Statement of teaching philosophy

Alex Richert

I began as a student of astronomy 6 years ago, and was immediately drawn to a career in research due to the broad and fascinating nature of the subject. At the same time, I was drawn to a long-term career as an astronomy educator, for two reasons. First, it is an extensive and beautiful subject that deserves appreciation as much as music or literature. Second, the principles of astronomy, both in terms of the physical principles involved in astronomical phenomena and the skills required to practice it, are useful in a variety of settings outside of the field. As such, I believe that it is important for students in introductory astronomy courses, especially non-majors, to gain an appreciation for the significance of the subject, as well as be exposed to some of the principles of scientific inquiry, mathematics, and so on that can and should be applied elsewhere in students' lives. It is therefore important to me as an educator to identify the most effective methods for conveying relevant knowledge and skills. In the process of identifying these key aspects of teaching astronomy, I have found it helpful to recall my own experiences as a student, and to identify those teaching methods that I found most helpful. Also, I have now taught ASTRO 11, an introductory astronomy lab for non-majors, for four semesters at Penn State, an experience which has further informed my approach to communicating the fundamentals of astronomy. As both a student and an instructor, I have identified three key principles for instilling lasting knowledge and skills: the inclusion of sufficient rigor and depth, the balancing of group participation and individual responsibility, and an emphasis on the "big picture," and on real-world applications of the concepts being communicated.

Providing rigor and depth

Mathematical modeling of physical principles is a central aspect of astronomy. Among instructors of introductory astronomy courses, the extent to which math should be included is a source of much disagreement. I believe that math itself is an important skill, and since it is a fundamental part of all astronomical inquiry, astronomy courses represent an opportunity for students to practice applying their math skills to real-world problems (even while recognizing that most students will not need to apply math to astronomical problems outside the course). Algebra is arguably one of the most important mathematical subjects, and while most college students have taken algebra, their knowledge of it is frequently incomplete, and their ability to recognize and solve problems that call for the application of algebra is often limited. While teaching and tutoring astronomy students, I have found that with some prompting, most students have the ability to solve math-based problems of the sort found in introductory courses. Students improve these skills through repetition, a principle which I have also found true in my experience as a student.

In addition to being useful in areas outside astronomy, I believe that math is an important tool for effectively demonstrating physical principles. In teaching ASTRO 11 for instance, I have found that assigning even fairly simple math-oriented problems— taking averages, solving simple equations— often deepens student understanding of complex concepts. For example, students are more likely to appreciate Kepler's third law (which relates the distance between two orbiting objects and the period of the orbit) if they have applied it themselves, as opposed to simply memorizing "the square of the period is proportionate to the cube of the distance." In a sense, applying mathematical formulae makes many concepts more "real," by showing students the way in which certain quantities can be used to predict other quantities (which is the foundation of theoretical science).

Balancing group and individual participation

Studies have shown that students learn best in small groups, particularly in the classroom setting, and I have observed the benefits of cooperative learning firsthand in teaching ASTRO 11[1]. Students are often more receptive to comments made by their peers, and I have also found that students learn better when they are taught by other students who have themselves just learned the concept in question (it can be very difficult for an instructor who is familiar with the field to communicate a concept to someone who has never encountered it before). Interpersonal communication is also an important skill in and of itself, which is why I include a substantial group participation component in student grades. At the same time, it is important to balance group learning with individual responsibility. I have structured the lab course to reflect such a balance. Students are required to work in groups of two or three, but they are required to complete their own copies of the assignment and to demonstrate independent thinking. This way, students cannot simply let other students do their work for them, and, hopefully, each student will come away with a similar level of understanding of the material (which will not be the case if the responsibilities of an assignment are divided among group members).

Seeing the big picture

I believe that it is better for instructors to teach fewer concepts with greater depth than to teach more concepts with less depth. The latter approach is less conducive to instilling lasting knowledge and skills, and the effectiveness of the former approach has been confirmed both through my own experience as a student and through my experience in teaching the lab course. In reviewing student feedback at the end of each semester, students are most positively responsive to those themes in the class that were stressed clearly and consistently throughout the semester. In the case of ASTRO 11, the most important overall theme is experimental design: asking good scientific questions, designing efficient and practical experiments, and correctly interpreting and reporting results based on the data obtained. I believe that establishing recurring central themes, such as the importance and nature of the scientific method, is the best way to impart knowledge and skills that students will take with them after the semester ends.

I have found that one of the greatest challenges facing students in applying the skills that they have acquired in a course is determining when and how to apply those skills. When tutoring students during homework help hours for lecture courses or while assisting students in class, I will often find that the students *in principle* have the skills to solve a problem, but they are unable to recognize that the problem they are facing is one where those skills apply. For example, a student might solve a problem where they use the relationship between distance, time, and rate to find the period of an orbit, but when the next problem asks them to determine an orbital distance through the same relationship, they will not recognize that the same mathematical and physical principles apply. The first step is to, as much as possible, explain relevant concepts to students in a "first principles" manner so that they understand the fundamental nature of the relevant concepts (or better yet, assist students in developing these explanations for themselves). When I started out as a student of astronomy in my freshman year, one of the most difficult concepts was understanding the relationship between the motion of the Earth through space and the apparent motion of objects in the sky. Students are often taught heuristic or memorization-based approaches such as, "at sunset, you will see the same stars that you saw in the sky three months earlier at midnight." Such approaches do not lend themselves

[1]The book "Active Learning: Cooperation in the College Classroom," for instance, provides an extensive review of research on cooperative learning at the university level.

to fundamental understanding, and students will not be able to manipulate this knowledge when confronted with a new problem regarding celestial motions. However, showing students three-dimensional representations of the Earth-Moon-Sun system and demonstrating the motion of the Earth on its axis and around the Sun from a "bird's eye view" will help to show students *why* the same stars are visible at different times and dates. When students finally internalize this concept, they will be able to apply it to a much wider range of problems. It is more difficult to teach in this way compared with heuristic/memorization-based methods, however it is worth the added effort because it creates a skill set that students will retain, and hopefully be able to apply, after the semester is over. Such bottom-up approaches to learning have been key to developing my own understandings as a student of astronomy, and I work to incorporate this attitude in my instruction.

The future

While I have found my time teaching so far to be enjoyable and rewarding, I hope to expand my teaching skills and seek out new experiences. In particular, I wish to teach an introductory level lecture course in astronomy. While teaching the lab class has occasionally offered me the opportunity to lecture, along with a few guest lectures that I have presented, I believe that the next step in my development as a professional educator is to teach a full lecture course. In addition to lecturing itself being an important skill, I look forward to teaching a course with a great deal more depth, as well as one where I have more control over the content and format of the class. A lecture course is more suited to the inclusion of in-class learning activities that will engage students at a deeper level. I continue to seek opportunities to share my appreciation for astronomy with undergraduates, and impart knowledge and skills that will help students be successful in their own careers and personal lives, and lecture-based courses represent the best opportunity to do so.