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What Should College Students Learn?

Phases and Seasons? Is Less More or Is Less Less?

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Abstract

Editor’s Note: One of the key goals of the Astronomy Education Review is to encourage open discussion about issues of interest to astronomy educators. We begin our series of opinion pieces with a contribution by veteran educator and author Jay Pasachoff on the subject of what we should be teaching in the introductory college astronomy course. We invite our readers to respond to his position and also to submit opinion pieces on other controversial topics. (Please see the "How to Submit" section of our site.)

1. Introduction

What should students learn as a result of a non-majors college course in astronomy? Should most or all of the course bring them to a high level of understanding of "traditional astronomy" such as phases of the Moon and the cause of the seasons? After all, some evidence shows that many or most students now come out of college courses without understanding these fundamental matters. On the other hand, should our goal be that they come out with some appreciation of the kinds of astronomy that are now carried out by today’s astronomers? Should we try to teach them about interstellar matter or black holes or quasars, or even exoplanets and the expansion of the Universe?

Throughout the year 2001, a battle raged in print and at meetings over what is appropriate to teach in college astronomy courses. The battle is part of a cleft, as I see it, between the main group of teachers and researchers who belong to the American Astronomical Society and a newer group that I might call "the educational establishment." The discussion led to a back-and-forth set of articles, letters, and an editorial in *The Physics Teacher* (hereinafter TPT), a worthy journal devoted largely to high-school and college education in physics and astronomy. Since few teachers of astronomy read that journal (which is distributed to members of the American Association of Physics Teachers), it seems appropriate to raise the

issue and to summarize the discussion here in the *Astronomy Education Review* (AER).

Furthermore, since only two of the many letters apparently received by the editor appeared in TPT, AER seems an appropriate place to continue the discussion and to find a place to display various comments and responses.

2. The Background of the Phases vs. Contemporary Astronomy Discussion

The wonderful *Private Universe* film (Schneps and Sadler, 1988) is a symbol of this controversy. That movie shows Harvard students in their graduation robes giving false or inadequate answers to questions about phases of the Moon and the cause of the seasons, as well as high-school students repeatedly misunderstanding the phenomena. Sadler and others seem to have concluded that since students don't understand phases and seasons, even after being taught them, there is no good to teaching anything more complex. In particular, they seem not to be willing to teach contemporary astronomy, since they claim students just won't understand it. I disagree strongly with that position.

Most professional astronomers are unaware of the depth of this problem and of the extent of the discussion that has been going on for a decade or more. A dozen years ago or so, recommendations for what to teach on a variety of elementary and high-school grades were formulated both by a division of the American Association for the Advancement of Science, as their Project 2061 (with the goal of bringing American students up to snuff in science by the time Halley's Comet returns in that year), and by the National Research Council, the operating arm of the National Academy of Sciences. (Project 2061 started in 1985, publishing its report *Science for All Americans* in 1989 and *Benchmarks for Science Literacy* in 1993; see their Web site at http://www.project2061.org/. The National Research Council published *The National Science Education Standards* in 1995. It is available free on the Web at http://www.nap.edu/readingroom/books/nses). An earlier project was *Scope, Sequence, and Coordination* of the National Science Teachers Association (NSTA).

The resulting books and tables are not curricula, but they do govern the curricula that are being made. Astronomers had inadequate representation in the committees drafting the materials, and the Education Committee of the American Astronomical Society protested the standards at a stage when drafts were available, but our comments were ignored. The result is that no modern science--such as mentions of galaxies--are recommended before 9th grade (see Pasachoff, 1994, 1996, 1997, 1998).

The new *Atlas of Science Literacy* (2001), a co-publication of the AAAS's Project 2061 and the NSTA (http://www.project2061.org/tools/benchol/bolframe.htm, click on 4. The Physical Setting, then on the box View Research) states: "The ideas 'the Sun is a star' and 'the Earth orbits the Sun' appear counter-intuitive to elementary-school students (Baxter, 1989; Vosniadou & Brewer, 1992) and are not likely to be believed or even understood in these grades (Vosniadou, 1991). Whether it is possible for elementary students to understand these concepts even with good teaching needs further investigation."

The idea that one shouldn't even try to teach abstract concepts on any level is one with which I don't agree, yet the educational establishment is pushing it not only on "el-hi" grades (the term for Kindergarten through 12th grade education), but also for college courses. Since the problem, in my view, lies not only in the recommended topics themselves but also in how objections to the educational establishment's views

have been treated within the Education Division of the AAS and by the editor of TPT, it is instructive to view the current controversy in chronological order.

