From the Editor of the Teacher Preparation Section:
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The American Association of Physics Teachers meeting in Edmonton this summer featured a wealth of excellent talks on teacher preparation. The three articles that follow were solicited from talks at this meeting. Two of the articles are by Teachers in Residence (TIR) at two of the four new PhysTEC primary institutions: Cornell and the University of Minnesota–Twin Cities. Jon Anderson, who took over TIR duties from Nancy Bresnahan this year, discusses the Learning Assistant program at the University of Minnesota, Twin Cities. This program features a novel implementation of the LA program in a large lecture class and has generated excellent student evaluations. Marty Alderman, currently TIR for Cornell’s PhysTEC site, discusses often ignored problems in providing high quality physics instruction to all students. These issues, including the allocation method used by high schools to assign physics classes to teachers, the Small School Initiative, and the role of private schools, may be unfamiliar to people who work in the university environment.

Finally, Richard Steinberg, a Professor in the School of Education and the Department of Physics and Program Head of Science Education at City College of New York, discusses his extraordinary experiences teaching high school in a poor area of Manhattan. During a sabbatical, Richard gained a teaching license through alternate licensure and spent a year as a high school teacher. The transition from the college classroom to an underprivileged high school classroom provides an eye opening picture of the challenges our future teachers face. Richard’s talk at the AAP meeting generated more post-talk discussion than any other I have ever attended.

The 2009 Physics Teacher Education Coalition (PTEC) Conference on the Preparation of Physics and Physical Science Teachers will be held in Pittsburg, Pennsylvania on March 13th and 14th immediately before the APS March Meeting. The theme of the meeting is “Institutional Transformation.” Registration information will be provided at PTEC.org when it becomes available.

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Away from the ivory tower: Real challenges teaching high school physics in an urban environment

Richard Steinberg

For the 2007-08 school year, I took a sabbatical and became a full time high school physics teacher in a public high school in New York City. In preparation, I spent the 2006-07 school year participating in an alternative teacher certification program. As a college professor teaching teacher education courses and standard introductory undergraduate physics courses, both populated by many New York City public school graduates, the experience was illuminating, and a little scary. The respect and admiration that I already had for many wonderful science teachers throughout the city grew even more.

Prior to my sabbatical, from my experiences learning physics I saw the beauty and elegance of the subject matter, often delivered to me by master physicists. From my experiences in education I saw the importance of setting up an environment, both affectively and cognitively, conducive to maximizing learning. From my experiences conducting physics education research I saw the need to understand and address specific difficulties students have learning the subject matter. After my first day teaching high school, I saw that all my experiences meant nothing compared to getting through the day unscathed (literally) and that all that mattered was my students’ success on a standardized exam that I was confident correlated little with anything that was important about knowing physics. It is clear that physics teachers are taught physics one way, are taught to teach it another, are told something different still by the school system, and are then put in a room where none of it works. Classroom management, which I will not focus on in this article, is a big part of the challenge, but not all of it.

My experience was in a poor area of Manhattan. Almost all of the students were Black or Hispanic. There were good support services. There were fewer than 25 students in each class and a relatively large proportion of the students eventually end up going to college. However, those that know more about the school system than me tell me that student background, student discipline, and overall challenges were not very different than what is encountered at many New York City public schools. This particular school requires physics though, which allowed me to get to know a full cross section of students. It also presented the challenge that many of the students were not motivated or interested in taking the course.

Challenges with student attitudes, expectations

I came with enthusiasm about teaching, about being with kids, and about having real fun with physics. Nevertheless, I ran into numerous challenges with the way my students approached learning including what appeared to be apathy and laziness. There were obviously many reasons for this, but at least part of it was a learned approach to school where success is based on being told what you are supposed to know and repeating it back on a test. “Is that going to be on the Regents?” “This problem is way too long” (about 10 minutes). “What do I do next?”

Students wanted (more like demanded) to be told exactly how to do things. They were not shy about their expectation of what the teacher’s job is. “How am I supposed to know what to do if you don’t tell me? Hey (Phil), go build a rocket but I am not going to tell you how.” This shout to a friend across the room was in response to me trying to get the student to figure out for himself how to convert 16g to kg after having already shown how to convert 7g.

Even my attempts to bring in fun, interactive learning activities met with mixed success. Much of this was tied to classroom management, such as disengagement during group work, disappearing equipment, and misuse of projectile launchers. However much of it was also the seeming disconnect of how these foreign experiences would help them with the test and an unfamiliarity of how to simply explore ideas and phenomena.

Challenges with student background knowledge, approaches

As I got to really know the kids, I was genuinely impressed that they were smart and capable of thinking at an appropriate level, at least when removed from the typical classroom expectations. When I talked to them about their hobbies, ambitions, or even why they approach my class the way they do, I truly believed that they had all the underlying intelligence needed to succeed.

Nevertheless, I would often see many students struggle with basic skills that I hoped they would have mastered by their junior year of high school. I was disappointed when I asked a class to solve 5x = 80 and so many came up with x = 75. I was even more disappointed when during one lab a group of 4 students (they happened to be a bright and engaged group) measured a volume twice, first 36ml and then 38ml, and then averaged the numbers and came up with 57ml. Student aptitudes with proportional reasoning, interpreting a graph, and reading and understanding grade level text were all problematic.

