assess/debug subassemblies/stages/experimental steps instead of approaching lab exercise as one large process
- Might be possible to provide access via kit acquisitions, lending and shipping of equipment, virtualization of systems, “instructor in the middle” approaches. Need to consider cost for students and university to ensure equitable access. Similarly, if kitting is an option, instructors might find themselves in a merchandise fulfillment role. FIRST assignment is to make sure students have the right resources. If you are considering kits see [Kits and software.]
- Demonstrations may be instructor generated or found online.
- Student-to-student asynchronous assistance through forums/discussion boards to encourage processes that reinforce understanding.

2) What do we do when some students attend on site and some remotely?

Challenges may be:

- F2f students might develop a different level of understanding than distance learners, because onsite learners have clear advantage for developing psychomotor skills, sensory awareness and access to instrumentation.
- Possible non-equitable distribution of student contributions (especially on teams)
- Will require sanitizing between users
- Proximity issues might prevent socially distanced users from seeing what they need to see.
- Decreased laboratory capacity might create need for more sections, and space/facilities might not allow this.
- Performing arts students will struggle to express themselves and interact with their peers if cordoned off into separate spaces

Possible approaches:

- Provide as much of the content remotely to all students as reasonable.
- The interactive experiences we often try for must be converted to something better described as “facilitated demonstration”. For an example of facilitated demonstration/tutorial see https://www.youtube.com/watch?v=gwcVr5VfXwA, or this video
- In many cases where an asynchronous approach is possible, supplementation with synchronous techniques (class demos, virtual office hours, …) with the instrumentation available might be highly desirable or even required.

## Recommended tools for teaching and assessment

Video submissions. Specifically, instructors should strong consider use of Voicethread. Voicethread is a tool that allow students and instructors to upload video and audio recordings, and then supplement those recording with audio and textual commentary. This is an excellent tool for students to visually record physical activities (for instance, conducting an experiment using a home laboratory kit), and then supplement that video with audio commentary that makes their thinking about, understanding of and evaluation of what they are doing evident. Instructors can add their own audio or textual commentary to student-submitted video, which can be an excellent way to provide rich feedback based on video recordings of a student’s performance. For instance, students could make video recordings of themselves performing a physical task, and instructors could then use Voicethread's annotation capabilities to provide students feedback and coaching on each student's performance. Voicethread is tightly integrated with Blackboard.

Forum participation. UofR instructors have two excellent tools for asynchronous interaction available for use: Blackboard discussion forums [https://tech.rochester.edu/services/blackboard-discussion-boards/], and channel-based discussion via Microsoft Teams. In the context of learning activities meant to build students' skills at physically connecting with materials, asynchronous discussion tools can be an especially efficient way for instructors and TAs to collect and field troubleshooting questions from students about procedures and equipment. Because these tools allow instructors to organize discussion by topic, instructors can use these tools to create stable resources students can use to find answers to their questions. Discussion fora can also be useful for structuring peer-to-peer interaction feedback. This may be especially useful in learning data analysis skills, where a core competence includes identifying and then addressing challenges to the validity of an analysis or conclusions drawn from it. Discussion fora can be a venue in which students make their analyses available for others and students can practice the skill of evaluating and communicating evaluations of an analysis.

Performance recordings and audio collaboration platforms might be useful for musicians, though they often require considerable skill with audio engineering to fine tune any collaborative performance online (and are often quite time consuming to learn and implement).

Portfolio development

Journals/notebooks/blogs/wikis

- Blackboard/Wikis [https://help.blackboard.com/Learn/Instructor/Interact/Wikis]
- Student teams and instructors can edit shared Google docs

Clear grade generation guidelines – Particularly in courses with a "participation" component clarity around expectations will reduce student anxiety. This will be even more important when some students can attend f2f components of the course, while others must participate online.

Modular organization

Build up to project - consider breaking larger projects into stages with regular feedback, rather assigning a project with a single deadline

Grading contracts

Student on student grading

Zoom Breakouts to facilitate small group discussion [https://tech.rochester.edu/zoom-tutorials/]

## Resources for Creativity and critical thinking, Data analysis, and Models

### Learning objectives:

This section covers three primary learning objectives: (1) *creativity and critical thinking*, where students demonstrate appropriate levels of independent thought, creativity, and capability; (2) *data analysis*, where students demonstrate the ability to form and support conclusions by collecting, analyzing, and interpreting data; and (3) *models*, in which students identify the strengths and limitations of theoretical models as predictors of real-world behavior.

### Rationale:

These three objectives are generally linked in that they all involve situations where students are encouraged to develop independent thoughts and ideas, whether by reacting to prior concepts and information or developing something new on their own.

### Takeaway strategies for online and hybrid instruction:

Because these objectives require independent work by students, they may lend themselves to the online format more readily than others. Attention must be paid to all students' access to tools, as discussed in the At-risk students and Kits and software sections.

### Examples:

- Modeling changes to flux in biochemical pathways
- Using archived or instructor generated data sets for analysis of genomic sequence
- Preparing a dance routine or a musical performance
- Designing experimental approaches for a research proposal
- Creating art based on prior models
- Designing electronics using circuit simulation tools.

### Challenges and potential solutions:

1) What do we do when students must attend remotely?

Challenges may be:

- Lack of immediate feedback from instructors and peers
- Feedback fatigue can be an issue as we try to compensate for lack of individual interaction
- Software use/licensing
- Students feel overwhelmed and "don't know where to start"
- First-year students' ability to develop peers in their major, that are often formed by lab and smaller performance interactions, are much more difficult.
- Students with insufficient computing resources might have issues running simulations and models on their own hardware.
- Students may have trouble conceptualizing models, and fail to understand benefits and shortcomings

Possible approaches:

- Provide structure for the project, help students learn how to break the project into stages.
- Advertise “group” office hours for online students for both efficiency and to connect remote students, especially for first-year students.
- Use mandatory breakout rooms during the first few class times for students to introduce and interact.
- Select web-based products that run from any browser
- Test on all possible platforms that students might use, including tablets
- Remote desktop to university computing resources
- Log in to University servers to run programs
- Video sessions with screen capture demonstrating proper use of all software tools.
- Screen sharing during online conferencing might help debug students’ issues
- Modeling might be directly addressed in lecture material to help students understand the purpose of modeling efforts

2) What do we do when some students attend on site and some remotely?

