Guest Editorial

Smartening Up Physics

Many months ago, Bernie Khoury wrote one of his lively and thought-provoking columns[1] in which he passionately advocated "watered down physics." This stimulated a discussion between us that he urged me to write up as a response. Now, sitting on an airplane on my way to the Miami AAPT meeting, I finally have time to do this.

Although Bernie's words are always memorable, I should perhaps remind you of his primary point. He argued that it is neither realistic nor useful to try to have every student take the standard introductory physics course, and that there is great virtue to teaching a less mathematical course that can be of educational value to far more students.

While I completely agree with this statement in principle, I object to the idea that such a course is necessarily "watered down" physics. My experience is that such a course for students with poor math and science backgrounds can in fact be "smartening up" physics.

Such students can come to understand the concepts of physics and apply them to the world around them better than undergraduate physics majors and beginning graduate students who have gone through a traditional physics program. These claims are based on my teaching of the introductory physics course for non-science students (sometimes referred to as "physics for poets"). The math prerequisite is high-school algebra. The course focuses on the "physics of everyday life" and uses Bloomfield's text of the same name. The focus is on conceptual understanding and being able to apply basic concepts of physics to explain and predict a variety of everyday phenomena. This is a large lecture course with no recitations, but to the extent possible in this setting, I use numerous proven pedagogical strategies, including Peer-instruction, interactive lecture demonstrations, context-rich problems, collaborative learning etc.

I discovered some unexpected problems with teaching this course that are directly related to my discussions with Bernie as to what constitutes a "watered down" or a "smart" physics course. First, many of these students, naturally feeling nervous about taking a physics course, availed themselves of the University supported tutors, which were usually junior or senior level physics majors.

Many of the students who used tutors were coming to me complaining that their tutors were either giving them answers that disagreed with what they were told in class or in my homework solutions, or telling them the questions were either impossible or dealt with material that was far too advanced for the student, because it was not covered until graduate or very advanced undergraduate physics courses.

Then I discovered that the graduate student TAs, who did grading or ran help sessions for the class, were similarly making frequent mistakes in answering questions. During the first couple of years (until I learned better), I would have the graduate TAs check my exams and homework problems by working out the solutions. I discovered that the best TAs did about as well as the best students in the class, and that the weaker TAs did considerably worse.

Although these graduate and undergraduate physics students had excelled in many physics courses and could solve textbook problems requiring elaborate mathematical calculations, they were in fact frequently incapable of applying basic physics concepts to simple real world situations.

So which is the "watered down" physics course? The course in which students learn to use Green's functions to solve complex boundary value problems, but have a totally misguided idea as to the physics involved in a microwave oven or the greenhouse effect? Or the course in which the students learn to use the concepts of physics to explain and predict phenomena like these in the world around them, even if their predictions are only based on simple algebra and conceptual reasoning?

While I agree with Bernie that we need far more physics courses that give a diverse group of students a solid conceptual understanding of physics even if the use of math is quite limited, I would argue that there is nothing "watered down" about those courses!

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1. B. Khoury, "Three Cheers for Watered Down Physics," *Announcer*, **32** (3) 4 (2002).