Moving STEM courses online

This living compilation of recommendations of particular relevance to STEM courses is the result of contributions and editing from many STEM faculty development community members, including J. Caulkins, T.-K. Francis, T. Litzinger, B. Meuris, M. Samuels, L. Tomaswick, E. Whitteck, K. Yasuhara, J. Morelock, D. May, and other members of the POD STEM SIG.

★ Material of particular relevance in STEM courses is starred.

As with most matters teaching and learning, these are “promising practices” and not “best practices,” because much depends on the instructor’s goals and context.

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Pre-course planning

- **Learning first:** Moving a STEM course online on short notice is challenging, but clear prioritization of learning outcomes and informed employment of technologies will help you be successful and efficient in providing your students with a high-quality educational experience. With the overhead of new tools and methods, it is especially critical to articulate clear, specific, measurable learning outcomes up front, in order to efficiently focus course prep and execution. Courses with lab or project components will require the most modification. Consider consulting with your local teaching and learning experts. At UGA, these include:
    - The Engineering Education Transformations Institute, including:

        - **John Morelock**, Associate Director for Educational Innovation and Impact, with expertise in a wide range of topics around teaching and learning (john.morelock@uga.edu)
        - **Dominik May**, Assistant Professor of Engineering Education, with expertise in online learning and especially online labs (Dominik.May@uga.edu)
    - UGA's Center for Teaching and Learning, including:
        - **Philip Bishop**, Senior Coordinator of Learning Technology, with expertise in leveraging eLC for learning (philip.bishop@uga.edu)
        - **Alice Hunt,** Assistant Director for Instructional Development, who can help connect you with appropriate CTL personnel for your needs (ahunt@uga.edu)
        - **Zoe Morris**, Assistant Director for TA Development and Recognition, with expertise in effectively leveraging teaching assistants in a variety of course contexts (zoe.morris@uga.edu)
- **Technology:** Focusing on your course's most important components, select the tools you intend to use for class sessions, student interaction, and collaboration. Consider each tool's level of institutional support, in terms of cost and technical assistance. Allocating time to test and practice with your hardware and software will almost certainly save you time and trouble. Alternatives for technologies are included later in the document according to the type of classroom environment they support.
    - The CTL offers excellent resources for how to use eLC to set up online course modules. Their library of tutorials and documentation can be found here: https://help.elc.uga.edu/faculty/
    - Several educational technology companies (including some textbook publishers) are making their services available for free for the Spring 2020 semester due to Coronavirus. This page documents many of them and includes relevant links: https://thejournal.com/Articles/2020/03/13/Free-Resources-Ed-Tech-Companies-Step-Up-During-Coronavirus-Outbreak.aspx?Page=1
- **Know your students**
    - ★ Especially if recent offerings of prerequisite courses have been disrupted, be ready to assess students' background knowledge and skills. Consider building a diagnostic quiz by selecting relevant questions from prerequisite courses' exams. Then, administer the quiz with nominal credit or credit for completion, presenting it as a way for you and your students to identify weaknesses that require review early in the term.
    - Poll your students to learn about their access to technology, needs, and concerns around online learning. Find out what computing (hardware, software) and network capabilities (bandwidth, reliability) they have readily available at home or wherever they can safely participate in course activities online. Find out what they normally use for communication (e.g., e-mail, eLC announcements). (example poll from D. Glabau, NYU Engineering)
    - Don't assume students are on email all the time—or at all. As early as possible, explicitly establish a shared expectation about when and where students should check for announcements or other communications.

- ★ **Your team:** Work with your TAs to clarify roles and communication expectations. Find out who has expertise with the tools you intend to use, and have them engage in training and practice, as needed. Share relevant suggestions from this document with your team.

