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Three fundamental questions to ask about scientific outreach

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I've listened to the exciting things going on with this program. I've learned, for example, a projects in my own state: A PRISM program, the Scientists, Kids & Teachers Partnership with the Chicago Schools, and on my own campus the "Engineering in the Classroom" project. So, I learned a lot about the details of your programs. Thus, over the next 30 minutes I want to take a step back and place these details in context. I want to give you a foundation for thinking about the work you're doing. Now, I said 30 minutes and meant it, my radio work has taught me to watch the clock very carefully.

Today I'll draw on my radio work, which has been intended for non-scientists and engineers - for the public, if you will. As you've heard I've created hundreds of pieces for public radio - all designed to help the public understand science and technology. And I've also worked with U.S. Diplomats to present scientific facts and figures, and to use science in policy making.

Three questions about why & how we do outreach

Today, I'll consider three questions that form the basis of my own work. They may seem obvious, but careful answers to them will provide ammunition for you to be an evangelist to the research community about your work with K-12 schools.

Here are the three questions: One, why should *you* - a research-oriented student or faculty - be doing this? Listen carefully there, because I'm going to share with you a tag line, a pithy description of what you do. Two, why are we doing this? What are the really big, deep fundamental issues? And third, what should be the outcome -- what are we looking for in a student or person whom we have touched with our work? (My answer here might surprise you! In fact, I'll spend most of my time on this last question.)

The answers to these questions seem obvious - likely a "given" when you touch on them over lunch with like-minded colleagues at this conference - but today I'll add nuance to them, and probe them more deeply because we need crystal-clear answers when we, as a group, press for the whole research community to become involved.

Question one: Why should YOU do this?

Let's turn to the first question: Why should *you* be doing this? Trained scientists and engineers, like yourselves, work very hard at increasing the technological base of the nation. Should you interrupt that very important mission for even a minute to engage in K-12 education? To be more precise I'm asking this question: Should *we* - by that I mean us: professors, graduate students, not only staff people or a special unit of the University - be doing this kind of outreach?

I could list the many ways that a research-based student, professor, department or university is ill-suited to do this job, but instead let's reverse the question: If Research Universities don't lead the way in scientific outreach, who will? If you think long and hard about this, you'll see that the universities are the only place in our society that will try to fulfill this mission.

We're the only institution fully committed to the idea of a general or liberal education - that is, an institution that believes in the broadening of the individual - *and* which has a true scientific research mission. So, to really take advantage of this core mission of a university means that we must lodge in the core of the university: That is, the professoriate and graduate students. For this reason I resisted and argued against me being an adjunct professor for life. In fact, I'm now the only engineering professor tenured for his or her outreach work.

Neal Lane's Civic Scientist

Let's probe the specific reasons why, then, it should be you, an integral part of a research university, who helps educate K-12 students. Neal Lane, the former Director of the National Science Foundation, argued that reaching out to the public takes someone with research credentials. [1] He spelled out the need for this role in a 1996 speech. Using the word "science" to mean "all science and engineering, research and education" he called for a new breed: The "Civic Scientist." That's the name I wanted you to remember - it captures in a catch phrase (as marketeers say) what you're doing.

He called for the research community to send out its own to talk to the public about technology: "I would argue," he said, "that scientists are the only genuinely credible people to deliver the message." Lane suggests clearly that we need to move out of our labs and talk to the public at large. He adds, "There are opportunities for talks at community meetings like the Kiwanis Club and the League of Women Voters", arguing that such meetings are "increasingly important."

Question two: Why should we reach out to the public?

Now, let's tackle the second question: Why are you doing this? The reasons for this are multi-fold.

Lane's avocation of his "civic scientists" hinged in part on the self-interest by the research community. He put on his NSF

Director hat and explained that if we don't educate the public then we won't be able to continue our research mission: "Science," he said, "can only be funded if the electorate and their representatives remain convinced of its value and contribution." He pinpointed who we should reach, noting that "without this understanding among citizens and policy makers, science and the American dream may only be a memory from the past and not a part of our future." To Lane the public's lack of knowledge about science and technology imperiled the American Dream: He cited the "opportunities, aspirations, and a better quality of life" that make up the American Dream, adding that "science has provided an important pathway to [fulfilling] that dream."

I find this a reasonable, first-order argument for the research community to engage in outreach. I like it partly because it appeals to the self-interest of our home communities - the research community. Perhaps that is enough, yet beyond this I think there are much deeper reasons.

Technological literacy impacts three main areas: First, democracy - we require technically literate citizens to make informed decisions. Second, economic productivity - technology savvy workers are needed to ensure America's long term economic health. My own institution now has a four-fold mission - the classic university triad of teaching, research and service, has now become a quad. We now have "building the economy of the state" as a fourth part. In fact, I'm told that the single largest reason for a leave of absence is for a faculty member to start a company. And, third, scientific literacy affects a person's life-long growth - literacy has a great effect on a person's life by helping them to apply technology in their own life - as workers, parents, and consumers.

