Chapter 21

Space Science Education in the United States: The Good, the Bad, and the Ugly

Andrew Fraknoi

As an astronomer and astronomy educator, I do not have any original historical research to report for this volume. Nevertheless, my hope is that this brief summary of some issues in the uneasy relationship between space science and education in the United States may be of use in getting historians and general readers interested, concerned, and perhaps even upset. A much more detailed overview of the state of astronomy education can be found on the World Wide Web.[1]

The history and societal impact of space science education in the United States is difficult to sort out from the complexities of education in general. If it were an experiment, any scientist would throw up his hands in despair and say, "There are simply too many variables!" For example, what was more important in determining the attitudes of today's U.S. adults about the space program:

- The various science education reform curricula in the 1960s that grew partly in response to Sputnik, or the growth of television as a pervasive, pernicious, and pseudo-educational medium?
- The Shuttle accidents and subsequent revelations, or the disintegration of the U.S. family due to the rise of divorce rates and single-parent families?
- The success of the Mars Exploration Rovers, or the consistently low salaries we have paid science teachers when compared to other professions requiring similar training?

These are very hard questions to answer.

To prepare this essay, I wrote to about two dozen experts in the field of space science education to see if they could help me find the most important parts of the literature on the impact of spaceflight on education. With one exception, they all wrote back quickly and courteously—to inform me that they knew of no such literature but that they were looking forward to our conference starting one.

1. See Andrew Fraknoi, "Astronomy Education in the United States, 1998; available online at *http://www.astrosociety.org/education/resources/useduc.html* (accessed 20 October 2006).

Has the Space Age affected education in the United States? It is a romantic notion that it has. Everyone cites great anecdotes, memoirs, and TV shows such as *How William Shatner Changed the World*. But no one has been able to tease out the effect of the space program from the myriad other factors that affect our educational system. And, as educational researchers are fond of pointing out, "The plural of anecdote is not data!"

A recent paper in *Astronomy Education Review* reported that no research could be found that looked at teacher knowledge of astronomy across grade levels and multiple astronomy concepts.[2] In the absence of relevant data, what I would therefore like to do, in the brief space I have, is to get the reader thinking just a bit about a few issues in the relationship between space science and education.

A Brief History of Space Science Education in the United States

Astronomy was a subject taught in U.S. high schools toward the end of the nineteenth century because it fit with the *mental discipline model* of curriculum.[3] Like Latin and Greek, astronomy was supposed to be good training for student thinking, whether students needed it later in life or not. This approach soon began to unravel as the schools became less elite and more practical, and colleges demanded more practical knowledge from high school graduates.

Also, school curriculum under the mental discipline approach was hard, repetitive, and boring. In 1913, Helen Todd, whose job was to inspect factories, surveyed 500 children who labored there under difficult conditions. She asked if, economic circumstances permitting, they would not rather be back in school. Four hundred twelve out of 500 said no. They preferred sweatshops to what she called the "monotony, humiliation, and cruelty" of school.[4]

In 1893, a Committee of Ten, set up by the National Education Association, was asked to report on a uniform curriculum for high schools that a variety of colleges could accept. (Before that, all colleges had set their own requirements and the situation was a mess, much like many of the local K–12 standards we have across the United States today.) The committee, chaired by Harvard President Charles Eliot, had many suggestions and many critics. But for us, one consequence was that they defined the main science topics as biology, chemistry, and physics—and

2. Eric Brunsell and Jason Marcks, "Identifying a Baseline for Teachers' Astronomy Contents Knowledge," *Astronomy Education Review* 3, issue 2 (October 2004–April 2005): pp. 38–46, available online at *http://aer.noao.edu/cgi-bin/article.pl?id=119* (accessed 27 March 2007).

3. Herbert Kliebard, *The Struggle for the American Curriculum,* 2nd ed. (New York: Routledge, 1995). See Chapter 1 for a nice introduction to the curriculum in the nineteenth century.