Challenges may be:

- Language barriers, particularly with first-year international students
- Peer feedback (especially tone deaf) can create complicated social consequences, thus affecting cohort mentality
- Expectations that the onsite person must convey information lost as a result of technical difficulties
- Computing labs will be accessible to some students, thus the issues with running on student-owned hardware may not be present

Possible approaches:

- Determine if it is possible to equitably stagger deadlines with a combination of online/socially distant students, which could permit the opportunity and time to give thorough feedback
- Create a referral process that extends beyond tutoring for when students do not demonstrate appropriate levels of independent thought and capability.
- Lab teams might be formed with conferencing, screen sharing, and remote control providing all team members with some form of access to university-owned resources
- There may be possibilities to formally test predictions of models and simulations experimentally, in the lab

## Recommended tools for teaching and assessment

Video submissions. Specifically, instructors should strongly consider use of Voicethread. Voicethread is a tool that allows students and instructors to upload video and audio recordings, and then supplement those recording with audio and textual commentary. This is an excellent tool for students to visually record physical activities (for instance, conducting an experiment using a home laboratory kit), and then supplement that video with audio commentary that makes their thinking about, understanding of and evaluation of what they are doing evident. Instructors can add their own audio or textual commentary to student-submitted video, which can be an excellent way to provide rich feedback based on video recordings of a student's performance. For instance, students could make video recordings of themselves performing a physical task, and instructors could then use Voicethread's annotation capabilities to provide students feedback and coaching on each student's performance. Voicethread is tightly integrated with Blackboard.

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Other possibilities to explore include:

Higher-level programs that can support generic models (Matlab, Octave, Mathematica, Labview, …)

Web-based simulations and exercises. See the section on general resources.

Performance recordings audio collaboration software

Portfolio development

Journals/notebooks/blogs/wikis

- Blackboard/Wikis [https://help.blackboard.com/Learn/Instructor/Interact/Wikis]
- Student teams and instructors can edit shared Google docs

Clear grade generation guidelines – Particularly in courses with a "participation" component clarity around expectations will reduce student anxiety. This will be even more important when some students can attend f2f components of the course, while others must participate online.

Modular organization

Breaking larger projects into stages with regular feedback, rather than assigning a project with a single deadline

Grading contracts

Peer feedback and grading

Zoom Breakouts to facilitate small group discussion among peers [https://tech.rochester.edu/zoom-tutorials/]

Examples/exemplars

Neuron simulation language (neuron.yale.edu)
HHMI biointeractive (https://www.biointeractive.org/classroom-resources)

# Resources for Experimentation and Design

## Learning Objectives:

This covers two primary learning objectives: (1) experimentation, in which a procedure is planned and executed to make a discovery, test a hypothesis, or demonstrate a certain fact. Experimentation is field-specific and can take various formats, and (2) design, Creating a plan, an outline, a sketch as a form and structure of a piece of work. A plan of a machine, system or object to be executed or constructed.

## Rationale:

These objectives share elements of *uncertainty* and being *open-ended.* The correct, or best, answer is unknown and needs to be sought. This requires both planning and iterative problem-solving. Students need to learn to approach this both systematically and, especially for design, creatively.

[Note that in a set piece experiment, where students use a standard procedure to record data for analysis, the learning objective is primarily data analysis. "Experimentation" here implies learning how to plan/control the experiment itself.]

## Takeaway Strategies for Online or Hybrid Instruction:

It is essential to retain the elements of uncertainty and open-endedness even online. Online or remote experiments should present students with options that influence the type and quality of the results they receive. Similarly, design projects should provide a chance to explore alternative approaches, assess, and modify.

## Examples:

- Cognition experiments in psychology
- Building a circuit and testing different attributes after using an oscilloscope or function generator
- Testing space limitations in dance
- Running a gel for DNA in biology
- Testing different drawing techniques and tools
- Experimenting with lighting set ups in photo/video studio
- Analyzing existing designs to improve them
- Creating a laser setup
- Constructing a synthesis of a natural product in chemistry
- Design an email system that can scale to 1M users
- Writing a script to execute a function
- Designing a part for a machine in CAD
- Design and plan a course with learning objectives and assessments
- Designing the layout of an artist's book or a website

## Challenges and Potential Approaches:

1) What do we do when students must attend remotely?

Challenges may be:

- Reduced access to tools, equipment, software.
- Lack of immediate feedback obtained when manipulating an instrument. Inability to "play" with experimental parameters.
- Students may get less timely (instant) feedback from instructors.
- Research that requires face-to-face interactions with community partners will be restricted. Access to dataset might be restricted to on-campus only if the data is sensitive, protected, or fragile (e.g., archived materials).
- Increased confusion and discomfort for students who have preconceived notions and expectations of what a 'lab' or 'studio course' is supposed to be.

Potential Approaches:

- Simulations have become more thorough and useful and allow students to see the effect changes in experimental parameters. See the general resources section.
- Provide students with a limited, but meaningful, range of experimental choices each with a matching set of data. Allow multiple iterations and ask them to explain the differences.
- Design is increasingly being performed by teams which are physically isolated from each other and from the fabrication site. There may be an opportunity to reorient instruction to emphasize processes/tools applicable to this environment.
- Avoid discussing experiments without the context of a hypothesis.
- Develop exercises where students must choose an experimental protocol that optimally tests given hypotheses, perhaps using examples where different protocols are best suited to different hypotheses.
- Emphasize materials/processes that can be more readily be fabricated remotely (e.g. 3D printed plastics).
- Special attention should be paid to the tools used in design in your field. These might include software, sketching, modeling clay, scripts, programming, etc. Check in advance whether students have adequate access.
- Consider Kits as an option.
- Consider use of commonly available materials as an option.
- Experiments planned by online students' might be performed remotely by on-campus teammates, TAs, or upperclassmen.
- Students ability to see that they are achieving the learning objectives defined for the experiment/design may help reduce their dissatisfaction/discomfort with online delivery.

