Teaching Statement

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Goals for Student Learning

The fundamental goal of physics education is to teach students an appreciation for the description of the world around us that physics provides. I aspire to foster a sense of awe, excitement, and curiosity for this in my students. Understanding the world around us in terms of simple questions such as "What is happening here?", "Why does this happen?" and "What would happen if ... ?" lies at the heart of physics, and I believe that all students are capable of understanding, analysis and evaluation at this level.

Appreciating the concepts of physics complements the quantitative understanding necessary for accurately predicting measurements and solving problems. Physics is very much a problem-solving-based field, requiring logical analysis and careful mathematical argument. In my teaching, I guide students through the concepts of physics and introduce them to the tools that are available to approach problems involving those concepts. With instruction and experience, students learn how to use various tools to solve physical problems. They also learn the limitations of these tools, and develop more powerful machinery as their understanding increases.

Although the teaching of physics focuses on foundational ideas and problem solving skills, there is no doubt that the most important skills for students to develop are life-long skills such as communication skills, critical thinking, organization skills, and meta-cognitive skills, such as learning how to learn. In particular, I hope to directly develop students' communication skills and critical thinking skills, while indirectly helping them with these other areas. The development of these skills is particularly important at the undergraduate level. At the graduate level, courses tend to involve the rapid development of content, which necessitates the prior development of many of these abilities. That isn't to say that these life-long skills can be ignored. In particular, I firmly believe that communication skills are an important part of any graduate course.

One of the major goals of my teaching at any level is to develop the skill of critical thinking, which lies at the heart of "thinking like a scientist". The ability to analyze a situation in its entirety, identify and question assumptions, evaluate the final results in the context of our understanding of the system, and evaluate the effectiveness of the approach are all important aspects of critical thinking. To me, these aspects of critical thinking go beyond logic and problem solving, and are skills that all students benefit from developing, regardless of their intended career.

Teaching Methods

I firmly believe that students learn best when they are engaged with the material. The role of a teacher is therefore to engage students with the material, and guide them through it. The deeper aspects of critical thinking are all espoused in the higher-order thinking skills of Bloom's taxonomy, and students need to grapple with the material to engage in these processes. I aim to foster an environment where students are actively interacting with the material. To do so, I structure my teaching to involve students in the development and application of the subject.

I start my classes by writing an indication of how mathematical/conceptual the class will be on the board, along with a list of the topics to cover. The first few minutes of a class review previous material and summarize important upcoming concepts. This helps students see how the class' material fits into the broader structure of the course. A class typically involves the development of a new concept, the construction of the tools associated with that concept, and example problems that are solved through interactive dialogue.

Physics education research has shown that traditional lectures are notorious for disengaging students. The best way to get students engaged in the material is through interactive learning. Presentations to the class should be punctuated with animations, whole-class responses, discussions and other activities, in order to make the class as engaging as possible for students. Techniques that I use include presenting a problem and asking students to make a prediction, getting students to actually do a calculation in class before we discuss it together, or even something as simple as holding a number of fingers up in front of themselves to indicate either an answer or a level of understanding. Small group activities such as think-pair-share and group discussions are other important approaches to get students thinking, talking, and interacting with the material. Most student learning will occur in peer-learning situations, which I try to promote as much as possible.

A technique that I use to develop higher order thinking skills is to not only ask a question of a student, but to then go on and ask them to justify their answer. "How confident are you in your answer? Does the student next to you agree with your answer? With your justification? Why?" This drill-down type approach exposes assumptions and looks towards the foundational understanding of the concepts involved. Where possible, I try to construct exercises to target fallacious preconceptions and assumptions through cognitive dissonance, which has been shown to be a powerful learning tool. The easiest way to construct such dissonance is to ask students to make predictions. Using physical demonstrations to test these predictions or showing how different predictions are mutually contradictory stimulates further thought. I also try to include examples from my research work to motivate interest in the subject matter through its applicability to cutting edge research, such as black holes and extra dimensions.

Teaching is not only about presenting classes, however, but also about providing high quality supporting materials, such as lecture notes, textbook readings, suggested websites, journal papers, and a well-constructed syllabus. Students have previously responded very positively to such material: "[The notes] are thorough, well-written, and I will hold on to them throughout my education. I loved them. SO great! Jolyon should write textbooks!"

Finally, I think that one of the most important factors in encouraging student excitement is my own level of enthusiasm and passion. I always try to give upbeat classes with a high level of energy, which students react to positively. As one student commented, "The best lecturers convey intense interest in their subject ... Jolyon's lectures had this quality, giving the impression that there was a great deal more interesting material just 'behind' the blackboard, ready to spill out at any time ... It is this quality that makes one want to pursue a subject further."

Use of Technology in Learning

The advent of information technology has introduced a number of new tools that can be used to enhance teaching and learning. While some of these require specialized equipment or classroom layouts, many can be straightforwardly incorporated into the classroom and beyond.

The internet is an excellent resource for teachers. Videos or animations from Youtube portraying physical principles can be used as demonstrations in classes, and online worked examples for introductory level courses can be used as supplemental materials. Activities for use in a range of different classroom environments are also readily available online.

Particularly at the undergraduate level, courses should have a dedicated discussion forum to promote interactive online engagement and peer-learning. Such a forum can be used to supplement office hours. Furthermore, peer-review of written assessments can best be implemented through this medium. Discussion forums can also be supplemented by wiki-style pages, wherein teams of students can be assigned to construct model solutions for different problems.

In the classroom, technology can assist in collecting student feedback, such as through the use of "clicker" or SMS technology, particularly in large classes where other methods become unwieldy.

