Revamping the Pedagogy in the Introductory Physics Courses at Stanford University

SPIN-UP Attendees:

Professor Patricia Burchat (Chair)

Professor Sarah Church

Dr. Chaya Nanavati (Physics Education Specialist)

Burchat and Church have taught in both the algebra- and calculus-based intro sequences. Nanavati assists the instructor and TAs in labs and discussion sections for all introductory physics courses and teaches one of the intro courses in the summer session.

The "REVAMP"

We are nearing the end of the third year of a three-year effort to improve the pedagogy in our three introductory physics sequences.

- Year 1 (07/08): Planning
- Year 2 (08/09): Implementation
- Year 3 (09/10): Refinement

What prompted the 'revamp'?

- Previous discussions/reviews focused on curriculum, not pedagogy.
- Few instructors and TAs using interactive techniques.
- Engagement of instructor with labs and discussion sections 'ad hoc' (and infrequent).
- "Cookbook" labs, often using ancient black-box equipment.
- Low attendance in many discussion sections.
- Students not satisfied by intro experience.

Year 1: Planning

- Committee of faculty, teaching staff, grad student.
- Surveyed students, TAs; ran faculty focus groups.
- Studied Physics Education Research literature.
- Assembled case studies of efforts at other institutions* and interviewed initiators of seven of these efforts:
    - resources invested?
    - results of assessment?
    - sustainability of effort?
- Described recommendations in a detailed report.
- Presented report to faculty for vote of support.
- Gathered financial resources.

* Case studies: Harvard, MIT, RPI, UIUC, U Maryland, U Oregon, UW

Year 2: Implementation

This was the toughest year. Implementing change can exposes problems you did not even know existed...

- Hired full-time Physics Education Specialist: essential!
- Invited four national figures in Physics Education Research to give workshops and/or seminars.*
- Continuously educate the students we are teaching on the purpose and goals of the techniques we are using.
- Train and continuously mentor the Teaching Assistants.
- Engaged volunteer School of Education graduate students with physics backgrounds and interests.

* Many thanks to Gary Gladding, Eric Mazur, Joe Redish and Carl Wieman for sharing their time and expertise during these visits.

Year 2: Implementation (continued)

- Implemented structural changes:
  - rooms for sections - location and acoustics matter;
  - furniture - small tables, movable chairs;
  - section sizes, scheduling - often run sections in parallel now, in adjacent rooms.
- Institutionalized weekly meetings between Chaya, TAs and instructor; engagement of instructor varies...
- Began revision of labs: predict → measure → explain.
- Introduced small-group problem solving in discussion sections.
- Continued to provide support for clickers in lecture.

Year 3: Refinement

- Use a variety of exercises in discussion sections: Tutorials, research-based simulations (PhETs), hands-on exercises, context-rich problems, old exam problems...
- Gather feedback from TAs after each discussion section. Gather frequent feedback from students.
- Use pre- and post-lab assessments to determine whether students are learning concepts.
- Enlist talented, motivated graduate students to mentor TAs, organize and facilitate small-group mid-quarter evaluations, etc.

Outcomes

- More faculty using interactive engagement in lectures: mostly clickers; Sarah Church uses JiTT; some use of PhETs (with clickers) in lecture.
- Graduate students engaged in discussions of pedagogy, teaching and learning!
- More use of undergraduate TAs -- sometimes very successfully.
- Higher attendance in discussion sections; growing appreciation of interactive discussion sections.
- Higher student satisfaction with laboratories.
- Some instructors and TAs now using interactive learning approaches in courses for physics majors and grad students.

Advice

- Ask for well-motivated (modest) institutional support:
  - Our Dean has welcomed the fact that we are asking for resources to improve student learning.
  - We emphasize that enrollments in the introductory physics courses are increasing. Currently, over one third of Stanford students take one of the introductory physics sequences.
- Talented, motivated graduate students are an incredible resource to leverage as teaching mentors and in developing or refining materials.
- Take advantage of efforts in other departments.

Other relevant changes at Stanford:

- BA in Teaching Physical Science - 2004.
- Engineering Physics Major - 2006.
- Minor in Education - 2009.

Information I would like...

- Is anyone using cell phones (+ online software) instead of clickers?
- Please let me know about any research or results on effect of interactive teaching for learning and retentions of under-represented groups in particular.