Abandoning the Standard Textbook: Field Guide and Sky~Centered Astronomy

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The introductory astronomy course I teach at St. Lawrence University is a "distribution" course that fulfills the University's one-semester laboratory science requirement. Hence it is populated mostly by students majoring in fields outside the natural sciences and a few science majors. The students are from all years of study; first-year students through seniors. Thus I face a broad audience and wrestle with many, sometimes conflicting, student needs and goals.

One arena where I have done much wrestling and have arrived at what I find to be a workable solution for all concerned is that of the textbook. Initially I adopted standard textbooks which I seemed to find much more interesting, engaging, and useful than my students. I have now evolved to use of a variety of texts with which I can more effectively engage the students and guide them towards knowledge of the sky, the process of science, and our current understanding of the universe.

I. Experience with Standard Textbooks

It was with great joy that I first browsed through astronomy textbooks and adopted them for my introductory astronomy course. I began teaching in the midst of the dramatic improvement of the texts, particularly the "one semester" length texts in the late 1980's and 90's. The text, two-color diagrams, and separate "plate" section of color images were replaced with many beautiful full-color photos, clear, multicolor diagrams, boxed "topics for deeper study," and essays of historical and cultural interest throughout the texts. These were accompanied by slide and transparency sets that proved incredibly useful in my classroom and laboratory. The texts were all wonderfully interesting and engaging descriptions and explanations of what we know of our universe and how we learned it. Among the texts I used were those by Snow, Morrison and Wolfe, Corwin and Wachowiak, Pasachoff, Engelbrektson, and Zeilek. I happily assigned reading from the text for each class, used the transparencies and slides from the text in classes, and cited the chapters and sections for further study. For all my enthusiasm about the books, however, my students did not seem to engage with them.

In class I tried to keep the text constantly "before their eyes," yet few students brought their books to class. Gradually I started noticing that the books students did initially bring to class looked quite new in spite of the "used" stickers on their spines. When I browsed the shelves of books sold back to the bookstore after final exams, I often found a sizable fraction of the beautiful astronomy texts stacked there … still quite beautiful.

Puzzled, I sought information about how the students used the text by watching them, surveying them in class, and talking with them, the teaching assistants, and other faculty. A few students thoroughly enjoyed the text, making a home for it on their permanent bookshelf. Some students dutifully read each assigned section. More students than any of us want to admit read only a few parts of the text after the first week or two of the term. For many students, the text was a "back-up" for when they missed class, and thus subtly excused missing class since it was perceived as a source of all the information they needed.

Even when students did read the text, I found that most commonly they "read" the text with the goal of "getting through" the section with little more than glances at the images. The diagrams that were sometimes the main topic of the text often didn't even get much of a glance! Happily assuming that they had read the text in the full sense of the word "read," I would discuss diagrams in class only to discover that many of the students didn't have the first clue as to their meaning.

Hence the students didn't find the reading that they did accomplish particularly useful since they found the material confusing in spite of their reading effort.

It dawned on me that one thing at work in this situation is the difference in how I and most of my students approach "texts." I, as a scientist and experienced learner, tend to focus primarily on images, diagrams, and equations and skim much of the prose. I can find it tedious and burdensome to learn from a text that is just prose. Most of my students are just the opposite, focusing on the prose and skimming or ignoring the images, diagrams, and equations (particularly the equations!). This was not just a characteristic of just those not majoring in a science as I realized that my introductory physics students, almost exclusively science majors, also tended to skip the images and diagrams (though they tended to develop great skill in equation-hunting through text they had not the least intention of reading!).

Aware of this difference in our approach to texts, I realized that I had to engage the students with the text — the images, diagrams, equations, and technical information — in class. It struck me that my task with these students was not to use their ability to read the text to teach them astronomy, but to teach them astronomy in the course of teaching them how to approach and learn from scientific, technical text.