Technology is also taking the classroom out of the classroom, allowing students to catch up on missed classes through online recordings. Such recordings are also likely to be an integral part of massive open online courses, such as the edX initiative. The distribution of educational materials in this manner, without the opportunity for personal interactions and direct engagement, introduces new challenges in implementing best teaching practices in this environment.

Although I have not yet had the opportunity to apply my thoughts on the use of technology into my teaching, I look forward to experimenting with these different ideas.

Assessment of Goals

The goal of assessment is to evaluate student learning: a student's mastery of the concepts, their ability to use that mastery to solve problems, and their ability to communicate what they have learnt. I know that my teaching has been successful when students demonstrate that they have gained an understanding of the concepts of my course, and can apply the tools I have provided them on problems appropriate to those tools.

Research has shown that the primary way in which students learn physics is to actively engage with concepts and problems. The fundamental form of assessment in my courses is therefore based on problem sets that test their conceptual as well as qualitative understanding. My students receive feedback on their problem sets as well as model solutions, and I encourage students to review graded problem sets to cement their understanding. In my experience, students appreciate this approach: "The TA for my section is GREAT! ... He graded our homework with great patience and left a lot of comments on every subtlety that would help us."

Particularly at the undergraduate level, problem sets should not be the only problems that students attempt. It is important to suggest a variety of unassessed problems for students, including both easier and more challenging problems for appropriately skilled students to engage with.

Communication is an often understated aspect of physics. Published scientific literature employs verbal descriptions and figures moreso than raw equations. Therefore, my courses contain a written assessment to emphasize the importance of communication, as well as to encourage self-directed learning. I use peer-reflection to provide preliminary feedback to students on written assessments in order to encourage critical thinking and self-reflection. Problem sets can also promote effective communication. Somebody who is familiar with the material should be able to gain a thorough understanding of the solution from reading a student's homework. In order to promote this, part of every problem set's grade is based upon the communication of the solutions.

I believe that timed examinations relying on memorization do not accurately assess understanding. I prefer to assign open-book take-home examinations in which students can take the time to think through their responses. This form of assessment also allows for written questions which can probe conceptual as well as quantitative understanding.

Teaching for Different Perspectives

Learning is a very individualized process, and everyone has their own way of going about it. I aspire to promote an environment where students can learn in their own manner. I encourage students to ask questions during class, or if they feel more comfortable, to come to office hours, or interact with either myself or other students online. Students are encouraged to work through problem sets together, as this fosters peer learning. However, I ask students to prepare their final solutions on their own, to help them accurately self-assess their mastery of the material.

Students come from a variety of different perspectives. Some want to study physics and learn all they can about it. Some want to be engineers, prioritizing the important applications of the subject. Others might just be interested in an exposure to the basics. By focusing on the concepts of the course and introducing tools to work with those concepts, students are able to gain the level of understanding that they desire. By exposing students to more advanced concepts, methods and applications, I hope to engage and encourage students with interests in more specialized areas to further self-directed study, without sacrificing attention from the core concepts and methods that all students should master.

Mentoring

I would not be where I am today were it not for the suggestions and encouragement of my advisors. Talented students can have the course of their education affected by having the right information at the right time, and so as others have been a mentor to me, I hope to be a mentor to my students. I hope to be able to guide them through career decisions, presenting the opportunities that they have before them, and encouraging them to follow what they want to do. I hope to inspire students to be interested in physics, and to help guide them through their academic journey. I expect mentoring to be one of the most rewarding aspects of my career.

Teaching Development

My approach to teaching evolves as I gain more experience. I regularly reflect upon my teaching, in order to identify what techniques work, and which aspects of my teaching can be improved. As part of this reflection, it is critical to seek feedback from my students, in order to more effectively understand and engage them. I solicit such feedback both in the middle and at the end of a course, so as to identify issues and benefit the students who have highlighted such, in addition to improving for future courses. Informal feedback at the end of classes can also be helpful to gauge student understanding, using techniques such as "mud cards" or "one minute summaries" (giving students a small amount of time to scribble a couple of sentences on a slip of paper at the end of class). I also hope to develop my teaching from discussions with colleagues and faculty development specialists.

Teaching Experience

I have been involved with teaching at the university level for eight years, primarily teaching tutorials/discussion sections and labs, along with a number of guest lectures. I have also assisted with teaching assistant (TA) training and development, wherein I attended and videotaped discussion sections, providing feedback and suggestions in subsequent debriefings, and made recommendations regarding the training program for new TAs.

Student feedback has been positive. Students have found my teaching to be well thought-out and engaging: "You are a fantastic TA. You were so helpful, always clear, and very well put together. ... You made the material accessible and interesting to me, and I wanted to do it."

My experience in curriculum design has been limited to a hypothetical course in advanced special relativity. However, I had the opportunity to adapt this curriculum into a module on special relativity for an electromagnetism course, for which I presented the lectures. Student responses to this module were very positive: "Your stuff on special relativity was great. Great introduction, very intuitive, clear, easy to follow and understand, with just enough rigor to make things concrete but not lose the concepts. Keep it up!!! Amazing stuff."

Conclusion

Physics excites me because of the beauty of its description of the universe. I am motivated to teach physics by my desire to share that excitement with everybody who wishes to learn. I also firmly believe that the problem solving and critical thinking skills that scientific thinking promotes will play a fundamental role in moving forward our society as a whole. My aim in teaching physics is to teach not only our theory of nature, but also to help develop the skills to be successful in this world.