UC SANTA BARBARA

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Physics at Your Fingertips

For many of us work has gone digital, meetings virtual and Zoom is the way du jour. Yet, with schools and universities transitioning to distance learning, some classes are tricky to convert.

Hands-on experiences are essential for fostering critical observation skills in budding scientists, for example, which means science departments are particularly hard pressed to figure out how to offer lab courses during the pandemic.

UC Santa Barbara's physics department has devised an ingenious solution for one of its intermediate lab courses: remote control. The department has configured experimental setups to be operated entirely through an online portal. Students can run the exact same experiments they would in person, but from their own homes.

The department began exploring options for remote labs when instruction first went online during spring 2020. Professor Deborah Fygenson was in charge of the lower-division laboratory sequence taken by physics majors, which typically enrolls over 100 students every quarter.

"We considered switching to a data analysis focus — having students watch and crunch data from filmed or simulated experiments — but these don't cultivate an interactive, experimental mindset," she said. "And it's important for them to acquire these skills at this stage in their education."

She tried offering a course in which students proposed, executed and reported on a physical measurement they could perform on their own. "It worked pretty well for a

class size of 20," Fygenson said. "But it became clear to me that there was no way that was going to scale."

Then Zak Espley, the upper division course coordinator for the physics department's Instructional Laboratory Group (ILG), showed her a remote radioactivity lab that the University of Queensland had set up years earlier. "That was the 'Aha!' moment," Fygenson recalled. "The equipment we have is too expensive and sophisticated to send them, or expect them to acquire, but maybe it could be adapted for them to use from the other side of a screen."

This course is the final of a three-part series physics students take during their sophomore year. It introduces them to fundamental concepts and experiments in optics and quantum mechanics. "It's a unique lab course where there are only buttons and knobs to turn," Espley said. It was a perfect candidate.

Since the department already had the equipment, it needed only to configure it for remote operation and create an intuitive user interface. The conversion began serving 70 students during summer session B and is expected to serve hundreds more before COVID-19 restrictions are lifted. The department also hopes to extend access to the remote lab to less-equipped schools around the country during off-hours.

Fygenson stressed that this is not a simulation or computer model. "It's an actual experimental setup," she said. "These pieces of equipment are the ones the students would be working with if they were here in person."

Every button can be pushed, every knob turned, and every switch flicked — even those that aren't involved in the experiment. And with all the buttons and dials rendered on the online portal, the computer screen essentially becomes no more than a piece of glass between students and the apparatus sitting in a room on the third floor of Broida Hall.

Many of the equipment's physical controls could have been swapped out for digital switches, but the team felt it was important to retain the experience as it is in person. "We wanted the students to see the knobs rotating at their command so they know it's real," said Espley.

For lab courses, the experience is crucial. "We definitely don't want students thinking what they see is computer generated with a pre-programmed outcome,"

said Fygenson. “We want them to realize that they’re actually manipulating the equipment, and let them make all the mistakes they would have made in person.”

Well, nearly all. “We did place limits on where the motors can go and just how far the knobs can turn to avoid damaging the machines,” Fygenson added.

Remotely operated lab setups started cropping up in the early 2010s, but they didn’t catch on. Connecting equipment to the internet was more complicated and expensive, and Fygenson reckons students were simply less accustomed to web-based interfaces. “I suspect those institutions that could best afford remote set-ups back then were also the ones that could afford to give their students direct access to the equipment,” Fygenson said.

The pandemic has changed that equation, and technological advances in the past decade have dramatically improved the potential user experience. Webcams now provide a much better picture and micro-computers, like Raspberry Pi, have become affordable.

What’s more, 3D printing technology has become ubiquitous and cost effective, which has enabled custom manufacturing on small scales. “We couldn’t have done it at this speed and cost without the department’s 3D printer and the computer aided design skills of UCSB alumnus and ILG staff member Raffi Shirinian,” Fygenson said.

“Every setup has at least one 3D printed part on it somewhere,” Espley added.

The team believes the remotely accessible experiments will remain valuable even after the campus resumes in-person classes. “In person instruction is best, but remote-controlled apparatus has some advantages — like greater access,” said Fygenson. “This equipment can be available 24/7. So, say a student wants to go back and check or redo something. With this they can.”

“If, instead of playing video games or watching YouTube at 2 in the morning, they want to hop online and push for greater precision in their measurement of Planck’s constant” she added, “more power to them.”

About UC Santa Barbara

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of faculty, students, and staff is characterized by a culture of interdisciplinary collaboration that is responsive to the needs of our multicultural and global society. All of this takes place within a living and learning environment like no other, as we draw inspiration from the beauty and resources of our extraordinary location at the edge of the Pacific Ocean.