2) What do we do when some students attend on site and some remotely?

Challenges may be:

- All the challenges listed under (1) above for students attending remotely, and additionally:
- Perceptions of "unfairness" between online and f2f students over access to hardware, instructors, etc. (Potentially acute because of the nature of these learning objectives.)

- How to retain essential elements of the creative experience (spontaneity, brainstorming, rapid exchange of ideas) when the class includes both f2f and online students. (On campus students may quickly interact face-to-face, while online, perhaps asynchronous, students may be entirely dependent on online tools.)
- Team dynamics and grading issues. See the discussion in the Teamwork, Communication, and Learn-from-failure section.

Potential approaches:

- Emphasize/require use of online tools (discussion boards, voice threads, Wikis) for all students to participate in creative discussions.
- If teams are involved, their composition should be considered from an online vs. f2f standpoint.
  - Separate (online vs. f2f) groups may help avoid sidelining of the online students within a team
  - On the other hand, in some cases it may be advantageous to have mixed teams with the on campus members able to 'do' some physical activities (perform the experiment, assemble the components of a design, arrange a lighting set up).
  - In either case clear definition of roles and responsibilities is of increased importance.

3) How will we teach students in person with social distancing protocols?

- Challenges may be: Checking out equipment such as cameras, tripods, light kits might be limited or not permitted for students
- Limited access to production spaces (dance studios, lighting studios, computer labs, painting and drawing studios, audio recording studio, etc).
- Reduced capacity in laboratories, studios, and performance spaces.
- Increased difficulty of performing activities that require multiple students to work in close proximity.

Potential Approaches:

- Designing 'Low-tech' class projects that do not require the students to check out special equipment or collaborate in person
- Dividing the class into small groups for demonstrations in studio (lighting demos for example)
- Strict space reservation system and training for students prior using production or laboratory spaces
- Extended hours (dependent on the amount of support available).
- Prioritize lab/studio activities (reserve f2f resource for activities where f2f is consider more impactful).
- Modify/simplify activities so that students do not need to be in close proximity to perform them.

## Recommended Tools for Teaching & Assessment

Simulations & Online Lab modules:

- Biology Corner [https://www.biologycorner.com/]

- PhET [https://phet.colorado.edu/en/simulations/category/new]
- HHMI Biointeractive [https://www.biointeractive.org/]
- The Concord Consortium [https://learn.concord.org/]
- The Biology Project (UArizona) [http://www.biology.arizona.edu/]
- ChemCollective [http://chemcollective.org/home]
- North American Network of Science Labs Online [https://www.wiche.edu/nanslo]
- OpenStax [https://openstax.org/]
- Project WET [https://www.projectwet.org/
- Wolfram Mathematica [https://www.wolfram.com/mathematica/]
- Labster [https://www.labster.com/]
- Unity [https://unity.com/products/simulation]

Virtual Design Studios
[http://itecideas.pbworks.com/f/Kvan%20pedagogy%20virt%20des%20studio.pdf]

Databases of Virtual Scans and Models

- https://www.morphosource.org/
- https://sketchfab.com/
- https://www.sketchup.com/plans-and-pricing/sketchup-free

MathWorks Simulink/MATLAB

Online labs for data science, big data, programming, etc. [https://www.vocareum.com/]

For lab and studio-based courses, project journals or lab reports are a recommended option for assessment when these are appropriate for your learning objectives. Short answer and essay questions can also work well.

## Resources for Community engagement

### Rationale:

**Community engagement** describes the collaboration between the University of Rochester and our larger communities (local, regional/state, national, global) for the mutually beneficial exchange of knowledge and resources in a context of partnership and reciprocity. The purpose of community engagement is the partnership of college and university knowledge and resources with those of the public and private sectors to enrich scholarship, research, and creative activity; enhance curriculum, teaching and learning; prepare educated, engaged citizens; strengthen democratic values and civic responsibility; address critical societal issues; and to contribute to the public good.

**Partnerships** are long-term and mutually beneficial relationships between the university and individuals, non-profit and for-profit organizations, education institutions, and government agencies. Partners bring individual goals, needs, assets and strategies, and through collaborative processes blends them into common goals and outcomes.

In the context of an individual course, community engagement often takes the form of learning activities planned and executed by the instructor in collaboration with non-academic community partners such as government agencies and non-profit organizations. These learning activities are mutually beneficial, in that they support the development among students of mastery of skills and knowledge that are critical aspects of their courses of study and in that they produce tangible benefits for the non-academic partner organization or the population that organization serves.

### Challenges and Potential Approaches:

In all delivery formats, community-engaged teaching and learning is dependent upon relationships the faculty maintain with their community partners. Because mutually-beneficial relationships are the essential foundation of community-engaged teaching and learning, in any format it is critical that the University and the course instructors attend to the ways that COVID-19 may have impacted the partner's needs and the partner's capacity to benefit from community-engaged learning activities. Circumstances connected with COVID-19 should be expected to have been at least as disruptive to our community partners and to the communities they serve as they have been to the University.

Thus, instructors should start any planning for fall courses with conversations with their community partners in which they ask whether the partner continues to be interested in collaborating during the Fall semester, and asks about the ways the partner's priorities, needs, and capacities have changed in response to COVID-19. In the early stages of planning, instructors should also learn about and accommodate any health and safety needs that might be relevant to the community partner but not necessarily apparent within the University. For instance, community partners that serve elderly or medically vulnerable populations may need to operate under much stricter protocols for social distancing and sanitation than may be required of students and instructors within the University.