The realization that I had to teach the students how to use the text naturally led me to question what text I wanted to focus on. Since this is the last science course (and only college-level science course) that most of my students will take, I wondered what I could offer them that would be useful and engage them with the natural world and science for a lifetime. I looked to their interests for my answer.

II. The Sky: Scientific Observing for Beginners

On the first day of class it is my habit to have the students stand to introduce themselves and state their reason for taking the course[1]. The majority freely admit that they are fulfilling the science requirement with the most conveniently-timed or least abhorrent course they could find. More than a few, however, add that they are interested in learning about the sky. By this they mean the constellations and star names (a reflection of the limits of their exposure to the breadth and depth of astronomy rather than a paucity of their interest in the natural world). Thus I decided to begin the course by focusing on this interest of theirs, and using it to lead them to deeper knowledge and curiosity.

The first quarter of my course is focused on the patterns and motions of the sky: the names and positions of constellations and stars, the diurnal motion, the annual motion of the sun, and the motions and phases of the moon. The beautiful texts I had adopted in my early years of teaching had given these topics only a cursory treatment. This reflected the changes in the interests of the astronomical community as the advances in instrumentation and computing made us much more physicists than astronomers. For astronomers, interest in the naked-eye sky atrophied to the skeletal structure of positional coordinates in the face of the incredible wonders physics revealed in the depths of the sky and the breadth of the spectrum. To my students, however, for whom the turning of the constellations, the annual oscillation of the azimuth of sunset, and the marriage of elongation and phase of the moon were abstracts, recitations of data from astronomical instruments as simple as photometers and spectrometers sounded little different than the incantations of a priest. For the course to illustrate science that is based on reproducible observations, I realized that the students needed to produce their own observations of the naked-eye phenomena I had initially thought too obvious to warrant precious class time. Since schedules and northeastern skies limit our opportunities to hold class or lab sessions under starry skies, I needed resources they could use on their own with only a little initial guidance from myself and the teaching assistants.

II. The Peterson Field Guide as a Primary Text

[1] A happy privilege of the small class size at a private liberal arts college!

Having broad interest in natural history as well as physics, it is my habit to investigate a field guide as the first step in learning about some aspect of nature. It seemed appropriate, then, to introduce students to both astronomy and learning about nature by through use of a field guide. The field guide is particularly helpful to my purpose of teaching how to approach a technical text since it is specifically constructed for the way a scientist reads a text: primarily images and diagrams that the prose supplements.

As an observing guide, the field guide serves very well with sky maps for dates throughout the year both with and without lines showing the constellations. The sky is also shown in detail in the atlas charts, allowing students to locate deep-sky objects we study. By the end of the semester, students are pointing out the positions of Cyg X-1, the Ring Nebula, Sgr A, M31, and M42 to their friends and describing the nature of the objects often hidden from their eyes by space or light pollution. This makes black holes, nebulae, and galaxies more real to them than any slide shown in class.

The field guide also has a number of graphic timetables for stars, nebulae, and planets. Hence with a little help in class and class observing sessions early in the term, the students learn to use the field guide on their own, increasing in confidence and proficiency as the term progresses. More than a few students have expressed surprise at their ability to interpret and extract useful information from diagrams that initially overwhelm them. This sort of confidence serves them well beyond the astronomy course!

Tables of information about stars, planets, and other objects form a data base which I have them use in a variety of calculations in class, lab, and homework assignments. We look up the positions of the sun, moon, and planets for different dates, find their elongations and determine when we can go look for them. We calculate azimuths of rising for Sol and other celestial objects and how long they'll be above the horizon. From the tables of the brightest and nearest stars, we plot their positions on the HR Diagram and calculate their temperatures, luminosities, and radii. These calculations which we must work through as a class, nurturing the mathphobes past their anxiety, are able to transform the columns of numbers into physical realities the students can comprehend, and in some cases, observe. This gives them a small glimpse of both the power and complexity of science (and math) as it helps them experience science as an approach to learning about the universe, not the reservoir of "answers" non-scientists sometimes perceive it as being.

