Physics by Inquiry: Deepening Understanding from Elementary Teachers to University Faculty

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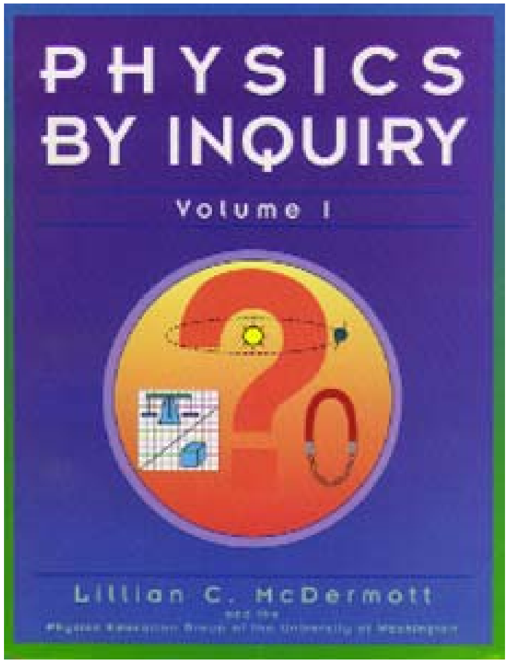
A word of thanks to the UW PEG

- This award could not have gone to a group of people with higher standards for research or greater dedication to service to the physics community.

Physics by Inquiry



- McDermott, L.C. & the Physics Education Group at the University of Washington (1996). *Physics by inquiry.* New York: John Wiley and Sons.

History

- Began in 1973 as worksheets that Lillian McDermott developed for a pre-service teacher course, working to create teacher-usable materials from Arnold Arons' *The Various Language*.
- Continued development with NSF funding.
- Many PEG graduate students contributed (Emily van Zee, Mark Rosenquist, Jim Evans, Peter Shaffer)
- Published in 1996.
- Adopted today by 45 institutions.

The Course (SCI 360)

- From 10-16 students (no TA).
- Pre-service elementary teachers, pre-service high school science teachers (UTeach), graduate students in Science & Mathematics Education, general education students
- No prerequisite [You mean our students could take it even if they have not had a physics course??]
- Focus on learning.
- Typically covers 3 PBI units (or parts of units).

Format

- Modeled after UW course (Physics 405/407).
- No lecture: Students work through exercises in small groups (2-3) with regular instructor check points, occasional group discussion.
- 2-3 in-class exams, including a comprehensive final.
- Writing assignments, including essays and papers.

Nature of the course

- Understanding developed though inquiry: PBI does not ask students to accept what they cannot test for themselves. [Operational Definitions]
- Understanding challenged over and over: PBI does not let students merely accept what they do not understand.

Effect of PBI on students

- Documented by research: More than 20 peer-reviewed articles.
- In Ohio, by 1997, over 2000 science and mathematics teachers completed intensive six-week summer Institutes in Physical Science, Life Science or Mathematics by Inquiry as part of *Project Discovery*; these teachers' students outperformed those in a control group on the NAEP.
- Students move 10% correct on pre-test to 80+% correct on the post test.

Qualitative observations

- Coding of student interviews and other artifacts yields consistent themes.

Rigorous

- “I never thought this hard in my whole life. My brain hurts.”