More generally, instructors should be respectful of the limits and demands COVID-19 may have placed on their partners and should emphasize preserving relationships for the long term over asking partners to make extraordinary changes to accommodate hybrid, online, or socially distanced face-to-face instruction. The same principles of community engagement hold true in each of the following formats. Faculty relationships with partners are crucial and take time to develop and negotiate.

1) What do we do when students must participate remotely?

- Populations that community partners serve - especially persons in socially marginalized groups and persons living on low incomes - have very little access to the technologies needed to engage virtually.
- Students and their community collaborators will miss out on the opportunity to explore physical spaces and physical interactions that are often an especially powerful aspect of community-engaged learning.
- Community-partners may or may not deliver online services to the populations they serve, and thus there may be very limited scope for online activities or projects to benefit those partner organizations or the populations they serve.
- Project management skills are essential if students are doing asynchronous classes and projects.
- Online delivery may be the safest option when considering the possibility that interaction between students and community partners may put community members at risk for exposure to COVID-19.

2) How will we work with students and partners in-person with social distancing protocols?

- Smaller groups will need to go out into the community together, considering that transportation of larger groups will not be possible in confined vehicles.
- Appropriate space at the partner site will need to be secured so as to accommodate social distancing measures, which might need to be more restrictive than what the University implements on campus.
- Safety and health of community members are just as important as safety and health of students and faculty.

3) What do we do when some students attend on site and some remotely?

- Effective communication and project management are central to community engaged learning in a blended format—communication between faculty, students, and partners (especially as time zones differ). Some faculty are working with Rochester-based organizations and others are working with organizations in other cities.
- Not all community partners have the ability to participate in both formats.
- Community-engaged learning is often logistically complex, as it involves the collaboration between students and community members, and involves differences in their schedules and the need to travel to interact. Because of this, the additional logistical complexities of hybrid instruction may make it especially difficult to execute activities that are mutually beneficial. Again, project management skills are essential if students are doing asynchronous classes and projects.

<u>Recommended tools for teaching</u>

- Consult with community-engaged learning staff in the Rochester Center for Community Leadership [https://www.rochester.edu/college/rccl/]
- [https://compact.org/webinarseries/]

Recommended tools for assessment

- Critical reflection journals
- Survey of community partners
- Pre/post tests
- Surveys of class knowledge/experience

Examples/exemplars

- This page includes a tool for browsing through syllabi of community-engaged courses from dozens of universities. Many examples of community-engaged learning activities and course designs. [https://compact.org/resources/]

## At-risk students in lab/studio/performance space environments

It is important that both the administration and individual instructors consider the potential obstacles in labs, studios, and performance spaces for all students who contribute to the diversity of our campus. There must be a focus on inclusive practices to ensure that we do not marginalize these students by failing to implement practices that can, in most cases, also be shared with all students.

The following sections discuss the challenges faced by some of these groups, though this listing is not comprehensive. Some useful resources and suggestions for dealing with the issues raised are also presented at the end of the discussion.

### Students with disabilities:

Potential Issues:

While students with disabilities can obtain access to accommodations, it is important to be mindful that in-person labs and performances have often relied on the group dynamic to achieve their objectives. This could be considerably more challenging with social distancing and could result in excessive physical and mental demands on disabled students, especially if there are limitations in lifting, auditory, or sight abilities. Additionally, being required to attend f2f meetings during a pandemic can exacerbate anxiety disabilities for some students.

Deaf/Hard of Hearing Communication Access, students can get interpreters but need to make a special request *outside of regular classroom hours* (https://www.rochester.edu/college/disability/current/asl-cart-request.html). This could be further complicated if web-based controls are used or if there is a combination of socially distant and online groups, where the timeliness of instructions and techniques have to be communicated via Zoom.

**Resource:** https://ieeexplore.ieee.org/document/7087284

**Possible Solution:** Communicate the potential changes in lab or performance expectations to the Office of Disability Services so that they can be prepared when students request accommodations for new lab/performance formats. Remain flexible in the modality that students choose to complete course activities and allow them to participate virtually when they need to do so. Carefully consider 'required attendance' policies and discuss these with the Office of Disability Resources as early as possible.

### Non-traditional students:

**Potential issues:**

Many of these students have familial and occupation responsibilities. It is Important to stay aware of this when considering the extension of lab or studio access into nights and weekends as a solution to social distancing problems.

Nearly all of our military service veteran students are not only non-traditional students, but also transfers from another college. This is another group that can be less familiar with labs and studios and how they operate.

Veterans have historically had difficulty adjusting to college coursework and also to the development of a strong peer group to study and complete coursework (https://www.military.com/veteran-jobs/career-advice/military-transition/veterans-in-college-face-challenges.html). It is important to be mindful of this in the creation of lab groups.

**Possible Solutions:** There are typically fewer than 100 military veterans across AS&E. Possible changes to labs, studios, and performances can be communicated to their student group, the UR Veterans Alliance (https://www.rochester.edu/diversity/staff/resourcegroups/veterans/). The Admissions Office, College Center for Advising Services, and the Hajim Dean's Office also proactively reach out to veteran students.

## Age, disability, ethnicity, gender/gender identity and expression, national origin, race, religion, or sexual orientation:

**Potential issues:**

If there is a combination of in-person and online groups, special attention needs to be paid to the group dynamic to be mindful of the potential for bias-related mistreatment of the above listed groups. While there is a bias-related concern referral process for the university (https://www.rochester.edu/care/reports.html), consideration needs to be given to what additional training TAs may need to deal with the issue, as well as whether a specific process for reporting bias-related concerns to the instructor is needed.

Underrepresented students have described examples of being excluded in the formation of small groups, especially if there are few or no other underrepresented students. In some cases this pushes students to change majors or even fields (https://hbr.org/2015/03/the-5-biases-pushing-women-out-of-stem). This dynamic could be aggravated in the current environment, especially if a combination of online and socially distanced face-to-face instruction is used (e.g., the perception of varying levels of responsibility and/or an unfair workload if the division of labor is not made clear).

