On Resistance to Implementing Physics Education Research Results in Physics Courses

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Over the past several decades a huge body of work has been developed under the label of *Physics Education Research* (PER) that has given us solid data that show us how to improve the learning outcomes of our physics students.[1,2] Converts to reformed research-based pedagogy based on the results of PER are numerous, and tend to proselytize about it to their colleagues. Since physics teachers are scientists and the data are overwhelming, it is therefore surprising that PER-based pedagogy has not been more widely adopted than it has.

In the U.S. Dancy and Henderson studied this using a web-based survey of 722 university physics faculty, and in 2010 reported their results.[3] A large majority of the faculty reported being aware of the research and were interested in using it in their classes, but the fraction of them who had actually implemented PER was considerably smaller than those expressing knowledge and interest. There were many factors related to this lack of adoption of PER-based instruction that were identified, but the primary one was a "lack of time."

This research matches my own observations of colleagues both at the University of Toronto and elsewhere. Furthermore, some have expressed overt hostility towards the type of pedagogy that the research indicates is most effective. Here I will use my own experiences to explore why, in addition to time, there might be such resistance.

The key result of PER for me is: most students learn best by interacting with their peers, and those interactions are most effective when they involved guided-discovery conceptually-based activities, especially when they involve real apparatus and/or simulations and/or interactive demonstrations.

In the physics education journals I kept reading about this key result and its implications in terms of the way we should structure our classes, labs and tutorials but I kept ignoring the research. In addition to my own arrogance and stupidity, there are some further reasons why this might have been so:

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- I was getting reasonably good evaluations from my students. I even won a couple of awards.
- In lectures I got to show off to my students how smart I am.
- It is not the way I was taught … and look how well I turned out!

This last point is perhaps the most important one. In fact, my own personal learning style does not involve a large amount of interaction with colleagues: instead I want to be given the textbook or journal article, a quiet corner, and to be left alone. It is my observation that many people who end up academics also have a learning style that is similar to mine. And we all tend to organize our courses in a way that worked best for us when we were students.

Finally the research results got through to me, and I realized that although I may have been organizing my courses in a way that worked for me and a tiny fraction of my students, it was not the most effective way for most of my students. Once I realized this simple fact, I began converting my classes, labs, and tutorials to research-based pedagogy. Although old habits die hard and there is always more to discover about teaching and learning, I will never ever go back.

There is another objection that I have heard more than once to implementing research-based pedagogy: it is based on the fact that when we devote considerable time to student-student interactions as a teaching technique, that is time that we do not have available to cover the material of the course.[4] This is a variation of the "lack of time" excuse mentioned above. But as Redish and Hammer wrote: "The idea that one has to cover a particular set of material, whether or not the students understand it, seems peculiar, but it is widespread."[5] The point is that we really must organize our classes so that the material we expect our students to understand is material that they *can* understand, which is always less than what we would like them to understand. Otherwise, if we swamp them with material that they cannot truly understand they will revert to trying to memorise and "plug-and-chug" their way through the course. Of course, PER-based teaching is all about increasing student understanding. That said, the triage process of eliminating favourite topics from a course is always painful for the teacher.

There is one small caveat in this for beginning teachers facing tenure or promotion decisions, where student evaluations are important. An example is Eric Mazur at Harvard, who is the main proponent of the PER-based instructional technique called *Peer Instruction*.[6] Before he converted he was doing traditional lectures and was getting outstanding evaluations by his students; however he was also seeing comments like: "Mazur is great, but physics still sucks!" After he converted to Peer Instruction, the learning of his students went up a lot but his student evaluations went down, and comments like "Prof. Mazur doesn't teach us anything, he makes us learn it for ourselves" began to appear. Mazur already had tenure at Harvard so could ignore this, but new teachers may not be able to do so. I never received equally outstanding evaluations when I was teaching traditionally, and in my case converting to research-based pedagogy caused my evaluations and my students' learning to both improve.

This note is based on the talk I gave when receiving the CAP medal for undergraduate education at the University of Calgary in 2012, and on comments I received both during and after that talk.

REFERENCES

[1] To get some idea of the scope of this field, a good place to start is PER-Central at http://www.compadre.org/per/

[2] A wonderful overview of PER is E.F. Redish, *Teaching Physics with the Physics Suite* (Wiley, 2003).

[3] M. Dancy and C. Henderson, "Pedagogical practices and instructional change of physics faculty," Am. J. Phys. **78** (2010), 1056.

[4] This objection is also given by high school teachers in C.J. Wenning, "Minimizing resistance to inquiry-oriented science instruction: The importance of climate setting," J. of Physics Teacher Education Online **3**(2) (2005), 10. http://www.phy.ilstu.edu/jpteo/

[5] E.F. Redish and D. Hammer, "Reinventing college physics for biologists: Explicating an epistemological curriculum," Am. J. Phys. **77** (2009), 629.

[6] E. Mazur, *Peer Instruction: A User's Manual* (Addison-Wesley, New York, 1996).

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