

**SEAN ROBINSON:** So we have a menu of about 20 experiments in the lab. Each student will do three or four over the course of a semester. New experiments come into lab every few years. They usually start with an idea, usually coming from a faculty member somewhere in the Department of Physics.

Sometimes, the idea for a new experiment is something that was in a research lab. Sometimes it's just something that's a classic technique which has, say, become a standard thing that the graduate students in a particular professor's lab have to do on a routine basis-- getting that into a mold that works within the structure of our semester, where students are typically spending about two weeks performing the experiment.

We want an experiment in this lab to be something which doesn't simply work when you turn it on. We want the students to have to cause it to work. We don't want people to simply turn the apparatus on and get data. We want them to cause the apparatus to give good data.

That usually means there's something they have to calibrate. It usually means there's lots of settings on various parts of the apparatus, which some of the settings give bad data and some of the settings give good data. And the students constantly have to be going back and forth between some preliminary analysis and data taking in order to evaluate whether or not the data they've collected is good, whether the settings they've set on their apparatus are any good.

Getting a piece of apparatus, which has been designed by a faculty member, as a beautiful piece of research apparatus which works in a reliable way, in the hands of an expert, and getting into something which a student, who is seeing it for the first time, can operate in a way where they have enough intellectual space on the apparatus that they can explore it, and understand how different parts of it work or don't work, and yet still have it be robust enough that it, say, doesn't break.

It will work consistently from one roughly two week period when a certain student group is working on it to when the next student group is working on it. That tends to be more of a design challenge. We get into a routine back and forth between the faculty member who's championing the experiment and the technical staff really understanding what parts of an experiment have to be changed.

And then, ultimately, someone has to write a manual for the experiment. There's a model

we've been using for the past few years where we get an experiment to the point where we think it's a pretty good piece of apparatus that a student will be able to learn a lot by performing it. Yet we still don't have any manual written for it, no instructions or anything. So if a new student were to just walk up to it at that point, it would be really a research project for them to get it working.

Within the structure of Junior Lab, we actually do have some room for that type of thing. And the second semester of Junior Lab, which is Subject 8.14, one of the experiments the students have to perform in the course of the semester is not simply something from our menu of roughly 20 experiments, but it's something they have to develop themselves.

They have to write a proposal, get that proposal approved by the funding committee, which is the staff in Junior Lab, and then, ultimately, perform that experiment, analyze the data, and then present it to their peers. We have a poster session that we close out the semester with in that course.

So something that has been useful for the past few years when we've developed a new experiment is we try to find one of these student groups in 8.14 who volunteers to perform that experiment without any guidance, without any manual. They run it through, basically, as beta testers, from our point of view, and tell us which things worked well, which things didn't work well.

And 100% of the time so far, when we've tried this, the students always discover something new that that apparatus can do, some new physics measurement that we didn't think of. And those new discoveries by the students who perform that the first time, without any guidance, inevitably, those become part of the manual that eventually future students use as the standard manual going forward.