"By making a personal commitment to examine the impacts that our own privileges, implicit biases, and stereotype threat cues can have on our students' experiences, we can engage in the process of self-transformation that is an important step toward achieving inclusive excellence in our classrooms." (http://www.math.lsa.umich.edu/~glarose/dept/teaching/resources/03TowardInclusiveSTEMClassrooms.pdf)

**Resources:**

https://www.nature.com/articles/d41586-018-05646-4

https://www.rochester.edu/college/bic/

**Possible Solutions:** When dealing with group work, limit the role of students in the selection of partners. Consider additional training for TAs and creating a clear process for reporting bias related concerns/instances to the instructor. Campus partners in this would include the Burgett Intercultural Center, The David T. Kearns Center, and the Office of Minority Student Affairs. Consider having students sign an agreement specifying the roles and responsibilities of each student when small groups are formed.

## Low-income students:

**An example**

Low-income students can be disproportionately affected by costs associated with having to purchase lab kits and software. To understand this, we must look at how we currently fund textbooks and supplies.

Here are the textbook expenses of an actual CHE student in Fall 2019:

| Course | Text | Amazon | Barnes and Noble |
|---|---|---|---|
| CHE 131 | CHEMICAL PRINCIPLES By ZUMDAHL EDITION: 8TH | $95.93 | $144.85 - $308.20 |
| CHE 131 | ANTI-FOG GOGGLES | $6.98 | $6.98 - $6.98 |
| CHE 131 | STUDENT LAB COAT: CHEMISTRY LAB | $16.95 | $22.98 - $22.98 |
| MTH 141 | CALCULUS, EARLY TRANS | $249.81 | $120.70 - $256.85 |
| WRT 105E | NETWORKS: VERY SHORT INTRODUCTION | $9.59 | $4.00 - $11.95 |
| WRT 105E | CRAFT OF RESEARCH | $8.99 | $8.45 - $18.00 |
| CHE 150 | Sustainable Energy, 2nd by Richard A. Dunlap | $136.11 | $70.50 - $150 |
| CHE 132 | CHEMICAL PRINCIPLES (Purchased in Fall) | $0.00 | 0 |
| MTH 142 | CALCULUS, EARLY TRANS (Purchased in Fall) | $0.00 | 0 |
| CLA 110 | ILIAD (FAGLES) | $13.49 | $15.00 - $20.00 |
| CLA 110 | METAMORPHOSES | $8.99 | $10.50 - $14.00 |
| CLA 110 | ANTHOLOGY OF CLASSICAL MYTH | $26 | $19.50 - $26.00 |
| CLA 110 | ODYSSEY | $8.99 | $14.20 - $18.95 |
| PHY 113 | PHYSICS F/SCI.W/MOD.PHYS, V1 | $185.12 | $162.40 - $216.55 |
| | Total | $766.95 | |

This is a considerable expense for students and often there is a significant amount of Federal Work Study built into a low-income student's cost of attendance to help pay for indirect costs. In this case, the student was expected to earn $2,923 to help fund indirect expenses, which he/she can only utilize by working at an on-campus job. In the case of first-year students, they may have to work significantly more than they are used to, in addition to transitioning to college life. Additional class expenses would exacerbate this.

**Potential issues**

Students often have limited resources to purchase additional equipment and/or software, beyond the aid already allotted to cover books and supplies. Low-income students have successfully used a variety of methods to access textbooks but being required to purchase additional software or kits could prove to be an insurmountable obstacle. The textbook problem at UR for underrepresented students has been, to some extent, alleviated by the Kearns Center's book lending library, but there is not a similar work around for kits or software. Significant additions to estimated course expenses should be communicated to the Financial Aid Office as soon as possible.

Low-income students who are unable to attend in person, including international students, may not have the requisite space to perform experiments, performances, and projects. Instructors need to be cognizant of potential space restrictions for students who are unable attend in person.

First-year, low-income students from under resourced high schools may have little to no exposure to labs, especially in the operation, use, and safety procedures for dangerous and/or expensive equipment or materials. Instructions, safety procedures, and definitions of terms should be permanent resources on Blackboard, so these students can utilize the information before, during, and after labs and/or performances.

**Resources:** https://www.chronicle.com/article/What-College-Students-Need-Now/248882

**Possible Solution:** Communicate with Financial Aid as soon as possible the likelihood and approximate cost of kits, software, and materials so that they can allow individual appeals. Partners in this endeavor can be the Hajim Dean's Office, The David T. Kearns Center, and the Office of Minority Student Affairs.

## Labs and Studios in a Hyflex environment: Course Kits and Software

Course kits and software can be important elements of toolkits supporting Hyflex teaching endeavors. While both can be highly valuable, attention to some details as these toolkits are being developed can contribute to a better experience on the part of the learners and instructors.

### Course kits

We define course kits as any physical resource meant to be taken possession of by a student in support of course work. Examples may be art supplies in support of an art studio, a musical instrument for a performance class, or an electronics kit to support an electronics lab. Such kits can be designed for a student to keep, or to be returned to the instructor or home department. Standing departmental review procedures should be employed to review for any safety concerns.

**Student purchases**:

The least impactful approach with respect to instructor or departmental effort is to have the student acquire the equipment on their own from a supplier recommended by the instructor. This removes the instructor from a fulfilment role, in which the instructor must assume responsibility for making sure the students receive the necessary materials. Ideally, the instructor would provide a link to the required purchase through a reliable vendor. In some cases, this might be accomplished in a single purchase from a vendor, though efforts should be made in advance to assure the reliability of such a vendor, and direct communication with the vendor to insure that they can absorb the additional sales from your students is highly recommended (a vendor that doesn't respond to such requests might not be reliable). Long-term reliability of the supply chain can minimize last minute redesign of future course offerings.

