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Preparing High Quality Professionals for Science Outreach

My Vexation

Because I am actively involved in several aspects of astronomy (i.e., research, teaching, and informal education) I have become acutely aware of a discrepancy between the focus of astronomy researchers and the focus of astronomy educators. Recently, with the indispensable help of my undergraduate students, I compiled the K-8 astronomy science education standards from 48 states and the District of Columbia. We found that the astronomy topics in the K-8 core are overwhelmingly 'Keplerian' — e.g., phases of the moon, the cause of the seasons, etc. Students are required to demonstrate a solid comprehension of the underlying geometry, but an understanding of the actual physics (i.e. gravity, angular momentum, etc.) is not required. It seems that in most states a student is considered well-educated in astronomy if, at the end of eighth grade, they have an understanding of astronomy comparable to Kepler's.

Nearly all of the astronomy education research thus far has focused on how well students understand Keplerian topics. This research has made clear that students often arrive at college bearing misconceptions about these topics that persist, often through their entire college education (think 'Private Universe'). Research on student understanding or misconceptions of post-Keplerian (even Newtonian) astronomy is conspicuously absent.

Research in astronomy, on the other hand, focuses entirely on post-Keplerian topics: stellar evolution, planetary studies, black holes, supernovae, the Big Bang, etc. These are topics that students (and teachers and researchers!) consider 'cool', 'interesting', or just plain 'far out'. Our understanding of these phenomena deepens nearly monthly, as new data or more complete theoretical models shed light on these phenomena. These topics are also sometimes controversial. The controversial and 'way cool' aspects of these topics mean that they are by far the most reported astronomy topics in the news, and therefore the ones the average citizen will most commonly hear about.

I am vexed by the lack of modern astronomy topics in science education for several reasons. First, I think we are missing out on a tremendous opportunity to bring the excitement of science to students. I have yet to meet a sixth grader who does not have burning questions about black holes.

Second, by concentrating so completely on Keplerian astronomy, we lose out on the power of astronomy as a demonstration of several of the stated over-arching goals of science education. The interdisciplinary nature of modern astronomy, which incorporates physics, chemistry, and even some aspects of biology, is a great opportunity to show students that the boundaries between sciences are not as distinct as they are generally presented. Many of the controversies associated with astronomy topics are less emotionally charged than, say, evolution or stem-cell research, and can help students to understand how science deals with controversy before they are asked to confront topics with which they may be more personally involved. This helps develop the critical thinking skills they need in other arenas in a non-threatening way.

Third, pre-Keplerian astronomers, as with most pre-Keplerian science, showed very little diversity. However, there have been many, many women heroes in astronomy, as well as many famous astronomers from the Indian subcontinent, South America, Mexico and Asia. Students of every kind will find an astronomer 'like them'.

Finally, astronomy is a living, vibrant science, conducted by an amazing variety of people around the world today. I would argue that it shows some of the best qualities of humanity in that it requires extensive international cooperation to accomplish, and that cooperation continues for decades. The ability of astronomers to agree on goals and methods for achieving those goals, and then to come together to chase those goals over decades is a triumph of the scientific community, and a terrific blueprint for accomplishing enormous tasks of all kinds. There is more to be learned from modern astronomy than science.

My Venture

Put entirely too simply, my goal is to increase the profile of post-Keplerian astronomy for everyone. Well, that's pretty broad. When I try to think of an approach to this goal that might be successful, I immediately begin to break it down into several distinct areas of impact: astronomy education research, K-8 core curriculum, and informal education (planetariums, museums, etc.). Probably, I ought to concentrate on one of these for now!

Astronomy teachers and professors ask legitimate questions about student understanding. Does it really matter if students understand about the phases of the moon? Can they go on to understand about black holes without

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being able to explain the seasons? What kinds of misconceptions do students hold about post-Keplerian astronomy? How deeply entrenched are these ideas? Astronomy education research is underway at several institutions. I am not trained in the field of education research, and so I do not see myself making a huge impact here, aside from keeping up to date, and making myself annoying by always asking 'What about post-Keplerian topics?' That should be fun.

My understanding of how K-8 curricular standards are developed is quite weak. I imagine (based on no experience) that several people get together in a room, close the door, and then write down what they think are the most important things for students to understand. They boil these down into the simplest possible statements of content areas, publish them in some manner, and move on to assessment issues. Presumably, there's a plan to revisit these standards at intervals, but how or whether that happens is a mystery to me. Presumably, the people involved are informed about science education research, and think hard about developmental levels, conceptual change theory, and other topics along these lines. Presumably, someone thinks about the teacher training process. When new standards are published (I know this happens sometimes!), how do we ensure that teachers are taught competently about these standards, so that they can teach them competently to students? Clearly, I first need to get a handle on how the whole K-8 curriculum is handled before I can have an idea of whether it could be changed. Astronomy education research at the K-8 level may have an impact here, provided that people who set the standards are informed about it.

The place where I might venture to have a direct impact is in the field of informal education (museums, planetaria, etc.). Informal education in astronomy tends to focus almost entirely on planetary astronomy. While this often diverges from Keplerian astronomy (we know MUCH more about Mars than Kepler did!), the focus is still on the phenomenological approach that is so apparent in Keplerian thinking. Visitors to the typical planetarium or astronomy exhibit in a museum are often informed about the temperature of Mars, or the pressure at the surface of Venus. Distinctly absent are explanations of (a) how we know these facts and (b) why the phenomenon exists (i.e. what's the physics behind Venus' appalling surface conditions). I suspect that this is due, at least in part, to the training of the informal education specialist.

Who are these informal education specialists? At a recent American Astronomical Society meeting, there was a special session on scientific visualization. During this session, it became clear that two distinct groups populate the informal astronomy education field: artists who dabble in science, and scientists who dabble in art. Perhaps not surprisingly, these groups have a very difficult time talking to each other! The artists kept complaining that the scientists didn't care about visual impact, and getting the 'point' across, and the scientists kept complaining that the artists didn't care about getting the science right. None of those present had actually had any formal training in informal education (most had no formal education training at all). Conversations with scientists and educators in other fields imply that this is a problem that affects all sciences, not just astronomy.

Maybe the answer is better-trained informal educators. The cross-section of these individuals with teachers is large. In addition to school field trips, planetaria and museums often run teacher-training workshops in the summer. Well-prepared informal science educators might be able to help bring teachers up-to-date on modern science, in addition to having a direct impact on students and the general public. The enthusiasm generated by the informal science community may even be able to overcome the inertial emphasis on Keplerian astronomy currently seen in the K-8 system. It worked for dinosaurs, maybe it will work for astronomy!

These observations have me mulling over the idea of a Master's Program in Public Outreach. The basic idea is to have science-trained bachelor's students (who should have a solid science background) enroll in a program where they (a) receive training in visualization and presentation techniques, (b) obtain training in technical and journalistic writing (c) develop understandings of learning theory, conceptual change theory and science education, and (d) participate in field experience within informal science education environments. I'm thinking of a two-year program, with an internship in one of our many local science museums, and a Master's 'thesis' that is a project in the field---an exhibit, planetarium show, children's book, etc. I would love to know what other people think of this idea, and what ideas others might have for what a really great Public Outreach Master's Program would look like.