4. Ibid., p. 6.

astronomy only as an elective. It soon began to slip into the noise of the demands on American curriculum, and today, few schools teach a separate astronomy class (and then only as an elective).[5]

It is true, as those who follow the politics of the space race know, that the National Defense Education Act of 1958 (the reaction to Sputnik) increased the amount of science and math being taught and led to some interesting curriculum studies and reform, especially in elite schools.[6] But it is not clear that things in science education got better in the long run. Other factors besides curriculum play an ever-increasing role in the education of our children. Teacher training or lack of it, latch-key kids, peer and media pressure against seeming smart (think of films such as *Dumb and Dumber)*, MTV—all have combined to "beat us" far better than the Russians ever could have.

What space science students do get in our schools today is mostly found in general science, Earth science, and physical science classes in middle school and high school. Numbers are hard to come by, but many factors are contributing to a decline in the amount of space science being taught. Let's consider just three of them.

First is "the less is more" movement among science educators and those who train them. This movement, which says we should teach fewer topics in science but in greater depth and with more hands-on activities, is generally a positive development in getting students to learn what real science is about. But there are already very few hours devoted to science in the curriculum. Generally, when time is short, basic biology, chemistry, and physics take precedence.

Next we have the lack of trained teachers to teach science. During the 1999–2000 school year, only 55 percent of high school students received physical science instruction (chemistry, Earth science, and physics) from a teacher with a major or minor in physical sciences. At the middle school level, only 18 percent of students received physical science instruction from a teacher with a major or minor in physical sciences. Nearly 50 percent of middle school students received physical science instruction from a teacher without a major or minor in *any* science or science education field.[7]

5. Kliebard, *Struggle for the American Curriculum*, discusses the Committee of Ten in his first chapter. For more on the effect of this group on astronomy teaching, see Jeanne Bishop, "U.S. Astronomy Education: Past, Present and Future," *Science Education* 61, no. 3 (1977): p. 295.

6. Arthur S. Flemming, "Government Science and the Universities: The Philosophy and Objectives of the National Defense Education Act," *Annals of the American Academy of Political and Social Science* 327 (January 1960): pp. 132–138.

7. Statistics in this paper about the state of the U.S. science education system come for the most part from the National Science Board, *Science and Engineering Indicators 2004* (Arlington, VA: National Science Foundation, 2004). Chapter 1 contains information about K–12 education, Chapter 7 about public attitudes toward science.

Finally, consider the effects of the No Child Left Behind Act (and the general tendency in the United States toward simple-minded, multiple-choice testing as a measure of teaching and learning). Right now, schools are required to test all students in math and English, but by the 2007–2008 school year, states must test all students in science three times: in grades 3–5, 6–9, and 10–12.

The good news is that districts that had shifted emphasis away from science in the last few years because the testing for English and math was first and science was still in the future, will now have to start putting more emphasis again on science, since science testing is going to be a reality! The bad news is that science exams will not be used to determine whether schools are making "adequate yearly progress," so the pressure from those exams is not as great. Still, science test results will have to be publicly announced (to the parents), so they will be part of how parents and the public judge the schools.

But the far greater issue will be that each state will be allowed to set its own standards and to decide just what kind of science tests to offer. And, make no mistake, once the tests are set up, science teachers will teach to the tests! Anything not being fully tested will be much less likely to be taught. In my home state of California, to take an example, far more high school students take biology than physics. As you can imagine, there is pressure to make the grade 10–12 tests about biology only. If that is so, it will tremendously accelerate the trend to take biology over other sciences.

How will space science do in all this? Unless its teaching and testing are mandated by the states, what teachers will have time to teach astronomy with the short school days and short school years and all the pressure to do well on the standard tests that are increasingly the hallmarks of the U.S. educational system?

How many of you know how much space science is in your state standards? How many of you have participated in the fashioning and review of those standards? How many of you have talked with a local science teacher and tried to encourage increased teaching of space science? Yet if we, who have a deep interest in space science, are not engaged in this process, how can we expect others to carry the torch for us?

