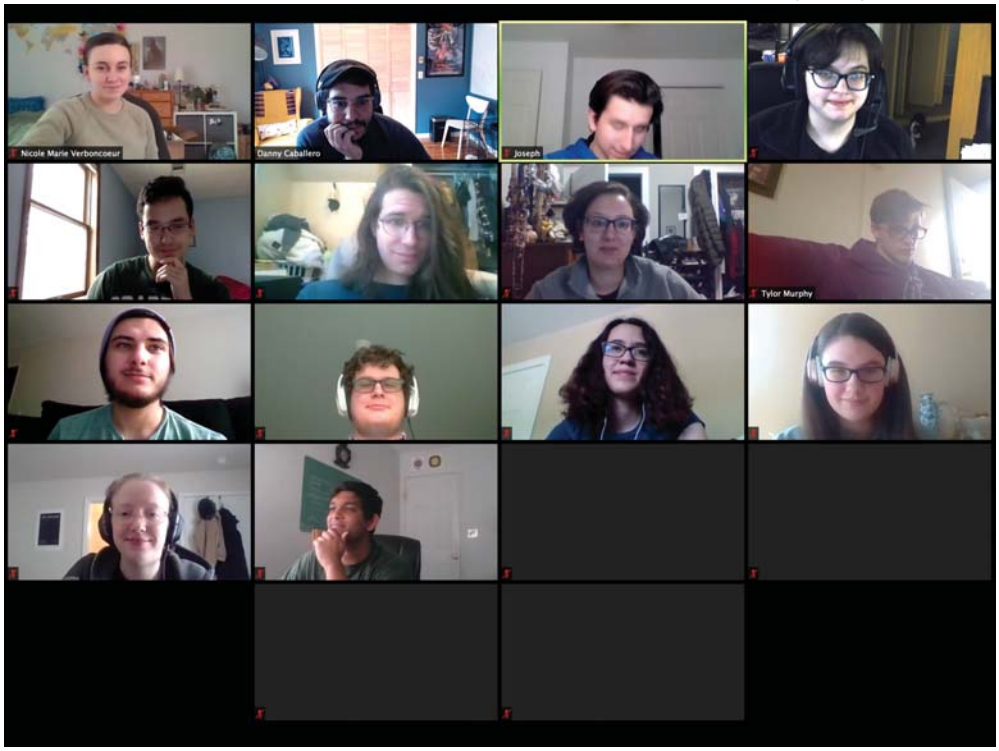
Universities overcome bumps in transition to online teaching

Instructors grapple with how to administer exams that meaningfully assess students, suppress cheating, minimize anxiety, and preserve privacy.

DANNY CABALLERO



STUDENTS IN DANNY CABALLERO'S UPPER-DIVISION electricity and magnetism class tune in via Zoom.

Teachers at universities worldwide are catching their breath as the first term in mass online teaching wraps up. The shuttering of campuses when social distancing was implemented to slow the spread of COVID-19 set off a scramble to deliver college education remotely. Faculty had to move their courses online, work from home, and engage students who had varying external distractions and uneven internet access. The difficulties of the transition—including the thorny issue of exams—cut across all subjects, but huge introductory classes and laboratory instruction pose particular challenges in physics.

"Our goal was to provide all components of instruction, even while satisfying constraints and accommodating students who have challenges at home," says Brian DeMarco, associate head for undergraduate programs in physics at the University of Illinois at Urbana-Champaign. Courses that serve engineers still have to meet the certification requirements for engineering, he says, and in the US all courses must comply with FERPA, the federal Family Educational Rights and Privacy Act. For example, graded assignments have to be returned to students via secure systems, not by email; and students cannot be identified in publicly accessible videos.

"Students and faculty had the rug pulled out from under them," says Vernita Gordon, who took on a coordinating role for remote teaching in the University of Texas at Austin physics department. Like many professors, she is also caring for her children, whose school is closed due to the pandemic. And faculty also have to deal with overtaxed Wi-Fi bandwidth: Another instructor in Austin recounted how he had lectured live to a dead connection; when he got back online he had to repeat 10 minutes of his lecture. "Everyone is doing their best," says Gordon. "But it's much harder for students to learn, and it's much harder to know what they have learned."

Many physics departments were already at varying stages of putting parts of courses online before the COVID-19 outbreak. Chris Waltham chairs undergraduate studies in the University of British Columbia's physics department. "We had all of the tools in place," he says. "I've been amazed at how seamless the transition has been." Still, he says, one concern is low attendance, "although most of the class appears out of the woodwork for quizzes."