To encourage more independent work and familiarity with the field guides, I allow the students to use them as references during the course exams, as well as requiring them to use it for part of each exam. Since many of them arrive in my course with surprisingly minimal skill in use of a reference book (they have to be told to use the index and read the table headings!), development of this skill seems a worthy goal of the course.

After final exams, when I browse the shelves of books sold back to the book store, I find fewer than 10% of the field guides have been sold back. This represents a victory to me in having taught them something useful in one semester of science.

III. Raymo's 365 Starry Nights For Sky-Centered Astronomy

To provide explanations of the information that is so well presented in the field guide, a supplementary text is needed. Chet Raymo's 365 Starry Nights explains the coordinate systems, physical phenomena, historical developments, and mythical contexts of astronomy in a sky-centered, clearly illustrated, engagingly written text. As a "popular" science level book, it is unparalleled in the information covered that includes the HR Diagram, stellar evolution, precession of the equinoxes, star and galaxy clusters, and stellar magnitudes. Topics not usually approached in this genre. Raymo's diagrams, particularly those of the Earth-bound observer viewing the sky, are some of the clearest illustrations of concepts, phenomena, and coordinates I have seen.

In readability, particularly for the style with which my students approach texts, Chet Raymo's work is outstanding. Students "running their eyes over the text" end up engaged with the material in a way they never report being engaged with a more typical astronomy text. Each semester, students seek out more of Raymo's books having found this one interesting and readable.

365 Starry Nights is organized chronologically, from January 1 to December 31 focusing on the constellations visible during each segment of the year. Thus there is some independence of the different sections, allowing use of the coordinate explanations in "October," or diurnal motion explanations in "May" to be used at the beginning of any semester. However, Raymo also manages to tie the book into a whole, building up the body of astronomical knowledge he presents, starting with Orion and the apparent magnitude scale through variable stars, the HR diagram, stellar evolution, and galaxies.

My use of this text is two-fold. I use sections of it as independent explanations of astronomy, but primarily, I use it in parallel with weekly observing assignments focused on the current evening constellations. Each semester, then, I assign a bit more than half of the book. Most of the students find it useful and engaging enough to keep with the intent of learning the sky of the rest of the year. Thus the stack of these books sold back to the bookstore after final exams is also quite small. Another victory.

IV. Supplemental Articles and Essays

The primary topic not particularly accessible through sky-centered texts is cosmology. For this I am forced to use supplemental material from different sources. I have used articles, essays, and videos by Timothy Ferris, John Gribbin, James Trefil, and other popular-level authors (see the Bibliography). These are written mostly in the style most amenable to the students' approach to reading, give a starting point for my classroom and laboratory discussions on cosmology, and serve to acquaint the students with availability, readability, depth, and variety of material available for people with interest, but little expertise in science.

Throughout the astronomy course I am open to the students about my goal of fostering life-long astronomical and scientific interest in them by exposing them to these different authors and materials. At this point, however, I have only a few anecdotal cases where I know I succeeded in this.

V. The World-Wide Web for the Latest Information

The explosion of new astronomical information and images in the past decades, has motivated some publishers to offer yearly editions of textbooks. Since the texts I use are not annual editions (though the field guide does carry dated information and with periodic new editions), the web is the tool that allows me to bridge the gap between the printed texts and current information. I have just begun to use it in the classroom, the lab, and for homework assignments. Its power to seize the attention of students is remarkable. With a recent significant computing upgrade in the SLU astronomy lab, I intend to increase my use of the web.

By use of the web, we can access the latest images of celestial objects from various observatories, daily spectral images of the sun (regardless of the clouds in northern New York!), diagrams of the solar system for any date with an ephemeris for any geographic coordinates, other astronomical or historical information, and even art work depicting astronomical scenes too distant in space or time to photograph.

As with the supplemental materials, by use of the web in the course, I strive to nurture students' interest in astronomy through use of a medium that is likely to remain available at their fingertips throughout their lives.

VI. Selected Bibliography

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