Science Education and Science Literacy

Lest you think that space science education is being uniquely singled out for failure, I note that things are not great throughout the arena of science education. In 2000, the National Assessment of Educational Progress indicated that in the United States only 29 percent of 4th graders, 32 percent of 8th graders, and a depressing 18 percent of 12th graders performed at or above the level termed *proficient* in science for their grade.[8] Roughly half of all freshmen entering California state colleges

8. Ibid., Chapter 1.

cannot understand English or math at the college level and need remedial courses.[9] It is also an interesting statistic that in 1956, the year *before* Sputnik, there were twice as many B.A.'s in physics in the United States than there were in 2004.[10]

The results of the lack of good science education in this country is that adult Americans know very little about science. Jon Miller of Northwestern University, the foremost science pollster in the United States, has come to the conclusion that fewer than 20 percent of adult Americans know enough science for minimal civic literacy. For example, 50 percent of adult Americans believe that humans lived at the same time as dinosaurs. Only 22 percent of adults in the United States can correctly define a molecule.[11]

At the same time that American science literacy is declining, the U.S. Department of Labor reports that in the next decade jobs requiring science, engineering, or technical training will increase by 51 percent—four times higher than general job growth. Where will all the trained people to hold those jobs come from? Clearly, the reports warning that the competitiveness of our country may be undercut by the lack of adequate education in science and engineering are worthy of far greater political attention than they have so far received.[12]

Now that I have thoroughly depressed you in general, let me at least mention one comparatively positive trend. Others in these conference proceedings are focusing their papers mostly on the programs involving human spaceflight. But these are only one part of how NASA has transformed public perception; the other part is the array of robotic missions and telescopes whose images are now part of the visual and verbal vocabulary of our times.

Even the lowest-level science textbooks are full of the images these missions have returned to us. Just think about the visual impact and drama of these:

- The Hubble space telescope views of star birth in the great clouds of cosmic raw material, black holes at the centers of galaxies, and the depths of galactic space.
- The Voyager mission images of Jupiter, Saturn, and their moons.
- The Galileo spacecraft's first close-up views of asteroids (and an asteroid with a moon).
- The continuing pictures from Spirit and Opportunity, the intrepid little Mars Exploration Rovers.

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9. This statistic has been cited by California newspaper reports for years. It is confirmed by the information provided by the California State University system, such as *http://www.calstate.edu/pa/news/2004/proficiency.shtml* (accessed 27 March 2007).

10. National Academies of Science, *Rising above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (Washington, DC: The National Academies Press, 2004), available online at *http://www.nap.edu/catalog/11463.html* (accessed 27 March 2007)

11. Miller's work is cited extensively in National Science Board, *Science and Engineering Indicators 2004.* See also Jon D. Miller, "The Measurement of Civic Scientific Literacy," *Public Understanding of Science* 7 (1998): pp. 203–223.

12. National Academies of Science, *Rising above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (Washington, DC: The National Academies Press, 2004), available online at *http://www.nap.edu/catalog/11463.html* (accessed 27 March 2007).

Planetary science, as Carl Sagan stressed, has in one lifetime converted the planets from dots in the sky to worlds with tourist attractions. And Hubble images adorn musical CD covers, advertising, popular books and magazines, and even toys.[13]

One benefit of all this is that people seem to have an almost proprietary interest in the solar system these days. Witness the public and media uproar that followed the perceived downgrading of Pluto's planetary status.[14] NASA officials have also told me that the millions of hits on the Mars Rover Web sites and images have far exceeded everyone's expectations. In this way, the vision of robotic spaceflight has succeeded beyond our wildest dreams. It is part of the cultural landscape—video games, movies, television, comic books, and amusement parks all take a public familiarity with space probes and the planets for granted.

A marvelous example of this was the television program *The West Wing,* created by Aaron Sorkin. Although the show portrayed mostly Washington politics and the lives of those working in the White House, it was also one of the best "stealth space science education" vehicles I have ever seen. (And, not coincidentally, it was one of the few shows on television that made being smart an object of pride rather than ridicule.) Throughout the series, Sorkin introduced NASA missions and astronomical ideas. (Even the program I directed at the Astronomical Society of the Pacific, Project ASTRO, was mentioned once.) And the president of the United States was shown as loving space science and robotic planetary exploration and eager to show off about it to school kids.[15]

We need to enlist other friends in the media and public relations world to do more stealth science—science that becomes part of our popular culture and can insinuate itself into the public awareness. We should be putting stealth science into our TV shows, malls, parks, airport waiting areas, fast food places, and anywhere else we can.

