Science Education and Alan Alda's Communicating Science Initiative

I recently saw a television interview of Alan Alda in which he talked about the mission of the Center for Communicating Science, an organization he inspired that is housed at Stony Brook University. One can read a similar and even more recent interview posted by the Voice of America at:
http://blogs.voanews.com/science-world/2013/01/04/alan-aldas-challenge-to-scientists/
In 2012 the Center posed the "flame challenge," prompting scientists anywhere in the world to explain to eleven years olds **what a flame is**. A graduate student was chosen as the winner based on his computer animated account of a flame. For 2013 the "flame challenge" is to explain to eleven years olds **what time is**, or what one could call the "time challenge."

Alda's expressed mission is to train scientists in the art of communicating science to the lay public. While I agree that better communication about science is essential to our future well being as a planet populated by humans, I think Alda is only partly correct in his vision and is missing a more important factor. That factor is the necessity for the lay public to be better educated in mathematics and science, not by popularized presentations from gifted expositors but by systematic long term study throughout elementary school, high school and college. There is no quick fix to the predicament of science ignorance that can be based upon a few gifted expositors entertaining the ignorant. I also do not think you can do very much to train scientists to be gifted expositors, any more than you can train the height of an NBA center. Some persons have the gift and many do not. Everyone can improve, of course, but what Alda needs is scientists who can **I**nspire, with a capital **I**. To some extent this is what Carl Sagan did in 1980 with *Cosmos*.

The desire expressed by Alda has been acted upon many times before in history. In 1860 the scientific giant, "Sir" (he rejected the knighthood when selected) Michael Faraday, gave a series of six Christmas Lectures for a lay audience. Admittedly his was an educated lay audience containing mostly young persons. The title was "The Chemical History of a Candle." Fordham University has made the entire lecture series available at:
http://www.fordham.edu/halsall/mod/1860Faraday-candle.asp

I strongly urge the reader to read these lectures. There is a very significant difference between Alda's amusing challenges and the depth and clarity of understanding in Faraday's lectures. Faraday draws the eager young minds into the problem and then begins the task of educating those minds so they can understand the beauty of the subsequent lectures. Faraday realizes that only an educated mind is receptive to the enlightenment that comes from exposure to the marvels of science.

I can express this sentiment in another way by referring to an old story about the Greek mathematician Euclid. We owe this story to Proclus of the fifth century C.E. who wrote *Commentary on the First Book of Euclid's Elements*. In this commentary it is established that Euclid lived in Alexandria around 300 B.C.E. Proclus wrote:

> Not long after these men came Euclid, who brought together the *Elements,* systematizing many of the theorems of Eudoxus, perfecting many of those of Theatetus, and putting in irrefutable demonstrable form propositions that had been rather loosely established by his predecessors. He lived in the time of Ptolemy the First, for Archimedes, who lived after the time of the first Ptolemy, mentions Euclid. **It is also reported that Ptolemy once asked Euclid if there was not a shorter road to geometry than through the *Elements,* and Euclid replied that *there was no royal road to geometry*.**

This sentiment is sometimes expressed in the general form: *there is no royal road to knowledge*. The point is that without careful and prolonged study one cannot understand any deep subject, no matter what discipline is considered. Amusing challenges and delightful lectures can whet the appetite but are no substitute for the depth and clarity created by long term study.

I am a retired physics professor. I was introduced to formal physics in high school. In college I took physics every single year, sometime two courses , or even three, per term. In graduate school I had to take many classes in order to again cover mechanics, electromagnetism, thermal physics and quantum mechanics at a more advanced level. Some of these I took again in their relativistic reformulations. A decade of formal training was involved. As it happens I also did a parallel program in mathematics that began in junior high school. I can't advocate the same experience for a lay person, who may do something similar in a trade school program, or in preparing for medical education, or in preparing for legal education, or in preparing for business school, etc. What we need to focus on, as a society, is the education of everyone in mathematics and science starting in elementary school and as a part of a required curriculum throughout high school and college (I believe everyone should be exposed to arithmetic, algebra, geometry/trigonometry, calculus, physics, chemistry, geology and biology). Then we scientists who do know how to communicate to the lay person will have the luxury Faraday enjoyed of presenting scientific ideas to receptive minds. I hasten to add that my own scientific education did not end with graduate school but continues to this day, albeit informally. By the time every lay person finishes college they too should be able to continue their self-education indefinitely.