If the nature of the kit is such that the purchase of a single item is not a possibility, major distributors of supplies in educational and technology arenas often have a customer service route for educators who might be able to help instructors assemble a course kit, in which all or many of the items you need students to purchase are available with one SKU, making ordering less error prone.

There may be special considerations for international students, who might not have access to large online retailers like Amazon, and large distributors might not do business in all parts of the world. One such case was mitigated by working with a friendly alumnus to help assemble a shopping list with the Chinese analog of Amazon. Another approach might be to provide such students with product numbers and ask them to assemble their own kits. This approach places a great deal of responsibility on the student and might best be considered a last resort.

Instructors should consider how much expense students will absorb in this process and should be sensitive to situations in which the purchase of a course kit might prove to be a substantial hardship. It might prove useful to maintain a few kits on hand to send to students in need. Such situations should obviously be handled privately. A small library of replacement parts might also be useful, especially if there are fragile elements in the kits.

**Instructor/departmental distribution to students**

An alternative to student purchases is having the instructor or department acquire course kits, and distributing them to students, either for loan, or sale. Under such an arrangement, there are many more logistics that must be covered using university resources, and the instructor must make sure those logistics are all arranged prior to the beginning of the course supported. Because of this added burden, this approach should be avoided, unless the equipment is unreasonably expensive for direct student purchase. If unavoidable, plans should include considerations to encourage return of equipment (e.g., deposits, grade withholding), how returned gear will be tested for damage and packaged for redistribution, and plans for equipment returned broken, shipping costs and delays, staffing to cover the fulfilment role, method of distribution, storage of equipment between course offerings, etc. If numerous lab and studio courses within a department or school require such logistic support, centralization of services should be considered.

**Build-your-own**

Custom design and fabrication of equipment for a course kit is certainly a possibility, though quite challenging. Time constraints for Fall 2020 coursework will likely preclude this option.

**How to communicate to students about kit requirements**.

Less-than-timely acquisition of course kits can be harmful to the smooth flow of a course. Early acquisition should be encouraged, and might be facilitated by an email to course participants prior to the start of the semester, and/or early availability of course materials through Learning Management Systems, such as Blackboard. Instructors should plan a very early assessment to determine if every student has acquired required course material, and determine in advance how failure to acquire kits will be handled.

## Computer software

Computer software can be used in Hyflex environments to support simulations and virtualizations, and a myriad of other educational endeavors. At the U of R, computing labs and classrooms maintain a number of software packages to support education, with Classroom Technology managing the computers to maintain reliable and predictable function. If students cannot make a package work on their own machines, they may be able to use on-campus computing lab facilities. This may not be an option for all students in Fall 2020.

Students will be working in a variety of device families and operating systems, and instructors must anticipate whether students will be able to run the required software on the systems they have access to.

Perhaps the most reliable way of using software in coursework is the use of web applications with well-known browser compatibilities. When this is not possible, and students must install software on their own machines, there should be installation packages available for all popular computing platforms, or different alternatives for every platform. The larger the user community is for a given package, the easier time the student will have finding help if they have installation problems. Instructors should rigidly avoid situations requiring them to support the products being installed – especially installation.

Instructors should avoid placing students in situations that might encourage software piracy and might strongly consider open-source products or products with the least restrictive license terms where available (and robust). In some cases, educational pricing of very expensive packages is quite reasonable, or perhaps free, to students. Some companies have made products freely available to students as part of a COVID-19 response. In some cases, it might be possible to work with University IT and Classroom Technology to arrange for remote access to University computers.

Instructors should be aware of the licensing, terms of service and privacy policies of web-based and other products, and assure that the intended use is in compliance and that students are not exposed to privacy lapses.

It is strongly recommended that instructors test (and test and test and test) all software on every computing platform students are likely to use, including somewhat older operating systems versions, if possible. Ideally, software solutions will be usable on tablet-based platforms, as well.

Similar to kit usage, instructors should make efforts to assess whether students are able to use software tools before usage becomes critical.

## Conclusion

In summary, careful planning is required to create the most trouble-free implementation of course kits and software usage in support of Hyflex classrooms. Every effort should be made to make acquisition and installation by the students as straightforward as possible. Instructors should avoid the role of support for acquisition fulfilment or software trouble shooting. Early assessment of whether students have acquired or installed necessary products is a valuable practice.

# A Hypothetical Case Study: Beam Loading

## The way it was

Professor Roebling has developed a laboratory exercise for his Civil Engineering 101 course over many years. The course is for young civil engineers. The laboratory component of the course, which has gotten better every year, is extreme, involving repeated visits to a large construction site. The instructor arranges for a bus, the whole class gets in, and they are transported to the site.

At the site, Professor Roebling trains the students in worksite safety, wearing a hard hat properly, not going through doors that have “Do Not Enter” signs on them, …. After the students pass an on-site quiz on safety, they are taught to use heavy earth-moving machinery to dig a ditch, and then they span that ditch with an iron beam. They use a huge front loader to apply force to the center of the beam, and use the latest in laser measurement equipment to measure the deflection of the beam, and industrial load cells to measure the force applied by the front loader. The students take the data home and try to determine if the beam followed the behavior given by the equation for a center-loaded beam in their civil engineering textbooks.

## New constraints

This year, however, everything is different, and Professor Roebling needs to change her course to accommodate for a world where some students may not be on campus, and may even be in distant parts of the world. For the students that will be on campus, they will not be allowed to sit near each other on a single bus.

Doctor Roebling decides that she will rent 4 busses to transport students to the site. She feels a little bit bad about students who might not be able to directly participate in this activity, but she intends to make every effort to bring those students into the event by using modern communication tools, video, Zoom, …. She reaches her contact at the construction company she’s dealt with on this for a decade, and is informed that their job sites are now entirely closed to outside parties because of COVID concerns, but that they can still carry out the lab exercise by screening the health of each attendee and training them in infection control. Doctor Roebling is very happy that there is a mechanism to continue her lab exercise as she has done every year for the last ten years!

