Learning Goals and Objectives

When teaching non-astronomers, such as in an introductory astronomy course, my main goal is to get students interested in the material. This means getting them to the point where they are not motivated solely by the desire for good grades, but also by genuine curiosity about the course content. I want them to walk away from my course thinking that astronomy is a worthwhile pursuit and a reasonable investment for (a small fraction of) the federal budget, and I want them to understand science in their everyday lives.

More specifically, in terms of course content, I want all students to understand and remember these four concepts by the end of the semester:

1. The Universe is governed by physical laws, and humans are capable of figuring out those laws through observations and experiments.
2. There is incredible variety in our Solar System and in the Universe. No two celestial objects are exactly the same.
3. Most our information about astronomical objects comes solely from observing their light, but we can get a lot of useful physical information out of light.
4. Space is big – celestial objects are very small compared to the typical distances between them.

I want students to think of science as a verb, not just a noun. To that end, I endeavor to give them some understanding of how we know what we know. For astronomy majors or astronomy grad students, this means that they should have a clear understanding of the relevant physical processes.

Teaching Methods

For an introductory course, the outline of the lectures is fairly straightforward. About a third of the semester is spent on general physics (orbital mechanics, radiation and spectra, telescopes and optics, etc.), and for the rest of the semester, there is a lecture or two on each planet or each class of objects. By discussing the entire Solar System and how we study it, over the course of a semester, I have many opportunities to illustrate the four key concepts.

When giving lectures, I try to interact with the students as much as possible. During discussion sections, I always encourage my students to ask lots of questions. I also have them interact with each other, in pairs or in small groups, when possible – for instance, on worksheets that walk them through the process of determining the properties of exoplanets from transit observations. As a TA for an introductory astronomy course, I found that the best discussion sections were the ones in which the students were doing more of the talking, when they were doing worksheets or review games. Students remember more that way. When in-class time is not enough, I encourage students to go to office hours, so that I can work with them individually.

In order to engage the students, I provide examples from recent space missions and other astronomy-related news. For instance, the meteor strike over Russia in February 2013 provided a great example of why students should care about astronomy, and I used it to illustrate how astronomers study asteroids and meteors.

PowerPoint slides have often been criticized, but I have found them to be effective in
certain contexts. For instance, when discussing geologic processes that occur on various Solar System objects, it is extremely useful to have images showing these processes. I believe that showing real photos of celestial objects resonates with the students, much more than drawing a sketch and saying that it illustrates geologic process X that occurs on object Y.

However, when working through examples of math problems, I think it is much better to write them out on the blackboard or whiteboard. Writing out all the steps of a problem forces the instructor to slow down, which gives the students more time to think about the solution.

Assessing Learning Outcomes

In discussion sections, I like to give quizzes every two or three weeks (on average). My quizzes typically have five simple short answer or multiple choice questions. Many students do not like the quizzes, but I stand by them. Even though my quizzes are only worth a very small fraction of the final course grade, they give students a clear incentive to keep up with the readings, and they can be used to lead into class activities.

I encourage students to check their understanding before they have to be graded on it. For homework assignments, this means working ahead, so that they can come to office hours a couple of days before the homework is due, if they have major questions. For tests, similarly, this means going through the posted practice test in advance, and coming to the instructor with questions. Working ahead in this manner gives students more opportunities to evaluate their own comprehension.

I give homework assignments almost every week. The purpose of the homework is to make students apply the key concepts that are introduced in the lectures, since there is a huge difference between watching the instructor work through a problem and being able to solve that problem without assistance. Doing homework problems is how students bridge that gap.

Questions on the homework assignments are usually short-answer format, with some requiring math. Homework questions are similar, in general, to the short-answer questions on the tests. Homework counts for a quarter to a third of the final grade. In order to give students some margin for error, and to allow for extenuating circumstances, each student's two lowest homework scores (out of twelve) are dropped.

There are three midterms (prelims) and a cumulative final exam, with a practice test posted online about a week before each test. The practice tests resemble the actual tests in terms of format and difficulty. A student who works through the practice tests should have a good idea of what to expect on test day.

In order to reduce test anxiety, and to allow for a student having an off day, each student's lowest midterm score is dropped. However, the final, being cumulative, is mandatory for all. Test questions are mostly multiple choice, and there are typically about five short-answer problems, which usually involve some math.

Math is an important part of astronomy, but when teaching non-astronomy majors, I aim to simplify it as much as possible. Tests include a sheet listing all necessary formulas and physical constants. Math problems on the tests are written in terms of proportionalities, when possible. Calculators and notes are not allowed, but numbers in the problems are chosen to make the arithmetic simple. I mainly care about whether the students have learned enough physics to be able to set up a problem correctly, so most of the possible points come from that.
Inclusiveness

In my experience as a TA, I found that the greatest differences in students' levels of preparation entering the class were due to how well they knew math. Some of them were already quite comfortable manipulating formulas, and others had difficulties understanding what an equation meant (how to explain it in plain English) or setting up the solutions to some homework problems. In terms of how I taught the course, the students' range of math skills far exceeded any other differences. In order to ensure that the expectations regarding their math skills were clear, I spent about half of the first discussion section reviewing math, and I told the students that any of them who were uncomfortable with that level of math should come to office hours, sooner rather than later, so that I could work with them individually and get them caught up. I also explicitly said that they would need to do basic math on the first quiz and on the first homework assignment.

In class, I avoid calling on anyone who has not raised their hand, as that is usually awkward, and it tends to alienate them. I do not want my power as an instructor to isolate me from my students. I try to ensure that students will be willing to talk to me about their concerns. I also have them do surveys to give me feedback after a few weeks of classes, asking what I can do to improve. In essence, I try to show that I care about them doing well in the class.

Professional Development

In the fall of 2014, I took the Teaching in Higher Education course that is offered through Cornell's Center for Teaching Excellence. This course got me to think more concretely about my goals for teaching and research. It has provided a lot of ideas on how to engage students and how to give them a deeper understanding of the material. For me, the biggest takeaway point was the concept that an instructor should try to have the students be as active as possible during classes, as opposed to giving long monologues during lectures. As a TA, I had noticed that activities were useful, but I was not really making a conscious effort to incorporate that principle into my teaching for every class. In the future, I will use more activities in courses that I teach. (Please see my sample syllabus for some examples.)

I am a Junior Member of the American Astronomical Society (AAS), and I typically attend two scientific conferences each year. In 2014, I gave oral presentations on my research at the international Asteroids Comets Meteors (ACM) conference, and at the AAS's Division for Planetary Sciences (DPS) meeting. These conferences provide opportunities for me to meet with collaborators and to hear updates from others who are doing similar research. Conferences also have posters and presentations about education and outreach, and I make a point of looking at those.