SEAN ROBINSON: There's an exercise we do very early in the semester, where we hand out to the students a bunch of small aluminum cuboids. They're long rectangles, a few centimeters on each side. And then we hand them a very cheap plastic ruler, a $0.16 ruler from an office supply store.

The cubes are machined to very high precision to be identical to each other. The rulers are very inexpensive. And we have them-- we say, go measure the length, width, and height of this cuboid. Don't tell anybody what you measured. But just write down your best measurement, and your best estimate of the uncertainty on that measurement, and along with that, come up with a measure of the volume.

Maybe, you measure the volume, say, by multiplying x times y times z, and an estimate of the uncertainty on that. And everybody thinks this is a very silly exercise. It's so easy. This is something you would do in elementary school. Here we are in our third year as physics majors at MIT. Why are we wasting our time on this?

But if it's so easy, then when we flip around the white board and show everybody all each other's answers, if it's so easy, why are the answers all so different from each other? That is a big moment of cognitive dissonance for the students. And then we spend the next, say, 15 to 45 minutes, really, just having a very active discussion about, what did these error bars that you reported to us as your uncertainty on the volume, what does that really mean?

Why is this person's error bar so small? Why is this person's so large? Let's look at the spread between all of the different people's numbers and compare it to what you reported as uncertainty. Are these things consistent? Are these inconsistent?

For the instructor who's leading that discussion, that's somewhat of a challenge because he's about to see some numbers, and lead a discussion on it, which he's never seen before. Inevitably, all of our instructors get up to the plate and do a good job at that. But it's remarkable, how much comes from this very simple little exercise.

The students learn a lot about random errors, which are statistical errors, which are something you can learn from a mathematics book on statistics. You learn a lot about systematic errors, which are very, very difficult, and no one really has a good understanding of. But it all comes up in this very simple exercise that everybody learns a lot from.

In general, it's always a challenge for a teacher to run a group discussion and get the students to actually participate in that discussion, right? In general, that's always something that's tricky as a teacher. People want to sit back, and be quiet, and just hear what other people have to say. It's always a challenge.

For this exercise, which is usually done at the end of a three hour session where they've been measuring other things, and then you flip around the board and show them the list of numbers, people are surprised. This is something-- this is numbers they just measured. And they're surprised what they see that everybody else did. It is not hard at all to get people talking and really get them all participating in that conversation.