Unfortunately, after Dr. Roebling calculated the costs involved in hiring 4 busses with drivers and health-screening every one of her students, the number came to 350% of the departments entire budget for laboratory support. She asked her chair if this was OK. She still doesn’t officially know, because the chair hasn’t stopped laughing long enough to answer. Our instructor probably needs to reexamine her entire plan.

## Reevaluating the (learning) objectives

After putting her disappointment, frustration, and anxiety over redesigning her entire lab module aside, she started by reviewing her learning objectives. She first considered the objective of “students will be able to work safely at construction sites” (her course-specific instantiation of Feisel and Rosa Safety objective[1]) While she’s always been proud to say “I teach my students safety in construction zones”, she came to realize that wasn’t in the original plan for her lab module, but became necessary only when she decided that her exercises would be held in construction zones! If students were not being taken to construction zones, they would not need to learn job safety.

Or would they?? Is this an important feature of the Civil Engineering program at their school? In fact, it is very important to the faculty, but discussion with other faculty members uncovered other opportunities, later in the curriculum that these students would experience. Dr. Roebling is off the hook, and does not need to teach this material in her redesigned lab!. Similar course objectives fell one by one; "Students will be able to remove tons of earth by driving earth-moving machinery", and "students will be able to make distance measurements using laser interferometer-based metrology equipment" went next, for very much the same reasons as the safety situation (Aspects of Feisel and Rosa's Instrumentation and psychomotor objectives[1])

Finally, she got to "students will make measurements of bending of a center-loaded beam fixed at two points" and "students will assess the accuracy of the beam-bending equations in their textbooks" (Aspects of Feisel and Rosa Models; Data Analysis; Psychomotor; Instrumentation; and Experiment objectives[1]). She tried to envision a session in teaching lab space where she could guide students through these objectives, but had trouble conceiving a way to do this for all of her students, given the strict social distancing protocols and the restricted room occupancies. Further, not all her students were going to be on campus.

## Planning

Dr. Roebling started investigating the possibility of having the students do the experiments at their own desks. She went to a variety of stores and bought a variety of arts and crafts, and other supplies. She found that she could reliably create repeatable bending by laminating three wooden coffee stir bars together, using white glue as an adhesive. It's no iron beam, but it will do the job.

How about measurements? She determined that she could make precise enough distance measurements using a clear plastic millimeter ruler. How about loading? Stacking pennies on the center of the wooden construct worked fine, and all students should be able to get coins on their own. For force measurements, she could either let the students do the exercise using "coins" as a unit of weight, or she could use a force-sensitive resistor and a digital multimeter to measure the resistance. She might need to come up with a way to calibrate the force-sensitive resistor --- perhaps something involving water measured in a measuring cup would work.

So, she designed a kit. Dr. Roebling at first considered assembling all the materials, boxing and shipping them to all of her students, with the intention of collecting them after the semester ends but did not see the logistics in place for such an operation. She was also aware of possible complications if she needed to ship internationally. Thus, she found adequate stir-bars and white glue, and a ruler on Amazon. She opted for products available through Amazon Prime, so shipping would be free and fast. She put links to the products on her Blackboard course site. She worked with an electronics distributor to put together a course kit that contained a force-sensitive resistor and a multimeter and put that link on the site as well. Realizing that she had some international students that might not have access to Amazon or her electronics vendor, she put descriptions up of the parts, and left instructions for students in that situation to do their best to replicate her recommended kit with their own vendors, but she made a note to try to track down some international colleagues who could help her assemble similar kits in Europe and Asia.

She noted that her kits would total $23.95 for each student, and she did not believe that would present an undue burden, but she put a note in her syllabus about contacting her directly in case of financial hardship.

Realizing that she might be have developed tunnel vision regarding developing this lab exercise, she sat down and discussed it with some colleagues.  One colleague pointed out that students might need a way to calibrate the force-sensitive resistor, and suggested something involving water measured in a measuring cup would work.  The other colleague pointed out that her laminated beam was not isotropic, and results would differ based on whether force was applied perpendicular to the laminated layers or in the other direction.  Instructions on how to orient the beam would need to be provided, or perhaps there was a better way to make use of the anisotropic properties in the experiment.  While the details weren't fully hashed out, Dr. Roebling saw the value of bouncing her plans off trusted colleagues.

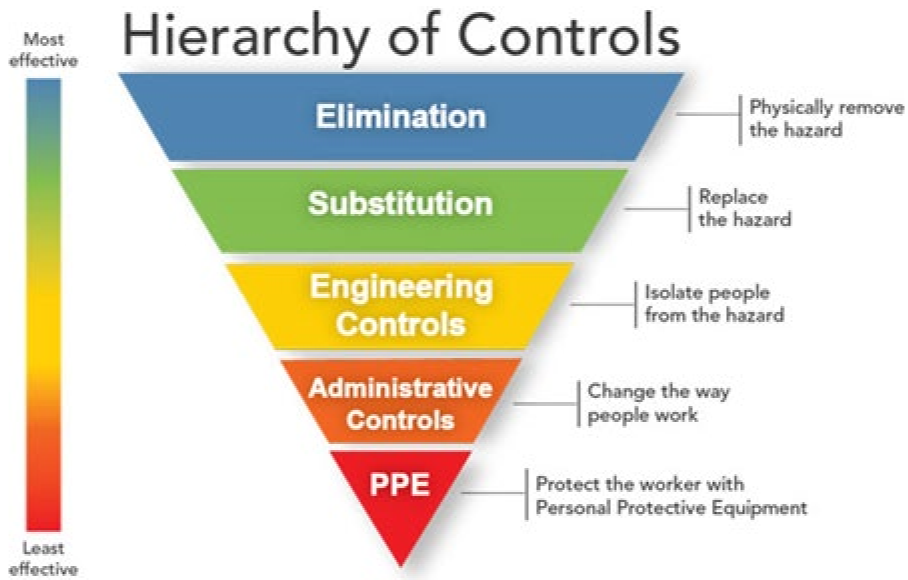
Even though the plan is now in place, there are plenty of details that should be pinned down well before the class starts.  The instructor must notify the students that a kit is necessary, and that they should be ordered in time for the exercise.  She might consider a mechanism to assess whether each student possesses the kit.  Instructions, and possible even videos, need to be produced to help scaffold the student experience.  Dr. Roebling is sure that even more details will emerge once the course starts up.

