David Meltzer—Iowa State University

At Iowa State we're starting a new physics education group. We're going to be focusing on three separate areas, although they're very closely interlinked: (1) new instructional methods, (2) development of curriculum to support the new instructional methods, and (3) basic research to support both of those efforts. One of the advantages we have is that at Iowa State there has been for several years a very active chemistry education research group led by Tom Greenbowe. It is one of the very few in the country and we expect to have very close collaboration with them. We should obviously be able to promote some connections between physics and chemistry.

The instructional methods we are focusing on are related to large-enrollment classes where you have 100 or 200 people in the classroom. This is something that a number of others have already touched on. We're trying to find ways to make instruction in that kind of very difficult setting more effective, and we want to develop curriculum to support those instructional methods. We want to develop curriculum that is appropriate for use in that kind of environment and yet promote active learning, active participation by the students. We also want to carry out basic research in physics teaching and learning that will support both of those efforts of curriculum and instruction for large enrollment classes.

The main theme of the work on instructional methods is finding ways to increase student-faculty inter-activity in the classroom, and to increase interaction among the students themselves in the large-enrollment classrooms. One of the methods we use is the "El-Cheapo" response system [flash cards]. You're probably familiar with these flashcards. Every student in the classroom has a set of these cards and it's not as fancy as Classtalk, but it's very cheap and it's very easy to implement. We can ask very frequent questions during these lectures. A lot of questions, a lot of answers for multiple-choice forms of questions – and we get instantaneous response from all of the students in the class simultaneously. Of course when one is fortunate to enough to have the expensive response systems it's quite effective to use those, but one needs a lot curricular materials to implement this.

You need lots of questions that are appropriate for showing to students in these large lecture classes, and you may be familiar with Eric Mazur's book. Kandiah Mannivannan and I have been working on something called a "Workbook for Introductory Physics." Each topic starts out with many of these multiple choice questions which we pose in large lecture settings. But it also has sections of free-response exercises, which students actually work on at their desks, working in groups or pairs, and they spend a lot of time during class working through these materials. This is very similar to things that you're probably familiar with from Alan Van Heuvelen, and also some of Randy Knight's work. So we spend a large amount of time in these "Large-room Meetings," as Alan calls them, having students work through these curricular materials.

The basic research we're focusing on is in a couple of separate areas. One is to look more carefully at the difficulty students have with different forms of representation of physics concepts. What I mean by that is the different ways one can pose a physics concept or a physics problem. You can pose it just using words, or you can use mathematical symbols. You can use a pictorial diagram or vector diagrams. You can use graphical ways of transmitting information. Especially now that these multiple forms of representation are coming into much wider use in physics education, it may be very useful to look more carefully at whether the difficulties students have relates simply to the form of the representation, and whether or not one form of representation or another is more effective in teaching certain concepts. This is actually related to something Arnold Arons discussed about the linguistic difficulties that we may be introducing in the learning of physics concepts. There are similar types of difficulties that we may be inadvertently introducing simply by using representations that the students find particularly difficult or with which they're unfamiliar.

Another research problem we're working on is to look at the factors that underlie the variability in students' success in learning physics. In other words, in a large class you'll have students, many of whom will be starting at apparently the same position. Their scores on pretests may be exactly the same. Everything about them, as far as you can tell, is the same and yet at the end of the course some of them have learned a whole lot and some of them have learned practically nothing. Why is that? What are the factors that lie behind that? How can we get a grip on that and how can we hopefully intervene to become more effective instructors for all of the students in the course?