3. History of the Current Discussion

At the January 2001 joint meeting of the American Astronomical Society and the American Association of Physics Teachers, at a highway hotel outside of San Diego, we had a pre-meeting Sunday session on education, *Astro 101--A Continuing Dialogue*, organized by Gina Brissenden, a consultant to the AAS Education Division. I commented on the desirability of teaching about contemporary astronomy, a theme of mine since the first edition of my college text in 1977 and, in turn, since I began to teach general college astronomy in 1972.

But I faced some people, for the most part from the education side rather than from the astronomy side, who I think drew the wrong conclusion from *Private Universe*. They conclude basically that teaching more complex conceptual matters is not appropriate since students won't understand them anyway. I conclude that we should be teaching the conceptual matters about the Universe as we understand it today, and that the "traditional" phases or seasons are not sufficiently important to know that they should be used as a roadblock.

After the session, Tim Slater, now appointed to a regular position in the Astronomy Department of the University of Arizona with a specialty in education research, asked me to summarize my views for a column he supervised for TPT. Then, at another session of the AAS/AAPT meeting on *The Impact of Physics Education Research on the Teaching of Astronomy*, I was aghast to find that I had not been exaggerating when I said that phases and seasons were being overstudied and overtaught. There was actually a paper entitled *Students' Initial Model State of Lunar Phases* (Lindell Adrian & Bao 2001). As I wrote in my piece for TPT (Pasachoff, 2001), "Do we gather the country's best astronomical researchers and teachers to discuss that subject? Is investigating the teaching of phases the best use of NSF education funds?" I continued the discussion at an Astronomy 101 panel at the June 2001 Pasadena AAS meeting.

To my surprise, even though I had been asked to do the piece by the person responsible for the TPT Astronomy Education column, the TPT editor refused to run my piece until he had a response to it to run immediately following. I take the resulting delay to be a sign of resistance of the educational establishment to contemporary views. So it wasn't until the following September that my piece ran, with a heading of *In My Opinion*, and it was followed by a piece *What Should Students Remember?*, by Daniel Caton, an astronomer at Appalachian State University (Caton, 2001). Actually, Caton basically agreed with me. He wrote, "I have settled into a mix of extremes: I teach Earth's seasons and lunar phases as usual, but I reserve a large part of the course for interesting topics of modern astronomy as well as side trips into current topics in the news."

4. Reponses to the Discussion

The December 2001 issue of TPT devoted a lot of space to the issue I had raised. My position was under attack to the extent that the attack even seemed personal! First, two Letters to the Editor appeared. Paul Camp of Georgia Tech wrote *What's Wrong with this Course?*, and Mike Seeds of Franklin and Marshall wrote *More on Teaching Intro Astronomy--Science as a Way of Knowing*. Camp misrepresented my position, in my view, and wrote that my idea that "an intro astronomy course should 'expose students to

the exciting wonders of modern astronomy' . . . is a retrograde notion, reflecting a belief that knowledge said is knowledge transferred, and is inconsistent with research on human learning." He goes on, "How will his students begin to understand Hubble's law, an idea remote from their experience and existing knowledge? In what sense is that teaching?"

I think that here we have a clear statement of the problem, and that it reveals an important cleft between the positions held by most members of the American Astronomical Society and what I am calling the educational establishment. If they are right, many of us are doing the wrong thing in what we teach. I don't think they are right, but they shouldn't be ignored since they have great influence on what will be taught in the future. Indeed, I think that if they succeed in taking over high-school and beginning college education with fundamental but unexciting topics, we will have fewer students enjoying astronomy and coming away with the desire to follow astronomy research in newspapers, in magazines, and on television for years to come. Secondarily, we would also have fewer students coming to higher-level courses, so professional astronomy will suffer in the long run.

Mike Seeds, who shares with me the experience of being a textbook author, had a more reasonable point of view in his letter. He has "revised [his] teaching and writing to focus on how, rather than what, we know."

> [His second goal is to] learn about our role in the origin and evolution of the Universe. [They] may not be lessons of practical value, but they will enrich the lives of our students.

But inspiration and enrichment don't seem to be part of the educational establishment's position.

The Editor of TPT, Karl Mamola of Appalachian State University, then chimed in with an editorial entitled *What and How to Teach*. He writes, "At first I was a bit skeptical about devoting two whole pages to the opinion pieces by Pasachoff and Caton in our September issue. But judging from the number of thoughtful and spirited responses we've received, it was space well used." Unfortunately, when I asked for copies of the responses, TPT declined, saying essentially that it was not their policy to release unpublished letters. That's too bad! I would like to know what all those writers had to say. If any of them are reading this piece, I hope they will send me copies of their letters.