However, I am confident that they were all smart enough to succeed in the course and that holes in their content and skills background were all addressable. What concerned me more was that they had approaches to thinking in general, and schoolwork in particular, which were flawed. They had an algorithmic approach, sometimes a skillful one and other times not, that seemed devoid of making sense of what they were doing. A careless mistake with a calculator could account for coming up with 57 as the average of 36 and 38, but if the students really understood what an average is and how it is calculated, then they would have realized how ridiculous 57
is. My experience with the students and teachers suggest that the algorithmic approach is institutionalized.

At one point still early in the year, partly out of frustration with the complaints that everything was too hard and partly to make a point, I put one homework assignment on the board that read (verbatim), “A car moves with a constant velocity of 9.5 m/s. What is the velocity of the car?” I was trying to convince them to step back and think as they go. Many students did not do the homework, but more surprising to me was that a few who were trying came and asked for help with this one. One bluntly stated, “I could not do this one because I did not know which formula to use.”

Consistently I tried to emphasize to the students the need to make sense of what is in front of them, but I feel I met with mixed success at best. For example, well into the school year, when I asked a question about the final temperature of a 10g piece of Zn at 71°C placed in 20g of water at 10°C, the few students who attempted to do the math and submit an answer came up with a temperature NOT between 10°C and 71°C. All signs suggest that rote algorithmic skills without an understanding of the underlying concepts and ideas is not only fleeting, but fosters an approach to schoolwork where students look to be told the algorithm and not make any meaningful sense of the material being studied.

Challenges with the emphasis on standardized, short answer exams

To the students and the principal alike, it is all about the Regents, an essentially short answer standardized exam given throughout New York at the end of the year in the different high school subjects. The physics Regents covers a breadth of material that is well beyond what is capable of being understood by my college engineering students in a year. My college students have the benefit of having been selected as the most able and motivated of the New York City high school students and also have considerably more science and math background. For the Regents, students are given the physics reference tables, which are tables of formulae and other information provided with the intent that students need not memorize to succeed. However, even the good students see the reference tables as a means of obtaining an answer to a question irrelevant to an understanding of the basic ideas.

Late in the year, I put on a quiz the following question, which is an actual Physics Regents question:

_The tau neutrino, the muon neutrino, and the electron neutrino are all:_

_A. leptons  B. hadrons  C. baryons  D. mesons_

82% of the students answered this question correctly. I could not help but juxtapose this result with these same students struggling to average 2 numbers, read a graph, or know how fast a bus is going when they are told how fast the bus is going. As far as I am concerned, my students were not given the chance to learn the difference between a neutrino and Newfoundland and the 82% “success rate” is a grossly misrepresentative measure of my students understanding of anything.

In working towards giving my students the chance to see that physics is something that is understandable, something that can make sense, something they can do, I gave them an independent in-class worksheet with 10 questions in the domain of physics. All could be answered without relying on the formalism from class or the reference tables. (See Figure 1 for sample questions.) However, there were 2 versions. The questions were identical, but the instructions were different. One set of instructions read:

“Use your reference tables to answer the following questions. Show all work including the equation and substitution with units.”

This is the language used on the Regents exam. The other set of instructions read:

“In answering the following questions, do NOT use your reference tables. Answer the questions how you would have answered them had you never taken a physics class. Explain how you determined your answers.”

The results are hard to interpret because of the number of students who put their heads on their desks for the entire time and because of students such as the one with the second set of instructions who handed in a mostly blank worksheet and told me “I do not know how to do this without the reference tables.” Nevertheless, I did see some alarming trends. Figure 2 shows the overall correct response rate for the 2 sample questions in Figure 1. Not only was the success rate higher for the students who were asked to pretend they never had physics, they went about attempting the problem more sensibly than students who were asked to use their reference tables. (See Figure 3 for representative responses for the first question.)
(Some) successes

It is distressing that after approximately 150 hours teaching physics to the same group of kids that I failed to make meaningful headway with so many of them; however, I saw how that does not have to be the case. One of my colleagues in biology did an enormous amount of project-based learning. His students chose, designed, and executed projects where they actually did and learned science. They went to class in a room filled with things growing, swimming, and smelling. One of my colleagues in social studies had his students read original historical documents and contrast points of view of different figures of the time. His students had lively relevant debates during class time. Even I had some successes. For whatever reason, students had a real good time playing with scotch tape and learned a foundation for electrical charge. Some students enjoyed the whole year and the way I taught physics enough to openly enjoy and value the experience. I felt genuinely good about what could happen.

After an exhausting and trying year, I was asked if I want to do it again. My feeling right now is definitely yes (assuming I could convince my wife to let me). I see that it is possible to work around the system and make a meaningful difference in something that is of such great importance. I just wish we could rethink the system.

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Figure 3: Sample student responses to accelerating truck questions for each version of the worksheet directions