The Mixed Blessing of Astronomical Pseudoscience

One negative result of this widespread but suffused public interest in space travel and astronomical ideas is that some of our cultural need for the supernatural has recently become translated into space-related terms. Whereas people in past

13. Images from planetary exploration can be found at NASA's Planetary Photojournal Web site, *http://photojournal.jpl.nasa.gov/index.html.* Hubble images are best organized at the Space Telescope Science Institute public information site, *http://hubblesite.org/newscenter/newsdesk/archive/releases/image_category/* (both accessed 27 March 2007).

14. See, for example, Andrew Fraknoi, "*Teaching What a Planet Is: A Roundtable on the Educational Implications of the New Definition of a Planet,*" Astronomy Education Review 5, no. 2 (2006), available online at *http://aer.noao.edu/cgi-bin/article.pl?id=207* (accessed 27 March 2007). References at the end of this roundtable discussion can lead you further into other responses.

15. R. Lance Holbert, David A. Tschida, Maria Dixon, Kristin Cherry, Keli Steuber, David Airne, "*The West Wing* and Depictions of the American Presidency: Expanding the Domains of Framing in Political Communication," *Communication Quarterly* 53 (October 2005): pp. 505–522; Staci L. Beavers, "*The West Wing* as a Pedagogical Tool," *PS: Political Science & Politics* 23 (2002): pp. 213–216.

centuries saw supernatural visions in terms of guardian angels or leprechauns or haunted houses, today these same feelings are expressed through UFO and alien abduction experiences.[16] A 2001 Gallup poll, for example, revealed that fully one-third of adult Americans believe that extraterrestrials are visiting Earth. And 31 percent accept the tenets of astrology, that the position of the Sun, Moon, and planets at the time of our birth can affect our personality and destiny.[17]

In a way, those of us concerned with education should be grateful for the growth of tabloid-level interest in alien life-forms or completely misinterpreted "faces" on Mars. Although some students or adults may become interested in space science through such nonsense, they can sometimes go on to learn or read about the real world of space and astronomy once their interest is piqued. Still, without better information about the scientific method in our schools, our media, and in our public consciousness, too few people have the tools to go beyond a fascination with pseudoscience to the real science that would await them.[18]

Still more disturbing, a 2004 Gallup poll said that 45 percent of Americans believe that God created humans in their present form at some time in the last 10,000 years. When asked about the origin of humanity and being given several choices, only 13 percent of Americans chose an answer that did not include something about God's role. A December 2004 *Newsweek* poll asked whether respondents favored teaching creation science in addition to evolution: 60 percent favored it, 12 percent were undecided, and only 28 percent were opposed. For many people, this seems to be only fair, in a loose, democratic sort of sense. Many of these people are the ones who have a problem understanding the scientific method and ways of deciding on evidence in science.[19]

16. See, for example, Carl Sagan, *The Demon-Haunted World: Science as a Candle in the Dark* (New York: Random House, 1995). A listing of resources about astronomical pseudoscience by the present author is kept at *http://www.astrosociety.org/education/resources/pseudobib.html* (accessed 27 March 2007).

17. National Science Board, *Science and Engineering Indicators 2004*, Chapter 7. Belief in pseudoscience is discussed on pp. 7–21 to 7–23. See also Martin Gardner, *Fads and Fallacies in the Name of Science* (New York: Dover Publications, 1957); Michael Shermer, *Why People Believe Weird Things: Pseudoscience, Superstition, and Other Confusions of Our Time* (New York: Owl Books, 2002); Robert L. Park, *Voodoo Science: The Road from Foolishness to Fraud* (New York: Oxford University Press, 2001).

18. This is the approach of Phil Plait, who uses these crackpot ideas to teach about science. See Philip C. Plait, *Bad Astronomy: Misconceptions and Misuses Revealed, from Astrology to the Moon Landing "Hoax"* (Englewood Cliffs, NJ: Wiley, 2002).

19. A Web site that keeps tabs on polls related to science and follows public attitude surveys about evolution is *http://www.pollingreport.com/science.htm* (accessed 27 March 2007). Useful introductions to this subject may be found in Mark Perakh, *Unintelligent Design* (Amherst, NY: Prometheus Books, 2004); Niles Eldredge, *The Triumph of Evolution and the Failure of Creationism* (New York: W. H. Freeman and Co., 2000); Tim M. Berra, *Evolution and the Myth of Creationism: A Basic Guide to the Facts in the Evolution Debate* (Stanford, CA: Stanford University Press, 1990).