Finally, later in the issue, Philip Sadler of the Science Education Department of the Harvard-Smithsonian Center for Astrophysics had an *In My Opinion* piece entitled *Choosing Between Teaching Helioseismology and Phases of the Moon* (Sadler, 2001). He writes, "Pasachoff and others may prefer to dismiss the disturbing truth that mastering basic concepts is difficult for students and complex topics almost impossible without learning the basics by focusing on phases and seasons." He adds, "The list of topics in introductory courses should be pruned back to those that have both terrestrial and astronomical application, such as angular measure and spectroscopy."

Sadler and I agree on one point: "For the majority of students in our survey courses, ours is the last science course they will ever take." But he concludes, "Let's leave them with an experience that makes science relevant to their future lives." I have concluded that "relevance" is often a code word for omitting modern topics of astronomy, on the grounds that they are too remote and abstract to be "relevant." Indeed, I

decided that since I am spending my sabbatical year on the diagonally opposite corner of the Harvard-Smithsonian Astrophysics from Sadler (perhaps dramatically illustrating our differences), I should go to see him instead of having our differences aired only in the pages of *The Physics Teacher*. We did have an interesting hour's talk, and even walked in together to a meeting of the Education Division to the amazement of those assembled. But I held out for having a goal in each astronomy course of inspiring students, and Sadler said, "Inspiration is overrated."

5. Further Discussion and An Invitation to Respond

Though I think it is usual for the writer of an original piece to have the chance to have the last word in response to critics, the TPT editor wouldn't publish my response until he had a response to it! So, only later in the spring did my response to Caton, Camp, Seeds, Mamola, and Sadler appear (Pasachoff, 2002). As I indicated, Caton basically agreed with me. I think Camp misrepresented my position; I don't replace "Shakespeare and Chaucer with Toni Morrison and Donald Barthelme." I do not say that "science is a mere catalogue of facts." But I do think that there are many examples from contemporary astrophysics that can be used to teach both science and logic. Camp (2002) also replied, incorrectly stating that "Pasachoff is not cognizant of the rigorous data that shows that, for the overwhelming majority of students, 'discussion' does not lead to learning." He seems to miss my points about the value of breadth and inspiration, and does not acknowledge that students in my classes are "doing science" in labs and during observational activities, but that there is more to their course than the limited set of topics he seems to be willing to cover.

My response was followed by a response to it by Sadler (2002), who writes: "Jay's 'main themes' are astronomical history, the methods of science, and contemporary research, topics that serve to 'enrich the lives of our students.' This high-sounding rhetoric held sway prior to filming of *A Private Universe*, before researchers found that misconceptions outlive even the most 'inspiring' of college science coures. Jay, if college astronomy students can be so muddled about 'elementary school stuff' like phases, what on earth do they make of solar neutrino experiments?"

A symbol of the current discussion is the educational establishment's phrase that "Less is more." I don't always agree with that slogan, which means often that so much should be left out of current high-school and college courses that only process and little content remains. Sometimes less is more, in that we shouldn't overload the course. But sometimes less is less. If students come away with only process, and dull topics whose explanations were known hundreds or thousands of years ago, we are losing their place in science literacy and losing our chance to help them appreciate how wonderful it is to continue to work to understand the astronomical Universe.

In my TPT response, I express my regret at Sadler's position from his first piece, but state that "at least here we have a clear statement of this absolutist position. I don't think we have to choose. My own feeling is that we have to teach what he is teaching, but we also have to teach more--we have to inspire students to understand the Universe as best as it is known today." And I point out that "we shouldn't be teaching exclusively to the least common denominator." Different students respond in different ways. For example, Bill Gates was recently quoted, in explaining how he got interested in medical philanthropy as, "I started out poorly because my biology teacher in high school made biology very uninteresting. I didn't like dissecting frogs, or test tubes; it all seemed too hands-on from my point of view." (*The Independent*, UK, February 27, 2001, p. 16, from a speech given at the Ninth Annual Retrovirus Conference, Washington, DC.) So the hands-on research we tout so widely isn't for everyone.

I hope that my colleagues realize the danger that we are in from educators trying to prune so much astronomical content from the courses that reach today's students. I hope that in AER we can continue to have a good discussion of just what is desirable for non-major college students to learn in their courses.

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124 - 130