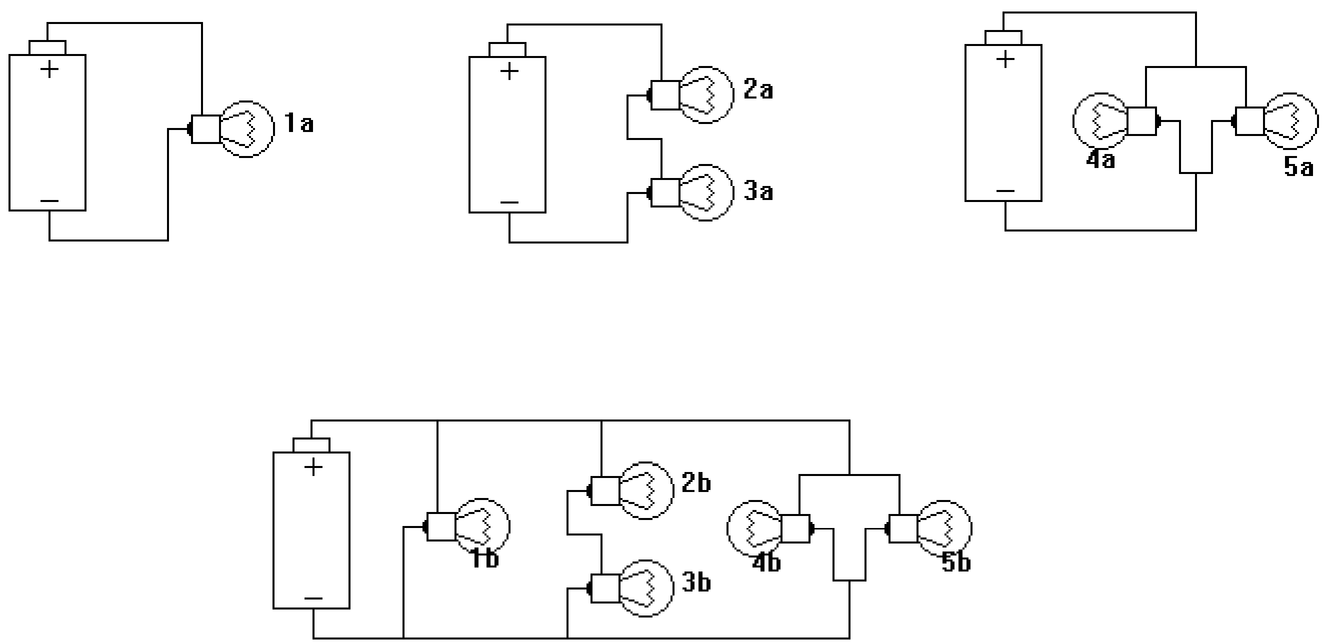
But empowering.

- What’s so interesting for me, when it came time to study, I thought, I don’t need to study because I already now all this. That was interesting. And I kept thinking, oh I need to study, I need to call my group members, and I need to do all these practice problems… but I didn’t even need to do that. Because I knew it at that point. That was cool. I liked not having to cram for the final exam.

Effect on students who have taken physics courses

- Yeah, just wait. You’re about to have to unlearn everything you thought you learned.

Circuits pre/posttest



How dare they have given me an A…

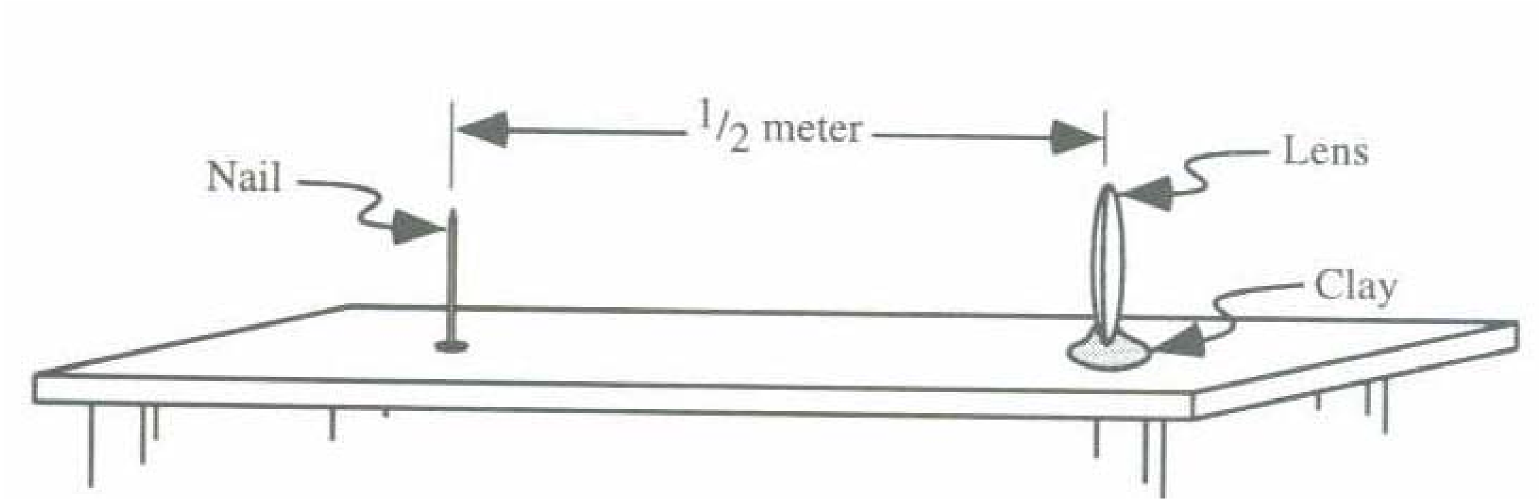
- Cause it's embarrassing to me, on that first day, when I did that pretest, I should have known it absolutely, even as a science teacher not even as an engineer, as a science teacher I should know that, that's my job, to know that stuff for my kids and I didn't know the answer to the questions. So, I think that's important. But it would have definitely changed my education if any of my classes resembled what this class was this summer. And it didn't.

