Adapting *Physics by Inquiry:* A Course for Non-science majors

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What is Physics by Inquiry?

- A physics curriculum developed at the University of Washington by the Physics Education Group (McDermott et al.)
- A guided-inquiry lab-based curriculum requiring only low-tech, inexpensive equipment.
- Emphasizes evidence-based reasoning and model development, as well as foundational skills such as proportional reasoning, constructing graphs, etc.

What is Physics by Inquiry?

- Curriculum divided into modules addressing topics such as Properties of Matter, Electric Circuits, Magnets, Astronomy, Heat and Temperature, Kinematics, etc.
- Originally developed to help underprepared students succeed in introductory physics. Now used to train pre- and in-service K-12 teachers (esp. elementary).

Perceived barriers to adoption

- Hands-on nature of class requires low student:staff ratio and well-trained staff.
- Highly interactive curriculum can be intimidating to plunge into.
- Developing good questions and problems is time consuming.

Goals of our collaboration

- Investigate topics that could be used in a one-semester course.
- Develop models for teaching the course with higher student:staff ratios and without graduate student TAs.
- Explore ways to integrate PbI with other content addressing various state standards for teachers.
- Develop ready-to-use materials to increase efficiency of adoption.

University of Minnesota

- Large comprehensive institution (50000 students)
- Class characteristics:
  - 45 students (non-science majors, a few Elem Ed majors)
  - students work in groups of 3
  - 3-4 undergraduate TAs

Getting started

- Decide to do it
  - Attended UW’s PbI workshops
- Get help
  - Borrowed material from other instructors
- Teach curriculum to small group of students
  - Selected 9 students from a previous course
  - Ran through experiments in seminar setting (4 h/week)
- Teach curriculum to full size classes (2 x 45)
  - Hold regular meetings for peer instructors (2 h/week)
    - Review material
    - Conduct practice checkpoints
    - Discuss common student errors

Cooperative group techniques

- Heterogeneous groups (rotated every 5 weeks)
  - Student assigned to groups on the basis of attitude survey/test scores.
- Groups self-assess performance
  - What are two ways in which your group works well together?
  - What are two ways in which you could improve how your group functions?
- Interdependence
  - 20% of each exam is based on a group question
  - If group exam average is ≥80%, then each member receives 5% bonus.
  - Group members grade themselves and each other on contribution to group learning (5% of grade).

CLASS assessment

- Colorado Learning Attitudes about Science Survey
- Survey of student attitudes about physics and learning physics given pre and post.
- Developed at University of Colorado for use with traditional introductory physics classes.
- 42 question agree/disagree Likert-scale

CLASS categories

- General problem solving
  - In physics, mathematical formulas express meaningful relationships among measurable quantities.
- Problem-solving confidence
  - If I get stuck on a physics problem, there is no chance I'll figure it out on my own.
- Problem-solving sophistication
  - If I want to apply a method used for solving one physics problem to another problem, the problems must involve very similar situations.

CLASS categories

- Conceptual understanding
  - Spending a lot of time understanding where formulas come from is a waste of time.
- Applied conceptual understanding
  - After I study a topic in physics and feel that I understand it, I have difficulty solving problems on the same topic.
- Personal Interest
- Sense making/effort
- Real world connection

CLASS Results

Positive shifts (multiples of standard error)

	F 04 (71)	S 05 (56)	F 05 (30)	S 06 (34)
PS Gen	2.7	4.9		2.0
PS Conf		5.1		2.3
PS Soph	3.9	4.4		2.1
Concept	5	4.0	1.5	
App Con	5.6	4.9		2.1
Modules	EC 1-4 PoM 1-12	EC 1-4 PoM 1-15	EC 1-4 PoM 1-8 LC 1-7	EC 1-4 PoM 1-10 LC 1-7

Summary

- We have successfully adapted the PbI curriculum to an environment with a 11:1 student/staff ratio using undergraduate TA’s (Peer Instructors).
- PbI can produce substantial shifts in students’ attitudes towards physics.
  - Shifts are most pronounced in problem solving and conceptual understanding categories
  - No large shifts seen in Personal Interest, Real World Connection, or Sense Making/Effort categories (??).