Question three: What is our goal?

This last aspect brings us to my final question: What outcome do we expect from your K-12 efforts? Most academics, likely even yourselves, want the result to be recruitment. Many call this the "pipeline problem": A startling number of high school students simply don't want to enter engineering and the sciences. Although an important goal, I don't find keeping the pipeline flowing to be the end all and be all of what we want to achieve. To illustrate some of the deeper issues I want to share with you a true story that shows how a lay-person uses scientific knowledge; a story that sets the stage for us to probe deeper about what exactly we want to accomplish.

In 2004 the *Philadelphia Inquirer* reported the story of a woman who had lost her child in a fire in Philadelphia. [2] The woman felt, though, that the fire covered up foul play; that someone had abducted her child. Six years later, she attended a birthday party where one of the children looked exactly like her child. Seeing an opportunity the women told the child she had gum in her hair and offered to remove it. While doing this the woman saved several strains of hair. She knew that from these one could get a DNA sample -- apparently she'd seen daytime television shows that featured DNA testing, or more likely had watched CSI: Crime Scene Investigator. Indeed, a forensics lab showed her to be the mother. Later she was reunited with her child -- although sadly she speaks only Spanish, and her child only English -- and the Police arrested the child's "adoptive" mother. Note this: The mother needed to know only the essence of what DNA testing could do, not how to do it, or even the exact nature of DNA. To meet her goals she need only to understand its technological aspect, its purpose.

This tells me that we want a kind of "technological literacy", but what exactly does this mean? I'll start with what we most often want to achieve.

Two temptations: Being an expert & always aiming for hardcore literacy

There are two temptations that we face when first approaching the public. The first is to be an expert. This is a legitimate and necessary role, especially natural for a graduate student or professor. But ultimately it's very limiting. "Expert mode" distances technology from the listener or viewer. Its says "science is something you cannot understand, you need my help." The role tends to turn off listeners.

Let me illustrate this with a quote from a focus group. To aid the syndication of my radio work, one of my producers did a focus group of program directors at public radio stations across the country. When doing this he shares only the spots with the directors, no information about me. Often, though, after they've given their comments, they'll ask "Who is this guy? Tell me about him." When told I'm an engineering professor, here's what one said: "Make certain that program directors don't perceive him as a professor who wants a radio show --- every school has got one and most of them sound terrible." Now, of course, I'm called "Bill" on the air, in fact "professor" is never mentioned at all. But I warn you, being viewed as an expert is a hard role to shake. Over the years I've got e-mail messages asking me for advice on building a concrete dome - it was part of a someone's home improvement project - and I've got questions about installing gas lighting. And oddly a request to help design a concrete submarine in Arizona. I usually send them a free CD of my radio pieces.

The next attempt to create a literate public (or temptation, as I like to call it) involves simply exporting our labs or classrooms - to attempt to create "hard scientific literacy." By this I mean a basic toolbox of skills - in mathematics, physics, chemistry, mechanics - that allow a person to delve into almost any technological area. Each of us in this room has such a toolbox. These tools are intended to meet the worthy, but perhaps impossible, goal of having a public that is as capable as us of making independent, scientific decisions. (In his Tanner Lecture, which is discussed below, Herb Simon discusses whether such a goal can even be met. [3]) Although I would argue we don't really make political decisions, for example, based on that toolbox. For example, if you wanted to know everything about, say, global warming, you could dig through the literature, perhaps reproduce the computer simulations yourself. Time and your own interests likely limit you, so you rely on experts, on your own judgment about what sounds credible, on looking at the types of arguments produced in favor or against global warming. So, if *you* have the skills yet don't necessarily dig any deeper, could we expect others to do so? Yet, this has been the literacy goal for the last thirty years or so.

Now, a fair amount of evidence shows that this effort has failed to penetrate the consciousness of the American public. In spite of all the efforts, by any reasonable measure we're a nation of scientific illiterates. One study showed three out of four adults in the U.S. and four out of five adults in Canada and Europe would be unable to read and understand news or other information that used basic scientific constructs like DNA, molecule, or radiation. [4] So, if you just looked at this on a pragmatic cost/benefit basis the effort would surely be abandoned.

Creating Shepherds for science & engineering

So, if it isn't hard literacy we always want - or can get - what do we aim for? I encourage you to broaden what you teach and what you get across, to move your focus beyond adding to our numbers, but instead to create another shepherd for the scientific flock.

