Version 1.0
May 5, 2017

Topics in Pedagogy

1 Introduction

The common reactions from non-scientists on learning that I'm a physicist reflect, I believe, mistakes we make in how we teach physics. I am interested to know if there are commonalities with your experience in other fields.

I am also interested to know if others have found a lack of traction with their colleagues for similar ideas; the following have been hobby horses for a long time. These issues still bother me, though I've by-and-large given up. However, I thought it would be fun to talk about them, and maybe I'd learn why some of my colleagues seem unable to hear them. And, I may be wrong.

2 Basic Pedagogy

Teaching in the Native Language; Physics as a Language Course

No subject should be taught in translation. Physics in particular has a precise language (mathematics), while in translation ('English') is confusing and often deeply incorrect. The most thoughtful students are often the ones most troubled by 'English' translations of physics techniques and principles that would be clearly understood in the native language.

Less is More: Coordinated Curricula

The Physics Department Curriculum is over-stuffed; there are too many required courses, some essential topics are barely covered or not covered at all (Thermodynamics, Optics, Special Relativity), and individual courses have curricula that do not fit in a quarter. We should instead teach commonalities and the necessary 'tool kit' early in the curriculum, so that one can then go fast and deep in the following courses [1].

Implicit Assumptions and Consequent 'Proof by Intimidation': 3 Examples

Physicists make implicit assumptions in posing problems, and then are troubled that students and the public seem scientifically illiterate. Some much-cited examples in which we (physicists) are talking about an ideal situation and the lay person (Phy Sci student) isn't:

1. "The public thinks that a child falling off a swing falls straight down" (they usually do);
2. "The public thinks that a ball rolling down a curved ramp will continue to curve on the floor after it leaves the ramp". (tennis balls often do);

[1] For example, linear algebra is the elegant and concise language in which to teach many topics in Classical Mechanics, Electricity and Magnetism, and Quantum Mechanics. Taught to proficiency once saves weeks in a 3-quarter introductory sequence.

3. "The public doesn't understand that Science is what brought us the IPhone."

When teaching, physicists often seem unable to see our own unstated approximations: In #1 the swing spends more time stopped than moving and that's when a kid would let go; In #2 we assume no friction, so no spin on the ball; For #3, unlike the two distinguished scientists who waved their Iphones in the air at lunch last week while making this claim, the students and public also credit Capitalism and Steve Jobs. Oy.

3 Assessment and Incentives

We are stuck on some very old and ill-motivated ideas. Some examples, bad and good:

Grading on a Curve– Statistical Basis?

(from E.E. Moise) Even if the shape of the curve for the US population is a bell curve, the correct *a priori* curve for the class is most likely the 'high tail' of a peaked distribution, i.e. a rapidly falling curve, rather than another bell curve.

Grading on a Curve– Goal?

My goal is that *every* student has mastered the material at a level beyond normal expectation [2]. Why plan on giving C's and D's?

The Ski Instructor Model

Ski schools are a good model to emulate. Students are self-selected to learn. Students are carefully placed according to individual placement tests, and if mis-placed moved to the right level. The goal is to foster enthusiasm while pushing current ability. There is no intent to permanently 'weed out' seemingly weaker students (who are often eventually the best).

Truncated Means Rather than Averages

In a quarter I typically give 8 Quizzes, 9 Problem Sets, a Midterm, and a Final. Rather than average the Quiz scores, I discard the 2 lowest grades, and average the remaining 6. The 2 lowest are typically not representative of what the student can do, and are often due to external effects (illness, room-mates, other commitments, e.g.). Einstein's, Pauli's, and (I'm told) Da Ponte's averages aren't so high–there are some zeros that drag them down. Average is the wrong measure of capability.

Final Grade: Not Holding Grudges

If a student has mastered the material by the end of the course (i.e. on the Final) they get a good grade. Why not?

4 At the Student Level

Socializing the Bullies

First-year Honors Physics (P141) suffers from 'hot-shots'– products (largely males) of

[2] This requires identifying early in the quarter students who just aren't going to make it–tends to be no more than two or three out of 40-50 in P141, e.g.; slightly higher in Phy Sci 111.

good schools with AP courses that covered the same material, and eager to show off. I have found that starting with a topic that none of them have had in a language none of them know is a 'levelling mechanism' while they get over it (see study groups below).

Study Groups

I announce that my course is paced too fast for anyone working alone–each student has to have a study group to keep up with the problem sets. However, 'the work you do has to be yours alone', and there's a quiz every week. It seems that study groups are particularly important for (some) women who take a while to realize that they can kick hot-shot butts.

Placement, Advising, Supporting the Weaker and Challenging the Stronger

1. Our Physics majors are advised by (well-meaning) folks who often know little physics and little about individual Physics Dept. professors and courses;
2. The ultra-conservative advice from the Physics Dept. encourages stronger students to go much more slowly than they could and should;
3. At the same time students with weaker backgrounds are given a weaker curriculum;
4. I confess that I advise joint Physics/Math Majors to drop the Physics degree– Math has fewer required courses and college is too good to waste on your major, especially if it is very dilute and cumbersome;

5 Other Annoyances/Malpractices

Whingeing on practices that won't ever be changed:

Testing Untaught Skills- 'Unpacking'

We (physicists) give problems on exams that students haven't seen; the problems are based on principles that we've taught, but gussied up so that the principles are disguised. However, 'unpacking' the underlying principle is a separate skill, not obvious, nowhere taught, and encountered only on Midterms and Finals.

Early morning classes and finals (Indefensible)

For many years the Phy Sci classes I taught had 8am Finals, it turns out for no reason (slots later in the day were assigned to classes that had papers rather than exams). We insist on teaching 9am classes to teenagers. We would be very attractive if 10:30 were the earliest start time; also much more effective.