[when I was taking physics classes]… I knew what I needed to know at the time but I carried very little with me from that experience. Whereas now, I think if someone had asked me in 5 years that I would still remember. I know it so well. And I'm comfortable talking about it with other people and just, it's just a really good understanding vs. just kind of knowing how to get through the course. So my content knowledge has expanded significantly, probably from nothing to, to significant in that area.

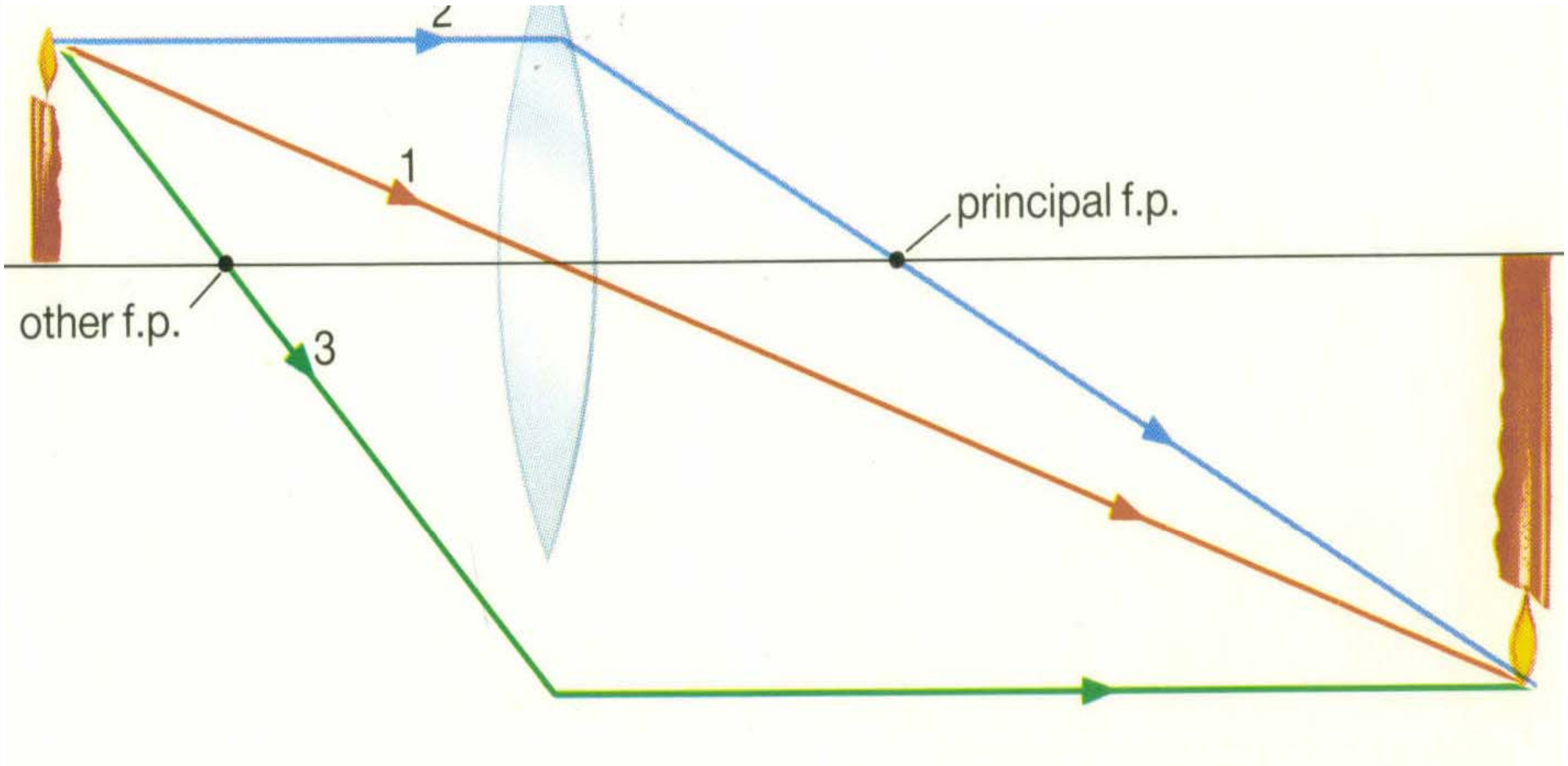
Graduate students: learning how others learn.