This ambiguity about (or ignorance of) the scientific method spills over into public views of the teaching of astronomy as well. The legislatures of a number of states (including Kansas) have begun to pass laws, at the behest of fundamentalist religious groups, to include anything that contradicts a young Earth and young universe in the subjects that should be taught "only as a theory" or taught with "alternative theories" or de-emphasized. This includes radioactive dating and Big Bang cosmology—ideas essential to understanding the longevity and formation of the universe. (The key issue is that the time scales of our modern understanding are too long to satisfy those who seek to promulgate a very literal interpretation of the Bible as science.)[20]

In response, scientists have begun to speak up and write about these issues. The Education Board of the American Astronomical Society has produced a booklet and Web site called *An Ancient Universe* to help teachers and school board members understand how we know that the natural world is old.[21] Other members of the space science community are now writing and talking more about the need to answer such claims, particularly to help beleaguered teachers in those states where the fundamentalist pressure is the greatest.[22]

We might note, as one example of why science educators are concerned, that religious radio stations now number almost 2,000—all but a few controlled by evangelical Christian organizations. They outnumber every other radio format except for country music and news talk.[23] In general, the political and media clout of evangelical Christian organizations is growing, while the amount of time devoted to serious science on the radio and many TV networks is shrinking. There are two syndicated short radio features about space science, *StarDate* and *Earth & Sky,* but their brief spots are hardly enough to overcome the relentless radio proselytizing of the religious right.

CASE STUDY: A NASA EDUCATION AND OUTREACH "ECOSYSTEM"

I hope it is clear even from such a brief introduction that those interested in the expansion (or even continuation) of astronomy and space science education in the United States have a huge task before them. Most teachers, especially at the elementary level, have little or no background in the field and are unlikely to teach

20. An excellent discussion of the history of the Big Bang theory may be found in Simon Singh, *Big Bang: The Origin of the Universe* (New York: Fourth Estate, 2004).

21. Andrew Fraknoi et al., *An Ancient Universe* (Washington, DC: American Astronomical Society, 2004), *http://www.aas.org/education/ancientuniverse.html*.

22. See, for example, Matt Bobrowski, "Dealing with Disbelieving Students on Issues of Evolutionary Processes and Long Time Scales," *Astronomy Education Review* 4, issue 1 (2005): pp. 95–118, on the Web at *http://aer.noao.edu/cgi-bin/article.pl?id=143* (accessed 27 March 2007).

23. Mariah Blake, "Stations of the Cross," *Columbia Journalism Review* (May/June 2005), available o the Web at *http://www.cjr.org/issues/2005/3/blake-evangelist.asp* (accessed 27 March 2007).

much of it without requirements to do so, or active training or assistance. Even many upper-level teachers see it only as possible appetizer for the main dish of the "regular" sciences.

Since there are only on the order of about 10,000 space scientists in the country, it is hard for a community that small to have a major effect. What is needed is either a larger community of interpreters to help us, or a "leveraged" effect where the work we do can translate into a cascade of influence. The first thrust is being pursued by the Astronomical Society of the Pacific, among others. For example, Project ASTRO is a program that trains amateur as well as professional astronomers (and college students) to partner with teachers in grades 4–9 to bring effective, hands-on astronomy activities into classrooms. It is presently operating in 13 regional sites around the country.[24]

The second thrust is far more difficult and requires the kinds of effort that only a major government initiative might have the resources to undertake. In the brief space I have, I would like to conclude with one specific case study where NASA's educational efforts have had a disproportionately important and salutary effect.

Today, about $40 million per year is flowing from the NASA's division formerly known as the Office of Space Science (now part of the oddly named Science Mission Directorate) to a whole range of educational and public outreach (EPO) programs. It has been, over the last few years, the largest investment space science EPO in the history of our country.[25] It's a good story about a little-known effect of spaceflight on education that I hope will be written up in more detail by future historians.

In the early 1990s Congress began to ask the science enterprise in the United States to document how it was benefiting the nation and it asked the science funding agencies, such as the National Science Foundation and NASA, to be more explicit in requiring such justification. At the same time, NASA's Office of Space Science also had some concerns about how effectively NASA's Office of Education was conveying the excitement of fundamental science, as opposed to piloted spaceflight done for political and other reasons (that sometimes wound up having little connection to science).