A mad scramble

Faculty members were generally given great leeway for how they transitioned to online teaching. Decisions about live versus recorded lectures, video platforms, how to run labs, and how to administer exams were largely left to individuals or team-teaching cohorts. Instructors submitted their teaching plans to university administrators. Many universities provided training in Zoom or other online platforms, and some physics departments have employed in-house technical help. Some institutions ponied up for electronic writing pads, document cameras, and other tools that teachers need for makeshift distance instruction.

"We had to figure out how to use webcams and microphones—anything we could get our hands on to start recording lectures at home," says Michael Dubson, associate chair of physics for undergraduate studies at the University of Colorado Boulder. "It was bumpy, but my colleagues and I stayed in touch and we all got things to work."

Approaches to distance teaching vary

by instructor style, class size and level, and student needs. "The way people have presented material in class may or may not translate well to the online context," says Gordon. Before the COVID-19 outbreak, her honors physics class for nonmajors was very interactive: "We would break into small groups, and a TA and I would circulate and talk to them," she says. "We can replicate that format to some degree on Zoom, but it's not the same. I feel the loss of the personal interactions pretty strongly."

Many instructors complain that breakout rooms on video-conferencing platforms hamper interactions both among students and between students and instructors. Physicist Carl Wieman of Stanford University says that getting comfortable with online teaching requires a "learning curve," but that if breakout rooms are used in groups of just a few students who have clear instructions and goals "there can be a lot of interaction." In fact, he says, for large classes the interaction could be better than in-person.

At Georgia Tech, the guiding principle has been to stick as closely as possible to the original course, says Edwin Greco, the lead instructor for a calculus-based introductory physics course with about 900 students. He and his colleagues have chosen to continue delivering their lectures at the scheduled time. They later upload videos of their lectures to allow students who are home in faraway time zones, encounter failures in internet connectivity, or have other conflicts to keep up with class on their own schedules.

During in-person lectures, says Greco, the instructor would pose a question every 10 minutes or so. The students would discuss the question with their neighbors for a few minutes and then submit their answers. "If most of them get the right answer, I move on," says Greco. "If not, I adjust the live lecture." That doesn't work as well online: Student discussion is harder to facilitate and web-based interactions are much slower. In person, he adds, "you can tell if someone is paying attention, but that's hard to do virtually."

Other instructors chose to teach asynchronously, sometimes in a flipped mode, with students watching lectures before attending virtual discussions. Some instructors, including Dubson, embed questions in their video lectures such that students can't continue until they commit to an answer. "This allows us to require that they think," he says.

Danny Caballero at Michigan State University is teaching a senior-level electricity and magnetism (E&M) class with 24 students. The class is small enough for him to stay in touch with his students, and his main aim is that they demonstrate understanding of the material. After in-person collaborations ceased, he had the students write and solve quizzes and review each other's work. Logistically, he says, the transition has been easy for him.

For many students, though, the transition has been tough, Caballero says. "They are taking three, four, or five classes online. They have varying financial situations—they have lost their campus jobs, it's not clear they all have food security." Anxiety among students is a big issue, he says. "Some are isolated, some are depressed."

JOEL FAJANS SOLDERS COMPONENTS for kits with microcontrollers, resistors, and other circuit parts for an advanced laboratory class at the University of California, Berkeley. Fajans delivered the kits to his 55 students, who had scattered over three continents when COVID-19 shuttered the university. From home, the students built amplifiers and measured and analyzed noise to obtain Boltzmann's constant.

Hands-off experiments

For most North American campuses, the term was at least half over when the lockdowns began. In lab courses, students had generally performed half or more of the experiments. Douglas Bonn had the roughly 100 students in his second-year lab course at UBC shift their emphasis to communications skills and writing.

In other classes, students switched to simulations, such as the free, interactive PhET experiments developed at CU Boulder in the early 2000s. The experiments in physics explore pendulums, Snell's law, gas density, circuit construction, and more; the full library includes simulation experiments in math, biology, chemistry, and Earth science.

At Illinois, teaching assistants went to the physics building to perform experiments in real time with undergraduates, who could partially run the measurements via Zoom. Another option is for students to do experiments from home with a smart phone or an iOLab, a smart phone–sized device that faculty at Illinois developed a few years ago, with built-in sensors that measure force, pressure, temperature, and other quantities. The pandemic has made the iOLab so popular that the manufacturer, Macmillan Learning, may not be able to keep up with demand, says Dubson. For some courses, instructors have created kits for students to perform experiments at home.

Many upper-division lab classes, however, require that students "get their hands on the equipment," says Bonn. "That's an interesting challenge, and we may delay those courses."