Instruction

- **Ensure students are set up to receive course notifications**. In ELC, you can send this page to students with instructions to set up daily summaries and email notifications: https://help.elc.uga.edu/getting-started/my-home-page/setting-up-notifications/
- For synchronous teaching (i.e., instructor(s) and students simultaneously online at the assigned class time), consider web conferencing tools like Zoom, which has interaction features like virtual hand-raising, breakouts for small-group discussion, and polling. MIT gave out a short guideline for better online meetings: https://www.media.mit.edu/posts/a-few-simple-tips-for-better-online-meetings-covid-19-edition/
    - You can still use tools like PollEverywhere for in-class formative assessment. Recording your class sessions will allow students to review.
    - For large courses, make sure your web conferencing license can accommodate your course, or consider asynchronous alternatives, like posting a recorded lecture (details below).
    - If you are new to administering web conferencing, have a TA who is more familiar with the tool share the host role, allowing you to focus on engaging students, while they attend to technical details like polls, breakouts, muting students, and fielding questions over typed chat.
    - Remember that not all students may be able to attend at the designated course class times during disruptions to on-campus teaching (e.g., they may be in different timezones, or sick, or experiencing family emergencies, or have limited internet access.) Accordingly, consider recording your live lectures and posting them later. You can record via Zoom.
    - ★ If your normal mode of teaching is writing on a board and are switching to slides, be aware of the tendency to present material too quickly (e.g., derivations, proofs, problem-solving process).
        - Be especially careful to include frequent points of engaging students and assessing understanding.
        - Establish a convention for students to signal to you that they want you to slow down. (Zoom supports this.)
        - If you have a tablet, explore the possibility of presenting live writing that way, but be aware that most people's handwriting is worse on a tablet than on paper. Take special care with mathematical symbols.
- For asynchronous teaching, record lectures using tools like Panopto and Camtasia.
    - PowerPoint (at least the Office365 version) also has a recording feature that records your face, slides, audio, and any annotations you make to your slides during the recorded presentation (e.g., writing through a stylus), and allows you to export the recording to a slideshow presentation format or MP4. See here for instructions.
    - Consider short quizzes on each lecture to help students hold themselves accountable for keeping up with course content.
- Whether synchronous or asynchronous, avoid long periods of non-interactive lecture.
    - Interweave active engagement and comprehension checkpoints to help ensure students understand and retain what you are teaching.

    - Engage students in practice problems, low/no-stakes quizzes, etc., to help them assess their understanding and readiness for the next segment of lecture.
    - Utilize interactive features like virtual hand-raising, breakouts for small-group discussion, and polling, all of which are supported in Zoom.
        - Alternatively, you can use an independent tool like PollEverywhere alongside web conferencing.
    - Don't forget the most basic online tool for instruction: email. (see: https://homonym.ca/published/online-teaching-with-the-most-basic-of-tools-email/)
- **Caption your class sessions** (e.g., with Google Slides' captioning, a web-based tool like Web Captioner, or Kaltura via eLC). (Zoom cloud recordings also provide a transcript, but quality depends on source audio.) There are many reasons why students might have trouble hearing the audio portion of live/recorded video, and students for whom English is a second language will also benefit. Test automated captioning for quality before teaching, especially if you are using a lot of technical vocabulary.
- Seek out online lectures that can supplement your instruction, providing students with additional perspectives on course topics (e.g., chemical engineering, chemistry, ecology & environmental science, geoscience, psychology, STEM via the National Science Digital Library).
- Don't forget to hold office hours, which can also be via web conferencing.
- In terms of additional tools, Google just announced that they offer their G Suite for education for free until July 1st. This includes Google Hangouts (for video conferencing) and Google Classrooms (for online classes) (see: Google News)

★ Labs and Simulations

- Begin by identifying the top-priority learning outcomes for the lab assignment.
- As with in-person labs, consider assigning pre-lab readings/exercises with an online quiz to ensure students are appropriately prepared for lab.
- UGA Engineering students have access to all software on computer labs via MyLab (http://mylab.engr.uga.edu/). If students are off-campus, they must access MyLab via UGA's VPN to simulate an on-campus internet connection (https://eits.uga.edu/access_and_security/infosec/tools/vpn/)
    - UGA CENGR has also enabled virtual access to some on-campus lab computers. Students can access this feature through MyLab. Contact Forrest Bridges (fbridges@uga.edu) for more information.
- For labs where the priority learning outcomes concern experimental design, consider giving students a research question to pursue and having them formulate a corresponding experimental procedure (or critique/augment/correct a provided draft) (source: Harvard). Educators at Arizona State are considering following this up by having a TA carry out the student-authored procedure, with students watching via web conferencing, and providing students with the collected data. This parallels industry practice in chemical engineering, where different people are responsible for designing an experiment and operating equipment (source: J. Schoepf), as well as how experiments on the International Space Station are done (source: M-I. Carnasciali).