So the Office of Space Science hired (in a quiet way) a series of dynamic leaders in the field of education to create its own EPO program—focused much more strongly on space science and not on what astronauts ate for lunch. Another aim

24. Andrew Fraknoi and S. Lalor, "Project ASTRO: How to Survive a Visit to a 6th Grade Classroom and Come Back for More," in *Amateur-Professional Partnerships in Astronomy,* J. Percy and J. Wilson, eds. (San Francisco, CA: A.S.P. Conference Series, 2000), vol. 220, pp. 260–263. Also see Andrew Fraknoi and D. Zevin, "Ten Years of Project ASTRO," *Mercury* (September/October 2003): p. 12.

25. See, for example, Jeffrey Rosendhal et al., "The NASA Office of Space Science Education and Public Outreach Program," available online at *http://science.hq.nasa.gov/research/Cospar_Manuscript.pdf* (accessed 27 March 2007). See also the publications listed at *http://science.hq.nasa.gov/research/epo.htm* (accessed 27 March 2007).

of the program was to involve space scientists in an active and leveraged way in the education effort. Eventually, the program would find its influence by requiring each of its instruments (missions) and research programs to devote 1 percent to 2 percent of its budget to EPO. When larger programs, such as the Hubble space telescope, were involved, those small percentages generated a considerable amount of money.

Dr. Cheri Morrow began to organize this community in smart ways and to write material to facilitate better EPO programs, but the real progress came with the appointment of Dr. Jeffrey Rosendhal, a veteran Washington and NASA hand, who in 1993 took this effort in a novel direction. After getting advice from education experts around the country, Rosendhal set up what he called an "ecosystem" for EPO. Rather than each scientist, each institution, and each mission pursuing EPO on its own, the ecosystem would coordinate and amplify the individual efforts so that the overall effect could be greater than the sum of its component parts.[26] There were two distinct parts to the organizing ecosystem:

- A series of topical forums to coordinate EPO activities among like missions (for example, among those exploring the solar system), and
- A set of regional brokers/facilitators to link missions and scientists to the real world of education.

The brokers were supposed to act like old-fashioned marriage brokers did—setting up relationships between the scientists and professional staff doing a NASA mission and local school systems, museums, educational publishers, nonprofit societies, etc. Although not all parts of this system worked right away, the coordination these strategically placed elements provided did help take the NASA space science EPO program to a new level, going way beyond the usual bookmarks, key chains, and pretty lithographs that were the hallmark of earlier mission outreach.[27]

Rosendhal and his staff also set up a series of small educational start-up grants (the IDEAS program) and a way for scientists who already had research grants from the Office of Space Science to request an EPO supplemental grant for some kind of educational project involving scientists or graduate students.

When all these vehicles for doing education and outreach were added together, by the year 2003, 400,000 people around the country had participated in 5,000 educational programs or events; 6 million had visited some Internet site sponsored under the program; and a whole host of curriculum modules and learning materials had been created and infused into the educational system.

26. See, for example, "Partners in Education," *http://spacescience.nasa.gov/admin/pubs/edu/educov.htm*; and "Office of Space Science Education Implementation Plan," *http://spacescience.nasa.gov/admin/pubs/edu/imp_plan.htm* (both accessed 27 March 2007).

27. The system's Web site can be found at *http://science.hq.nasa.gov/research/ecosystem.htm* (accessed 27 March 2007).

As someone who served on the review committee that was set up to see how well the system was doing after the first few years, I can personally attest to the fact that the leaders were open to criticism, able to make changes and course corrections, and had the best interests of education in mind.[28] I was also impressed by the fact that the system worked not only by itself, as NASA education has often tended to do, but was willing to partner with respected institutions and programs in the outside world.

An excellent example of this is that the program, instead of merely inventing more curriculum modules of its own, worked with such curriculum developers as the GEMS program at the Lawrence Hall of Science. And instead of developing curricula focused solely on NASA missions, the investment was in modules that would increase students' general background in space science (including elementary ideas that are often taught incorrectly in the schools.)

