Teaching

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June 19, 2015

My teaching record spans over 10 years. Since appointment as associate professor at U. Maryland in 2009, I have taught one lab course and several lecture-based courses (mostly at 400 and 700 level). In this Teaching Portfolio, I provide a discussion of my teaching goals, methods, and outcomes, with evidence gleaned from these recent teaching experiences.

1 Strengthening communication

Before beginning a new course, I always consult with my colleagues who have previously taught it for guidance. I try to incorporate what I learn from them into my own teaching strategy, especially when their ideas are intended to enhance the instructor-student dialogue. One of the most successful examples of this was a suggestion to construct course websites with piazza.com (developed by a former UMD grad student); among many valuable resources, its asynchronous Q&A bulletin board has allowed my students to learn from each others' questions, and contribute directly to their peers' learning experience by proposing answers themselves, as well.

2 Setting standards

Establishing an appropriate degree of difficulty in a physics course, especially in the first semester teaching it, is often nontrivial. On the one hand, the material should be matched to student expectations and abilities based on their experiences with previous classes. On the other, the instructor has a practical responsibility to insist that essential fundamental concepts are thoroughly understood (especially when they are prerequisite to more advanced classes). Furthermore, the instructor has an *intellectual* responsibility to the students and him/herself to avoid simply rote adherence to the textbook and its author's sole perspective and voice on the subject.

I have always sought to set the difficulty of my courses fairly high. Ideally, all the students should feel challenged: that they learned a great amount but perhaps not every topic covered, and that the course as a whole was very near – but not beyond – the threshold of being too hard. This choice has been largely successful, with many course evaluation comments conveying an appreciation for the rigorous approach (see Section 5 on student comment highlights below).

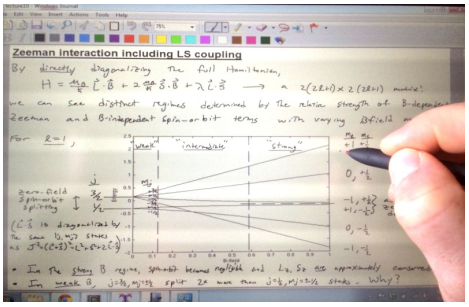
However, there is a risk in doing this: one might initially set the standards too high, and only learn too late to make substantial changes that the students are not able to rise up to the standards set. This occurred when I volunteered to teach PHYS165, "Introduction to Programming for the Physical Sciences" in Fall 2014 (this class covers the basic elements of computer programming using MATLAB and applies it to simple physics problems from elementary Newtonian mechanics). In contrast to my previous experiences with several different courses, where I was able to use student reactions to help calibrate the level as the the course went on, in this class such feedback from the students was weak and the class ended up at a level which was apparently beyond what the students could handle. At the end of the semester, I was therefore pleased to find one student's evaluation comment including the quote below:

> "Professor Appelbaum was an excellent teacher who really knows his stuff. He's a great presenter of material and always emphasized that we learn. . . I enjoyed the course."

However, comments from some other students were unfortunately not as positive, and in stark contrast to the rest of my altogether-satisfying teaching record, numerical scores for this class were particularly disappointing. Future semesters will clearly require more active engagement and a recalibration of difficulty level. I am eager to rise to the challenge of turning this particular course – now required for Physics majors – into a success (see Section 4 on incorporation of computer-aided numerical methods, "Subject matter" below).

I enjoy lecturing immensely because – in addition to the standard elements of logical argument and detailed mathematical calculations – it allows extemporaneous exposition and a bit of theater. This spontaneity creates a dynamic environment to convey not only the bare physics, but also gives me an opportunity to inspire my students with enthusiasm and excitement for the subject. To further success toward ultimate learning outcomes, I have applied several innovations that complement my personal style and enhance valuable interaction with the students, as detailed in the next two sections:

3 Lecture materials



I do not use the white-/chalk-board on the walls, but rather a Tablet PC with projector. This is allows me to 1. write the notes facing the students so that they hear my voice loud and clear, and so I can see raised hands for questions, 2. view each page in its entirety, exactly as the students see it, to keep the visuals organized and logical, 3. make adjustments to text and figures beyond simple erasure such as resizing, color, reshaping, copy & paste, etc, 4. save the notes for distribution to the students as PDF files on the course website after any adjustments, corrections, additions, etc. are made following class, and 5. quickly review the previous lecture's notes in the beginning of each class to remind the students what they learned, its relevance to the present topic, and to give them the opportunity to ask lingering questions in an *ad hoc* discussion.

