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

Leon Hsu
University of Minnesota

Karen Cummings, Southern Connecticut State University
Jack Taylor, Baltimore City Community College

AAPT Summer Meeting 2006

Supported by NSF DUE #0410804
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 Pbl 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 Pbl 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)

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

• We have successfully adapted the Pbl curriculum to an environment with a 11:1 student/staff ratio using undergraduate TA’s (Peer Instructors).

• Pbl 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 (??).