Assessment, cheating, and stress

Exams, especially at the introductory level, are perhaps the trickiest and most controversial aspect of the move to remote teaching. Disagreements over how to handle them have strained relations in some departments. "How can we be equitable to students? How do you avoid biasing against those who don't have good internet access?" says a state-university physics professor who did not want to be identified. "It boils down to the balance between suppressing cheating and meaningfully evaluating students." The

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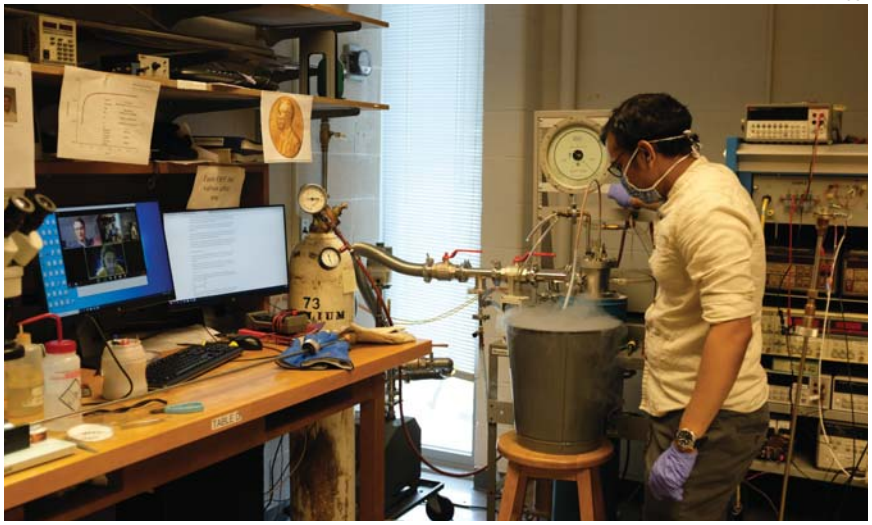

PHYSICS GRADUATE STUDENT SHUBHANG GOSWAMI measures superconductivity in thin films. The experiment is part of a senior-level lab course at the University of Illinois at Urbana-Champaign. Undergraduates participate remotely and can partially control the measurements.

decisions are "heartbreaking," says the professor. "I have grave doubts that we are on the right path."

In the large freshman E&M class Dubson team-teaches at CU Boulder, the third exam of the semester was administered online, with no security measures. "We have bits of evidence that significant cheating was going on," he says. For the final exam, Dubson and his colleagues considered several options. One was proctoring software. But between students saying they lacked webcams and known problems with the software, the instructors nixed the idea. They considered giving students varying selections from a large bank of questions. "That approach is probably the most fair and least stressful for students," says Dubson. "But it's very time consuming for the faculty to put together."

In the end, Dubson's team went with a format in which students submit the answer to one problem before they can see the next one, and they can't revisit problems. The order of questions was randomized, says Dubson. "That makes it nearly impossible for students to collaborate during an exam, but it does not prevent a student from hiring an impostor to take an exam in their place." The approach is unpopular with both students and faculty, he says. "No one regards this as a reasonable test-taking environment. Students can't ponder questions and budget their time. It increases the stress on students. But most students accept the need for some exam security measures."

The University of Illinois at Urbana-Champaign has contracted with an online proctoring company, but the physics faculty have decided not to use it, says Timothy Stelzer, a high-energy theorist who is team-teaching introductory calculus-based E&M for engineers. The class has 600 students. "We didn't want to invade privacy," he says. "I'm not convinced that proctoring solves the problem [of cheating], and it adds a lot of stress." The instructors extended the time for the final exam from 90 to 120 minutes to accommodate slow internet connections, and they offered the exam at different times. In addition, the first question requires students to agree to an honor code; only then can they see the actual test.

UT Austin's Gordon also included an oath of honor. And she opted for proctoring software that locks browsers, records clicks, and uses artificial intelligence to monitor student movements. "It's the best in a set of unsatisfactory solutions," she says. After using the software for a midterm exam, it seemed "much less invasive than I feared," she says. She watches the students via webcam only if the software identifies suspicious behavior.

The exam issue is thorniest for lower-division courses. At higher levels, classes are smaller, and faculty are more comfortable assessing students with open-book exams or projects.

But Wieman says open-book exams can work at all levels. They allow for more meaningful questions and are better tests

of realistic problem-solving capability, he says. At Stanford, where many of his colleagues are choosing the open-book route, exams turn into a learning experience "with far less artificial hoop-jumping and guessing at instructors' idiosyncrasies," he says.

