Inquiry-based labs give physics students experimental edge

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New Cornell University research shows that traditional physics labs, which strive to reinforce the concepts students learn in lecture courses, can actually have a negative impact on students. At the same time, nontraditional, inquiry-based labs that encourage experimentation can improve student performance and engagement without lowering exam scores.

"Typical physics lab courses are designed to help students see or observe the physics phenomena that we typically teach in a lecture course," said senior author Natasha Holmes, the Ann S. Bowers Assistant Professor in the College of Arts and Sciences at Cornell University. "In our previous work, we had this idea that these labs weren't effective. But we were pretty sure that we could restructure the labs to get students engaging and really learning what it means to do experimental physics."

The researchers created a controlled study in which students were divided into five lab sections for the same introductory, calculus-based physics course, focusing on mechanics and special relativity. Students in all five lab sections went to the same lectures and had identical problem sets, homework and exams. However, three lab sections followed the traditional model; the remaining two sessions were inquiry-based labs, with students making their own decisions about gathering and analyzing data.

"The students in the new labs are much more active," Holmes said. "They are talking to each other, making decisions, negotiating. Compared to the traditional lab, where everyone's really doing the same thing and just following instructions, we now have all of the students doing something completely different. They're starting to be creative."

The exam scores were the same for students in the traditional and inquiry-based labs. However, the traditional lab model negatively impacted student attitudes toward experimentation and failed to engage students with high-level scientific thinking, the researchers found.

Another telling distinction: Students in traditional labs completed their tasks as quickly as possible, often breezing through the instructions and finishing the two-hour session in 30 minutes, then leaving. Students in the inquiry-based labs tended to work for the full two hours.

"We think it's teaching them to have ownership over their experiments, and they're continuing to investigate," Holmes said. "We actually had trouble kicking them out of class—which I think is a pretty good problem to have."

Holmes believes the inquiry-based lab model is applicable to other disciplines, although physics has distinct advantages over chemistry or biology, where trial-and-error experimentation could result in wasted chemicals, materials and time.

The findings were published in a paper, "Direct Measurement of the Impact of Teaching Experimentation in Physics Labs," published Feb. 10 in *Physical Review X*.

More information: Direct Measurement of the Impact of Teaching Experimentation in Physics Labs, *Physical Review X* (2020). journals.aps.org/prx/abstract/ … 3/PhysRevX.10.011029

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