- “Did you *know* that was going to happen??”
- Students can learn by responding to questions rather than just by being told the answers.

And examining their own understanding.



“[Expletive deleted]! How can I know this and not know it!”



Effect on teachers:

- “Most of the inquiry that I have tried requires some significant leap to reach the final conclusion. With [Physics by Inquiry] you have all of these small decisions that the kids make and remake as necessary. It really does a good job of teaching inquiry.”

Learning about learning: You have to do it.

- And I know now, having gone through it, it’s not something that I could just look at the book and say OK, I’ve got this. It’s something that you have to do, in order to learn it.

Teachers need to learn by inquiry.

- …there is only so much you can learn in college the way it's taught, it's taught traditionally for the most part in a big classroom and then you just solve problem and problem and problem, problem after problem and then actually in any area a lot of teachers, I had to anyway, have to go back and teach myself… If I would have learned [the PBI] way in college, oh! "

Learning about assessment

- Student A and Student B
- “I would go home at night and I would think it about for hours. Like I would fall asleep thinking about we had this one question that was asked at this point, and why was it asked…”

Teachers are asked to evaluate test questions

- Which of the possible choices for answers is correct and why? Why are the others wrong?
- Based on what you know about student difficulties in understanding electric circuits, are the "distracters" (the wrong answers given as possible choices) good ones to help a teacher find out whether a student really understands circuits or not? What would be some other possible distracters (wrong answers)?
- Is this a good question to test students' understanding? Explain why, or explain what would be a better question.

2 The wires connecting the battery and the lightbulb create a closed circuit. What would happen if one of these wires were cut?

F The battery would lose its charge.

G The glass would crack.

H The light would go out.

J The wire would become hot.

The learning continues

- “Generations” of learners

Enabling research on student learning:

- Marshall, J.A. & Carrejo, D.C. (2007). Teachers' mathematical modeling of motion. *Journal of Research in Science Teaching*, 45(2), 153-173.
- Carrejo, D. & Marshall, J.A. (2007). What is mathematical modeling? Exploring prospective teachers' use of experiments to connect mathematics to the study of motion. *Mathematics Education Research Journal, 19*(1), 45-76.
- Marshall, J. & Young, E. S. (2006). Pre-service teachers' theory development in physical and simulated environments, *Journal of Research in Science Teaching, 43* (9), 907-937.
- "Inquiry Exercises as a Lecture Supplement for Preservice Elementary Teachers and General Education Students", Jill A. Marshall and James T. Dorward, *American Journal of Physics*, *Physics Education Research Supplement,* **68** (7), S27-S36, 2000.

Post Script

- On April 3, 2008, the committee charged with revising the undergraduate Physics curriculum at the University of Texas voted unanimously to count PBI as an upper division physics course and cross list it as a Physics course.