Many universities have adjusted their policies on course withdrawal and grades. "A lot of students come in well-prepared," Stelzer says. "But there is a population for whom that is not true, and that tends to be the same people who don't have access to the internet and have a harder situation at home—sharing computers, occupying cramped spaces, or taking on extra family responsibilities." To accommodate such inequities, and to be sympathetic, he says, many instructors have loosened deadlines for labs and quizzes. And most universities have extended the deadlines for dropping classes to just before—or even after—final exams.

Many universities have ditched grades this term in favor of pass/fail. A few, such as Georgia Tech, have retained grades, despite student complaints. And many institutions are giving students the choice of either a grade or a pass/fail. At UBC, the science dean issued a rare decree requiring faculty to calculate grades with two different weightings for the final exam—30% and 5%; students will receive the better grade. Or they can opt for pass/fail. In late March, the American Physical Society sent a letter to department heads urging their graduate admissions committees to treat this term's grades "holistically."

Overall, the wholesale transition to remote teaching created a mad scramble and a lot of improvisation. But many faculty say they've learned things they'll take forward for future online teaching and for when in-person classes resume. Jonathan Wurtele of the University of California, Berkeley, notes that his campus occasionally closes due to smoke from nearby fires. "We will put the knowledge of remote teaching to use in the future," he says. Similarly, Karen Daniels of North Carolina State University says she'd be comfortable teaching remotely for a day or so if she leaves town to attend a conference. But, she says, "even if we have found replacements for all the parts of a normal face-to-face class, it's not the same. We are not delivering what we need to."

Online office hours, for which students choose a time slot for a video conference, could continue to work well especially for commuter students, according to several instructors. Many professors found that students were good at helping each other in the text chat boxes in video-conferencing software, and they hope to incorporate that type of help in their in-person courses. Andrew Loveridge of UT Austin notes that with the transition to remote teaching, "we are forced to think about every part of our courses. Nothing will survive on its own inertia."

Toni Feder

COVID-19 pandemic modeling is fraught with uncertainties

Policymakers face a plethora of predictions on how the disease will proceed and when it might resurge.

A self-described optimist, Pinar Keskinocak doesn't like to be the bearer of bad news. But the model she co-developed at Georgia Tech of the COVID-19 pandemic in that state paints a "really bleak" picture of what lies ahead when physical distancing slowly erodes after shelter-in-place and stay-at-home orders end.

The model, which forecasts the outbreak in Georgia at the census tract level—county subdivisions that average 4000 inhabitants—shows that even if lockdowns had been extended through mid-May instead of being lifted 1 May, the rate of new infections would come roaring back once people returned to their daily routines.

Georgia was one of the first states to end shelter-in-place orders and permit some businesses to reopen. Although continued adherence to social distancing guidelines will tamp down the state's peak numbers of new infections, even strict compliance—including the voluntary quarantining of all persons in households where only one member is infected—won't prevent the outbreak from surging to levels far higher than those yet experienced. The real peak of new cases in Georgia, says the model, is predicted to come in June or July (see graphs on pages 26 and 27) and potentially overwhelm healthcare facilities in some parts of the state.

The Georgia Tech model's findings, which were shared with state government officials—Keskinocak won't say exactly whom—before governor Brian Kemp's decision to lift stay-at-home restrictions, presented a different portrait of the pandemic from the widely reported modeling results coming from the University of Washington's Institute for Health Metrics and Evaluation. Until 26 April, after which it was significantly revamped, the IHME model had predicted that the peak daily death toll from COVID-19 in Georgia had already passed, even before the mid-April zenith it had forecast for the nationwide death rate. On 3 May, a new, hybrid version of the IHME model was projecting that daily deaths in Georgia would peak on 30 May, well after the forecasted 1 May peak in daily US deaths.

Another model, developed at Los Alamos National Laboratory (LANL), reported with 96% confidence as of 3 May that the daily rate of new cases in Georgia has peaked. Although LANL's model doesn't explicitly include the effects of interventions such as sheltering in place and social distancing, it assumes that some social distancing measures will continue through the forecast period. LANL modeler Dave Osthus says the model won't be adjusted to account for the ending of lockdowns because the extent to which people will actually change their behavior is unknown.

Many other models forecast new infections and deaths at the international, national, and state levels. The Centers for Disease Control and Prevention (CDC) regularly compiles on its website the forecasts of nine COVID-19 models, including LANL's. Some show the rate of new deaths slowing nationally; others show daily fatality numbers remaining flat. Most of the included models assume the continuance of the social distancing policies that were in place on the date of model calibration. A few make no such assumptions.

The unknowns about the disease and its transmission produce large error bars