The students respond quite positively to this teaching modality and the comments entered in student evaluations reflect their appreciation. For example:

> ". . . very refreshing to be able to spend less time copying notes and more time absorbing the professor's unique perspective on the topic."
>
> ". . . technology-driven teaching style is innovative and kept me engaged."
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> ". . . I really enjoyed the use of electronic notes during lecture and feel like I learned a lot during the course."
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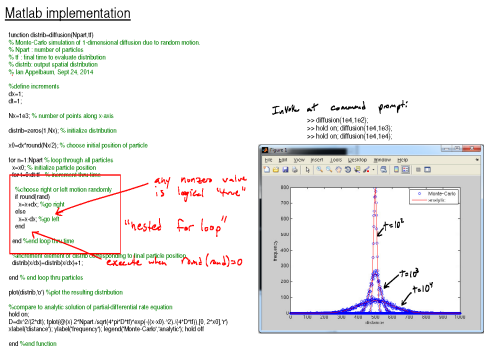
> ". . . The lectures were very well organized (I especially liked that the PDF notes were available online) and well thought out."
>
> ". . . This professor is by far one of the best lecturers I've had at this university . . . He is very well organized (something I've never seen in the phys. department), and has a well-designed website with easily accessible notes/assignments."

At the end of the semester, I collate these notes and related materials. Several have been made available to others online as self-published books: Quantum Physics (from PHYS401 and 402, ISBN 9781312303119) and Solid State Physics (from PHYS731, ISBN 9781304791009).

4 Subject matter

Another aspect of my teaching style is an emphasis on incorporating numerical analysis with computer environments such as MATLAB to complement the usual analytic approach to solving problems, commonly adhered to in textbooks.



After comparing the calculations to the conventional textbook result, we then often are able to explore similar physical problems that elude simple analytical methods. Furthermore, I have found it very effective to include tasks asking the students to reproduce the numerical results themselves on their PCs for homework. Although they are sometimes initially unfamiliar and uncomfortable with this kind of assignment, it ultimately has had an overwhelmingly positive reaction from students as evidenced by course evaluation comments:

> "...I also appreciated the focus on numerical analysis, which allows one to gain a much stronger intuition about the subject than only working on the few examples that can be solved analytically. Overall it felt like I gained an excellent understanding of the basics of quantum mechanics, as well as a number of universal mathematical and analytical skills."
>
> "Good use of matlab code and visuals to cause understanding. Excellent professor."
>
> "Computing projects were fun"

I feel very strongly that in addition to aiding the learning process, an ability to translate scientific concepts into relevant mathematics and instruction in an objective computer language (interpret the resulting data) is an essential part of training in any STEM field that should be required as part of an undergraduate degree in this 21st century. Making use of computers can and should be done in the teaching laboratory setting as well: After teaching PHYS375 Experimental Physics III (Optics) in Fall 2009, I undertook a complete redesign of experiments to use MATLAB for data acquisition in addition to replacement of optical hardware, manual rewrites, etc. In fact, I have had former students tell me – long after the course was finished – that their experience learning how to employ the computer to do numerical modeling using theory or automate experimental measurements subsequently led to getting a job requiring that skill, or helped them decide what career path to pursue.

Partly for this reason, I was pleased that the new Physics curriculum recommended by the departmental committee I co-chaired in 2011 now requires students to take either a 100- or 400-level course on numerical methods in physics. The lower-level course I taught in Fall 2014, PHYS165 "Introduction to Programming for the Physical Sciences", will then attract a different student profile, leading to a more positive outcome.

5 Student evaluation comment highlights

@ U. Maryland, Physics Dept.:

- Spring 15: **PHYS402 Quantum Physics II**
  "very insightful and clear." "Good use of matlab code and visuals to cause understanding. Excellent professor" "I really enjoyed the use of electronic notes during lecture and feel like I learned a lot during the course. His ability to clearly describe the topics, often taking a different approach than the book, was nice as it gave us two different perspectives on the same problems." "Professor Appelbaum has been instrumental in helping me to wrap my head around the most difficult branch of physics."

- Fall 14: **PHYS165 Intro to Programming for the Physical Sciences**
  "Professor Appelbaum was an excellent teacher who really knows his stuff. He's a great presenter of material and always emphasized that we learn. . . I enjoyed the course."

- Spring 14: **PHYS402 Quantum Physics II**
  "Great course, I learned a lot. Very good instruction style that introduced us to physics in the real world" "Love the teaching style. Very accommodating and easy to follow." ". . . always answered questions helpfully and patiently . . . " "He did an amazing job teaching us the mathematical underpinnings of QM." ". . . comes up with different possible ways to teach and make us understand the lecture. Thank you for that."

- Fall 13: **PHYS731 Solid State Physics**
  "I learned a lot from the course and feel it gave a great survey of a vast and interesting field of physics" "Computing projects were fun" "The lectures were very well organized (I especially liked that the PDF notes were available online) and well thought out. Overall this was a great course" "instructor was always prepared for lecture and explained the material in a knowledgeable fashion" "The teaching was clear and concise."