One of the truly great science teachers (and researchers) of the twentieth century was Richard Phillips Feynman. In the 1960s I had the good fortune to hear some of his lectures live. At one point he had a idea similar to the Alda's idea, even if at a higher level, to communicate real physics to college freshmen. Feynman thought that introductory physics courses (at the college level) were boring and simpleminded and aimed at uninformed minds. He thought he could do better and introduce the students to *real* physics in an exciting way. He gave himself a communication challenge like the "flame challenge" but for two entire years of courses in mechanics, thermal physics, electrodynamics and quantum physics. His audience wasn't made up of eleven year olds but of Caltech freshman and sophomores who were bright, well educated already and eager to learn. Feynman viewed his effort as an experiment in education. I have excerpted a small portion of the Preface to *The Feynman Lectures*:

> The question, of course, is how well this experiment has succeeded. My own point of view—which, however, does not seem to be shared by most of the people who worked with the students—is pessimistic. I don't think I did very well by the students. When I look at the way the majority of the students handled the problems on the examinations, I think that the system is a failure. Of course, my friends point out to me that there were one or two dozen students who—very surprisingly—understood almost everything in all of the lectures, and who were quite active in working with the material and worrying about the many points in an excited and interested way. These people have now, I believe, a first-rate background in physics—and they are, after all, the ones I was trying to get at. But then, "The power of instruction is seldom of much efficacy except in those happy dispositions where it is almost superfluous." (Gibbon)

This is from: http://www.feynman-physics-lectures.co.uk/Feynman_Lectures_on_Physics_Volume_1_Chapter_00.pdf where one can beneficially read the entire Preface in which the issues considered here were also considered. Feynman's misgivings underscore how difficult the problem of explaining science to eleven years olds really is since he had trouble explaining introductory physics to Caltech freshmen.

There have been many great science communicators in recent decades. I will mention a few at the risk of omitting many equally capable individuals. Included are: Richard Feynman, Martin Gardner, Steve Strogatz, Percy Diaconis, Roger Penrose, Christian de Duve, James B. Conant, Kip Thorne, Mark Kac, James Watson, and Francois Jacob. Some of these were simplifiers for already well trained practitioners (e.g. Kac's beautiful paper in a 1966 *American Mathematical Monthly* "Can you hear the shape of a drum?"). These men share a criterion I feel is most important. A great communicator has the ability to present a simplified version of science that when challenged and probed can be made more and more precise even if more advanced and more difficult. Instead, too many simplifiers (popularizers) are really falsifiers who cannot defend their simplifications against closer scrutiny. Wormholes and Time Machines by Thorne, the last chapter of his popularized book *Black Holes & Time Warps*, is a great example of presenting all the detailed doubts about the very popular (movies and TV shows) lay notion of time travel to the past. Time travel into the future (see http://www.fefox.com/ARTICLES/SpaceTravel.pdf) is possible and easily justified by relativity theory, but travel to the past is only suggestible using highly doubtful scenarios such as macroscopic wormholes, faster than the speed of light travel, and passage through black holes. The doubts are so great that Stephen Hawking has proposed the **chronology protection conjecture** that says time travel into the past is impossible. Thorne does not sensationalize and spells out the doubts. Unfortunately, the same can not be said for Sagan in *Cosmos*.

Very recently MOOCs (Massive Open Online Courses) have begun a revolution in education. They make free lectures available to almost anyone in the world, often by outstanding lecturers. They make possible the obtainment of education at home, alone, and whenever time is available. There is controversy regarding the efficacy of this approach and its sustainability if free. Cheating on online exams is an issue as is course content (imagine a course on evolution presented by a creationist). For the occasional lecture series of the Faraday type I see no problem with the approach and believe it can contribute to mathematics and science literacy. To me the biggest problem for the student is to appreciate how scientific understanding builds on foundational subjects and topics. The order in which topics are learned is critical to understanding the advanced and deeper ideas. We don't study calculus before we master arithmetic. In the end there are no short-cuts, no "royal roads," and one must become *committed to years of study*.

I recommend that the Center for Communicating Science devote its time to locating already known, outstanding communicators and try to get them involved in MOOCs. That would impact many persons worldwide. But more importantly, the rest of us need to restructure our entire education system, from kindergarten through college so that mathematics and science are a significant component of the curriculum, year after year, so that our citizens are prepared to understand the advances in science and engineering already here and yet to come.

Ronald F. Fox
Smyrna, Georgia
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