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2006-09-05
PHYS 4810

How we teach and how students learn — A mismatch (McDermott L. AJP 61(4), 1993, p295)

This paper discusses learning difficulties common in introductory physics students. It provides several concrete examples which are easy to understand, and it is usually clear how to address those issues. The paper cites several findings which are vague and difficult to interpret (the questions below mention a couple of these). The paper's general points are forehead-slappingly good, and contrast the way physics is usually taught. It stressed the importance of teaching reasoning skills in addition to physics knowledge, but unfortunately it didn't strongly address what methods could be used to do this.

Questions:

- The impulse-momentum/work-energy example had me confused for a little while. They applied the same force over the same distance to two different objects, and asked to compare their kinetic energies and momenta. It was obvious that their kinetic energies were equal, however I assumed that this implied their momenta were also equal. Only after some calculations did I realize that this wasn't the case. And I'm supposed to know this stuff. That wasn't much of a question, but it is food for thought/discussion.

- "Some seemed to treat the symbol '=' as if it represented only a mathematical relationship in which the variables may take on any values, provided the equality is maintained." What does this mean? How is this erroneous? As a side note, I heard from one of my friends the other day that a common technique taught for interpreting word problems is to replace the word "is" with "=", which I had never heard and sounded absurd to me.

- "... the instructor must insist that students *confront* and *resolve* the issue." How exactly is this done? The "issue" may not even be apparent to the student.

Learning to think like a physicist: A review of research-based instructional strategies (Van Heuvelen, A. Am. J. Phys. 59, 1991, p891–897)

This paper identifies the problem in physics education that students are too passive in their learning experience. It makes the excellent analogy that when a student learns a musical instrument or a sport, individual skills and techniques are taught and practiced independently, whereas in physics the whole method is demonstrated and then asked to be repeated a couple days later. The paper is generally insightful, but lacks in examples and tends to speculate. As an added bonus, there is a hillarious terrible computer analogy, which is repeated below.

Questions:

- "[Students] believe in impetus forces, **ma** forces, the force of inertia, and the force of momentum." To students, what is an impetus force or an **ma** force? It is hard for me to reason about misconceptions given only their misnames.
- "A computer would become very confused if given two conflicting sets of operating instructions, one stored many times over a period of years and the other provided a few times 1- or 2-week period. If we want to the computer to assimilate a new operating system, we must bring up the old system and dump it before the new system can be saved. Having both operating systems present at the same time leads only to confusion." Hahahahahaha! I'm not counting that as a question; it was just too funny to leave unnoticed.
- I wouldn't consider a "hierarchical chart" the way to build a framework. Even if this is how a mental framework is ideally organized (I don't think it is for me, at least), presenting the chart probably won't accomplish anything. "Yes, the stuff you're learning really is all unified, I promise." Supposing that a hierarchy is the way we'd like the students to organize their knowledge, what would be a good way to construct it? Supposing we can "tell" students something to help construct a framework, what might we tell them (as opposed to having them do an activity)?

- The “system physics” model seems like something that is generally true, but may be overgeneralizing. It depends on the details of how it is taught; for example we wouldn’t want students adding energy to force to see if they sum to zero. Overgeneralizing is not necessarily bad in a pedagogical context, but it strikes me more as a “rule of thumb” than a “mental framework” (much like “replace is with =”). What are the details of this pedagogy? What are possible negative effects of this approach?