This approach now provides Dr. Roebling with the basis for a solid lab experience in Civil Engineering 101.  Is it the same experience it used to be?  Perhaps not, but perhaps some of her learning objectives would be more effectively met than they were before.  By using pre-lab workshops to have her students design an experiment to assess whether the beam bending matched predictions, she could help her students understand modelling approaches better.  Perhaps she could even follow up the lab exercise with personal trips to the construction site, which she could video and share with the students, or develop a next exercise on how the properties uncovered in the beam-bending experiment would be incorporated into the construction of larger structures, like roads and bridges.  Perhaps she encountered important learning objectives in her usual labs that just could not be met in the Fall 2020 world, and she could start having discussions with her department on strategies to get these objectives taught in future courses for this particular student cohort.  In any case, there are features of Dr. Roebling's updated lab plans that she likes very much and will very likely leave them in future course offerings.


1. Feisel, Lyle D., and Albert J. Rosa. "The role of the laboratory in undergraduate engineering education." *Journal of engineering Education* 94.1 (2005): 121-130.

## Hierarchy of Controls

For socially distanced face-to-face learning, relatively little is available in the way of guidelines or examples of best practices. However, the task force proposes adoption of a modified "Hierarchy of Controls" (HoC) approach (modeled after NIOSH protection guidelines) to guide development for this case. An HOC attempts to reduce risk by considering different levels of controls (with higher levels being more favored). The figure below (copied from the CDC website) shows an HoC.




Assume that an activity has been chosen for face-to-face delivery. The HoC concept can be applied to design-in social-distancing as follows:

- **Elimination**. Can the required content be delivered in some other way?
    - If an activity has already been prioritized for face-to-face delivery, elimination will generally not be an attractive option.
    - If the required content is not essential to achieving the learning objectives for the course, elimination should still be considered for activities which fall into category 3 (no acceptable online option) because of the administrative problems they present (unable to deliver the content to the online portion of the class).
- **Substitution.** Is there an alternative face-to-face activity that can be used to deliver the same key content with less difficulty social-distancing? As examples:
    - Redesign of a complex experiment, which requires close cooperation among several students, so that a single student can perform the required manipulations.
    - Refocus of a large creative project from synchronous to asynchronous cooperation (each student building constructively on the previous students' work).
    - Reweighting of the project choices presented to students so that they favor use of media/materials which are disposable and/or can be more easily fabricated remotely.
- **Engineering Controls**. Are there physical barriers that can be used to improve social distancing? As examples:

    - Plexiglass sheeting used to separate an interviewer from interviewees.
    - Relocation of equipment used by different students during a laboratory to multiple rooms.
    - Use of video cameras to allow one student in a team to interact directly with the test apparatus while the others participate remotely.
- **Administrative Controls**. Can laboratory rules and protocols be changed to improve social distancing? As examples:
    - Staggered start and dismissal times (e.g. five minute intervals) so that students do not assemble and enter the studio/lab in a single large group.
    - Prepositioning of required materials at student work spaces (or delivery of the materials by a TA) to avoid students gathering at a common distribution point.
    - Detailed scheduling of open lab/studio time for projects to limit the number of students working at any one time.
- **PPE.** Is additional personal protective equipment (face shields, gloves, etc.) necessary?

While controls higher in the hierarchy are generally preferred (e.g. engineering controls > administrative controls) in practice combinations of measures at different levels are likely to be necessary.

## Recorded sessions

Working with online students in a Hyflex environment will very likely require making use of recorded sessions. For reference, please keep in mind the following policies/best-practices, which are currently in use. [Subject to modification but, we believe, likely to remain essentially intact for the fall semester.]

1. **Mandatory Recording of Course Sessions -** All synchronous Zoom or other video-based sessions summer courses, regardless of size, must be recorded and uploaded for student use. The required recording guidance applies only to the course itself (class, recitation and discussion sections, labs, PLTL Workshops, etc.), not optional supplementary sessions such as drop-in office hours. For tutorials on how to record in Zoom and upload into Panopto, please see the following video tutorials: AS&E tutorials and Central IT tutorials.
2. **Recording of Office Hours –** Recording of office hours is not encouraged due to student privacy concerns. Instead, instructors can provide written summaries of common questions asked during office hours when useful for other students.
3. **Use of Panopto for Uploading** . Always use the Panopto tool when uploading video to Blackboard, as loading recordings directly into Blackboard itself can tax the system. Panopto also automatically captions recordings for accessibility.
4. **Student Notification of Recording.** University counsel has issued guidance that instructors should notify students that synchronous Zoom sessions are being recorded using one or more of the following methods:
    1. Syllabus statement (sample: "Please note, all online classes will be recorded.")
    2. Verbal statement at outset of first several class sessions
    3. One-time email to all students
       For students with privacy concerns, Zoom permits students to turn off their cameras and/or mute as needed. (See section above on student engagement for key points when considering prohibiting students from doing this.)
5. **Deletion of Video Recordings** - video recordings may be discarded only once every student in the course has a resolved final grade, including the final resolution of all N and I grades.

   The intent of the recording policy is to ensure that students have the ability to complete their coursework when they experience disruptions in their learning conditions. Instructors needing greater flexibility around recording core course sections must do the following:

- Provide equivalent asynchronous learning opportunities for students if lectures or other class activities will not be recorded
- Ensure that those equivalent asynchronous learning opportunities meet credit hour regulations
- Ensure that those equivalent asynchronous learning opportunities meet accessibility standards per notification letters for required accommodations for specific enrolled students
- Receive approval of their plans from their department chair or direct supervisor