- For labs where the priority learning outcomes concern experimental procedure, your options include video, virtual, and DIY labs.
    - Provide **demo video of the lab procedure** with detailed explanations. Consider a live webcast showing execution of the procedure, interleaved with questions and other engagement and assessment activities.
    - Explore whether your lab can be done **online**
        - Refer to this catalog of options (source: L. Tomaswick, Kent State).
        - For physics, chemistry, and engineering focused labs, LabsLand has many **remote labs,** meant to simulate in-lab equipment for a variety of subjects. It is subscription-based, but they are offering free subscriptions until Summer 2020 for universities affected by COVID-19. (Contact dominik.may@uga.com for further details.)
        - Labster also offers 130+ **virtual lab** opportunities in the STEM fields, based on simulations. We do have preliminary experiences with that option at UGA and students liked the level of interactivity (Contact dominik.may@uga.com for further details.)
    - For labs with simpler equipment and procedural requirements, consider adapting them so that students can conduct them at home. This might require that some equipment and materials be shipped to students. Appropriate lab kits might even be available commercially.
- For labs where the primary learning outcomes are about analyzing/interpreting data and integrating theory, consider providing data (e.g., as generated in a previous course offering) and refocusing the assignment to analysis and reporting.

★ Projects

- Many components of projects/capstones can be shifted online via web conferencing, collaborative authoring tools (e.g., Google Docs/Sheets/Slides), and tools for recording and publishing audio and video recordings. These components include client and mentor meetings, proposals/pitches, virtual poster galleries, design, evaluation/test plans, reflection on learning, and online portfolios of design artifacts and other project documents.
- Hands-on design and fabrication are more likely to require rethinking. As with experimental labs, some of these activities can be adapted so that students can conduct them at home. This might require that some equipment and materials be shipped to students. For some project domains, the focus could shift to mock-ups and low-fidelity prototyping with widely available craft materials (e.g., cardboard, clay) or illustrations (e.g., drawings, SketchUp 3-D models).

Quizzes and Exams

- Provide multiple opportunities for both you and your students to check whether they are meeting expected learning outcomes. Consider frequent low-stakes or no-credit quizzes, in and out of class time.

- Early in the course (or during the shift to online), have students complete a no-credit practice exam/quiz that involves all of the question types and exam-taking mechanics you intend to employ later in the quarter. This gives both you and your students a chance to notice and adapt to exam design/administration problems.
- Be especially careful about exam length, erring on the side of giving students more time, especially while they are less accustomed to online exam-taking mechanics. Even when the exam tool and format are familiar to students, network outages can disrupt exams.
- During the exam, make yourself available for questions and have a communication channel for broadcasting clarifications/corrections (e.g., Zoom).
- Consider measures to disincentivize and prevent the simplest forms of cheating. Find out if your institution supports relevant tools or services for online exams.
    - **Accept that the exam will effectively be open-resources (textbook, notes, web) and design questions accordingly.**
        - eLC does have a lockdown browser, but it can cause technical glitches that often require IT intervention to resolve, and UGA's CTL recommends using it (and other online proctoring services) only as a last resort.
    - Consider a larger number of shorter, more focused mini-exams/quizzes, vs. one or two high-stakes exams, to reduce student stress and provide both you and students with more frequent measures of their standing in the course. This also moderates the effects of unexpected exam design/administration problems (e.g., network outages).
    - Avoid grading schemes like curving that can pit students against each other and allow a small number of bad actors to negatively impact the grades of ethical students.
    - As prep time permits, use a tool like eLC quizzes that supports randomized question variation (e.g., response choice order for multiple choice, question pools).
    - Consider having students pledge adherence to an honor code. Even if your institution does not have an honor code, you could formulate one for your course. Note that research recommends an honor code that is formal and detailed and references consequences of code violation (Gurung, Wilhelm & Filz, 2012).

See Also

- DePaul University's D. Stanford's meta-resource: http://bit.ly/rtresourcelist
- Indiana University's "Get Started" guide
- Northern Virginia Community College's B. Bayraktar's meta-resource: https://tinyurl.com/PivotOnline
- Universal Design for Learning for distance: https://www.washington.edu/doit/programs/center-universal-design-education/resources-and-training]
- https://onlinelearningconsortium.org/
- https://topr.online.ucf.edu/pedagogical-practice/

Sources

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- Chronicle of Higher Education (article collection)
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- University of Wisconsin-Madison
  - https://assessment.provost.wisc.edu/student-learning-outcomes/writing-student-learning-outcomes/
- POD Network open discussion group
- https://docs.google.com/document/d/1y4mHF4rBMlUGxKZ9XxPHiMTDAKMJuB-osSiUQYjUBGQ/edit#heading=h.msf2rxuriaj0 (Michelle Francl, Bryn Mawr)

Relevant Literature

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