- Fall 12: **PHYS731 Solid State Physics**
  "Ian is the most organized, effective teacher I have had in graduate school. Because of his preparedness and ability to explain physical concepts clearly, we were able to cover a lot of material. This course was an elective for me, and I was pleasantly surprised at how much I learned, how much I enjoyed learning it, and how easy it was to learn it. Ian's technology-driven teaching style is innovative and kept me engaged. Finally, the problem sets were illustrative and pitched at a level I felt was reasonable, yet challenging. Again, this course was incredible and I'd recommend it to any graduate student who is even mildly interested." "This class was wonderfully designed and taught." "This was a fantastic course that I think really did a good job of covering a wide range of topics at an appropriate level of depth."

- Spring 12: **PHYS401 Quantum Physics I**
  "I found this course extremely enjoyable. It reminded me of why I decided to become a Physics major. Professor Appelbaum was very knowledgeable and applied mathematical formalisms that were originally unfamiliar but ultimately extremely helpful." "Professor was very coherent and very methodical. He taught the material very well and cared greatly about the students."

- Fall 11: **PHYS731 Solid State Physics**
  "I enjoyed the course immensely." "Good lectures, difficult but rewarding homework." "Overall, a class I enjoyed and was worth taking."

- Spring 11: **PHYS401 Quantum Physics I**
  "This was probably my favorite course that I have taken so far. I really appreciated the mathematical derivations of universal mathematical concepts, and then seeing directly how they applied to quantum mechanics. This was in my opinion much better than simply stating the results and then working with them. I also appreciated the focus on numerical analysis, which allows one to gain a much stronger intuition about the subject than only working on the few examples that can be solved analytically. Overall it felt like I gained an excellent understanding of the basics of quantum mechanics, as well as a number of universal mathematical and analytical skills." "...this was easily one of the most engaging, challenging, and rewarding physics courses I have taken at UMD. It was very refreshing to be able to spend less time copying notes and more time absorbing the professor's unique perspective on the topic. I hope other students do not pass up an opportunity to take this course." "...I've never been more excited about a topic I was learning, and I believe that is all because of Dr. Appelbaum."

- Fall 10: **PHYS375 Experimental Physics III (Optics)**
  "Prof. Appelbaum was a good, enthusiastic, and helpful professor." "I'd highly recommend Appelbaum."

- Spring 10: **PHYS401 Quantum Physics I**
  "This professor is by far one of the best lecturers I've had at this university. His lectures compliment the text, presenting material in different (often simpler) styles. He is very well organized (something I've never seen in the phys. department), and has a well-designed website with easily accessible notes/assignments."

@ U. Delaware, ECE Dept.:

- Spring 08: **ELEG646 Nanoelectronic Device Principles**
  "Helps a lot in and out of class...I like the computational methods used in micro- and nanoelectronics, which was taught by the instructor. His lectures help promote my understanding of semiconductor devices to a higher level...Great class, well taught. Intense projects but very helpful in understanding the subject."

- Fall 07: **ELEG340 Solid-State Electronics**
  "Highly knowledgeable...he was a great teacher and really knew what he was talking about...More than willing to provide help or extra material to students who seek it...genuinely cares about how his students perform in his class...very helpful and open to any questions at any time...Professor did a tremendous job teaching the subject. Lectures were very effective and clear. This class made me realize how much I love engineering..."

- Spring 07: **ELEG240 Physical Electronics**
  "Great teacher...effective, and helpful...available for help almost any time...the course has better prepared me for my future engineering courses...the topics we covered were very interesting..."

- Fall 06: **ELEG340 Solid-State Electronics**
  "Professor provides slides with the material and explains the slides well....Professor Appelbaum exhibits great knowledge of the subject material. Lectures are straightforward...Dr. Appelbaum was able to instill a passion for the subject matter...The level of caring presented was appropriate and genuine...overall this was one of my favorite courses this semester..."

- Spring 06: **ELEG/PHYS667 Magnetism and Spintronics**
  "The professor is nice and well prepared. Thank you. . . .He is a good researcher with huge knowledge in this field. Young, energetic and ambitious researcher, I learned a lot in depth from him. . . .The course should be made compulsory for students specializing in Magnetism and Spintronics related fields..."

- Fall 05: **ELEG340 Solid-State Electronics**
  "The instructor is one of, if not the best that I have had. . . He is very knowledgeable of the subject matter and communicates it well. . . He was also very helpful in office hours. . . . Professor's knowledge of the material was thorough. Lectures were well presented. . . Professor Appelbaum is a very good professor. He is extremely smart and knowledgeable of the material in this class. . . Very extensive knowledge of the material. . . I liked Appelbaum's visual teaching method. . . "

- Fall 04: **ELEG667-018/PHYS667-018 Magnetism and Spintronics**
  "Dr Appelbaum is a good instructor, helps students a lot, he supplies them with extra information, he is interested in the subject and is well-prepared. . . it was very beneficial for my research. Now I feel more comfortable in the literature. I got a better understanding of what is going on in spintronics. . . the class was very well structured and included all the basics. In the presentations more advanced topics were included and the instructor made sure the explanations were clear the most important points were made. . . . I enjoyed the course very much and it was very useful. . . ."