The Growth of the Community of EPO Professionals

Now don't get me wrong. NASA's Office of Space Science was not alone in making investments in and becoming more sophisticated in its understanding of the real worlds of education and outreach. The National Science Foundation, the national observatories, the American Astronomical Society, and the Astronomical Society of the Pacific were also increasing their involvement in these areas around the same time. Universities, research labs, and observatories also found it to their political advantage to become more involved in public education. But there is no question that the NASA investment and involvement were the most significant, both in terms of the size of the budget and the sophistication of the approach.

As a result, there was suddenly a critical mass of education and outreach workers in the United States, all doing work outside the traditional classroom—and a new profession may have been born.[29] Think about how a job category becomes a "profession" in this country, whether we are thinking of lawyers (who have done a great job with this), podiatrists, teachers, or NASA historians. Some of the factors that make a profession include professional organizations, journals and newsletters, awards, and a shared literature. Soon, most professions develop a mode of certification—a way of training candidates for the profession which guarantees that certain shared goals and standards will be observed (and that those who do not share those goals and standards will be excluded). Such modes of certification can include undergraduate or graduate degree programs, apprenticeships, examinations,

28. The review can be found on the Web at *http://newfrontiers.larc.nasa.gov/PDF_FILES/NASA_OSS_EPO_TF_Report_FINAL.pdf* (accessed 27 March 2007).

29. For more on the specifics of this development, see Andrew Fraknoi, "Astronomy Education and Public Outreach: Steps and Missteps Toward an Emerging Profession" *Mercury* (September/October 2005): p. 19, available online at *http://www.astrosociety.org/pubs/mercury/34_05/epo.pdf* (accessed 27 March 2007).

certifying boards, professional development programs, and (of course) fancy certificates printed on parchment to put on your wall.

The new profession is just beginning to make its way through this list. There is now a journal, called *Astronomy Education Review*;[30] there is an annual conference, held by the Astronomical Society of the Pacific; and several awards (including the American Astronomical Society Education Prize, the Klumpke-Robert Prize, the Las Cumbres Outreach Award, and a new education prize from the Astronomical League) are now given specifically for education and outreach work. At least one group, at the Center for Educational Technology in Wheeling, West Virginia, is beginning to think about a master's degree program in EPO work. Several of these profession-building steps are happening with NASA support but there is still a way to go before the community of such workers becomes a profession.

For example, there are still no agreed upon standards for entering the profession, so that some people come with extensive background in science and/or education whereas others are trained on the job. Many scientists dabble in the field without feeling the responsibility to get to know the literature of astronomy education, in the way that they would if they dabbled in a field of space science research. To some degree the new EPO profession is still what physics education researcher Joe Redish calls "a community of weakly interacting individuals." Nevertheless, the seeds of a new profession seem to have been planted and NASA's efforts have been a major cause of why some of those seeds may be starting to bloom.

Although some disturbing recent changes in the NASA funding picture may profoundly impact the support this fledgling profession that NASA has had such a strong part in creating, I suspect the sense of community and the movement toward professionalization could well continue if the funding is diminished.[31]

CONCLUSION

So what can we conclude about the impact of the space program on education in the United States from this brief review? There were certainly strong influences on small subgroups, which are recorded mostly anecdotally and are worthy of more serious study. There are cases, such as the NASA Office of Space Science ecosystem, where a small, leveraged infusion of funds can make a significant difference in the

30. The journal is available only online at *http://aer.noao.edu* (accessed 27 March 2007).

31. The new Administration at NASA is indicating that they do not believe that education should be a primary mission of the Agency. They are also being quite honest in letting Congress and the public know that they simply cannot accomplish all the goals set for NASA with their present funding. By giving higher priority to piloted spaceflight, replacing the Shuttle, continuing the International Space Station, and other (often politically motivated) programs, they are consigning science and science education to lower priorities. Many commentators are predicting this will soon translate into lower funding and thus to less money being available for the EPO system.

effectiveness of EPO programs. But changing the educational system in the United States as whole is a monumental undertaking, one completely beyond the resources of a small government agency, a single industry, and a group of enthusiasts. Whether space science can play a pivotal role (or even a supporting role) in bringing such a change about remains to be seen.

The educational system in our country reflects and enforces our best and worst values. Pockets of entrepreneurial effectiveness can be found among vast bureaucratic morasses of lazy and lackluster learning and teaching. Having an influence on this system will require a concentrated national effort whose expense and difficulty might well put the Apollo program to shame.