We would like an educated member of the public to understand how the scientific enterprise works in our political and

economic climate. We want to encourage an appreciative public, one that at least understands how much needs to be spent on science and technology. I think the science and engineering community would be well served by a society that, while perhaps "illiterate" in science in the very formal academic sense, is at least aware of what science is, of how it works, and of its horizons and limitations. We would also like them to be able to identify scientific frauds. You might call this approach "science awareness," rather than literacy. The objectives of this approach are to help students, and society in general, feel more comfortable with new developments in science and technology. They need not so much to understand the details but to recognize the benefits, and the possible risks of technology.

Nanotechnology as an example of the type of questions facing the public

Let me give you a current example of the type of question or issue the public is faced with. We all know of nanotechnology, which allows engineers to manipulate atomic sized particles to create tiny machines. They'll be able to create, for example, toothpaste filled with nano-particles that repair damaged teeth, or pills that are really tiny pacemakers. Although still a young technology, the National Science Foundation forecasts the U.S. Market will be one trillion dollars by 2016. Yet this promise may never be fulfilled, but not for lack of technological know how or resources: The U.S. Government alone will pour 3.7 billion dollars into nanotech over the next four years. But to really thrive a technology needs more than a scientific side, it must fit into our world socially and legally. For nanotech storm clouds already loom on the horizon.

For example, Britain's Prince Charles suggested that nanotechnology could be a disaster like thalidomide - the drug that caused grotesque birth defects in the 1960s. His remarks signal to our research community the work yet to be done in creating a public receptive to their technology.

I suggest they look carefully at two negative role models: Biotechnology and nuclear power. Nether industry conveyed to the public the benefits of their product, nor did they listen to public concerns. In the absence of intelligent dialog, heightened concerns grew over the risk, nearly crippling both industries. Better public engagement could have prevented this backlash. The public isn't going to accept any technology where there hasn't been detailed studies of risks and benefits.

Right now the lack of information about nanotechnology invites alarmist scenarios. The nanotech industry needs to educate the public about what exactly nanotechnology is, and it needs to listen carefully to public concerns.

And there are other ways nanotech needs to fit into our world before being fully accepted - consider legal and regulatory aspects. The EPA is deciding whether to regulate nano-materials under the Toxic Substances Control Act, or to classify them as naturally occurring "ultra-fine" materials - the same as dust, forest fire smoke, volcanic ash, bacteria and viruses. And Patent Examiners are grappling with nanotech. If you use nano methods to make a tiny motor is that legally any different than a full-sized motor? In the past a simple change in size hasn't been patentable absent some other utility or novelty that comes from miniaturization. All of this decisions, of course, need someone with a level of literacy about the methods of science.

To researchers who enjoy conquering the technological problems of creating a nanotech world, these social, legal and regulatory concerns may seem like dull things. Yet, some fraction of the nearly four billion dollars being invested into nanotechnology needs to be used to answer these questions. If not then these tiny nano-sized machines will bite back big time. It is these kind of scientific-oriented policy or ethical questions that we expect a literate public to grapple with.

Simon's questioners & cross-examiners

What does this mean for the K-12 efforts you are engaged in? Herb Simon, a Nobel Laureate in Economics, felt we should produce citizens who are more effective questioners and cross-examiners than they would be without training in science and technology. [3] He used the analogy of courts and legislatures as models of deliberation. They do not rely on experts to make the final decisions, but they do make use of them. To Simon "far more important than subject matter is the method of science: The nature of scientific evidence, the ways in which that evidence is obtained, and the ways in which it can be interpreted."

This is one of the reasons I do commentaries that reflect life-cycle analysis: Looking at the impact of a technology from cradle to grave. This highlights that there isn't often a simple technological quick fix to every problem, and shows how to analyze a new technology.

What to expect for scientific awareness

What we expect from this "literacy" is the following: First, an awareness of how the engineering enterprise works; second, having the public feel comfortable with knowing what engineering is about, even thought it may not know much about engineering technically - I like to think of the commercial from the 1970s asking "if we can put a man on the moon, why can't we make a good cup of coffee?", a technologically literate citizen would understand how to answer it. Third, we would like the public to understand what can be expected from engineering, and fourthly we want them to know how public opinion can best be heard in respect to technology's impact on society.

Another way of capturing the essence of this approach is to think of this is technological humanism: It develops the habit of apprehending a technology in its completeness - a completeness that is lacking in either a purely science-based or a humanities-based approach.

The real battle: Technological determinism

I want to use the last five minutes to take a big step back and put all I've said in context. You see, the argument over hard literacy versus awareness distracts from the main problem. I think that our battle is not so much with literacy, as with technological determinism. This is such an academic word; I've been looking for years for a good replacement, but haven't found it.

By technological determinism I mean a belief that technology shapes our lives with a ruthless logic all its own. In fact, which of us doesn't carry in their head an image of a great whirlwind of innovation that sweeps through our world, creating blessings and havoc? This view is only half true, and because of this, dangerous.

Its truth lies in the degree to which science does effect our lives. Never before has such a complex web of technology permeated a culture. For sure, in every century some marvel reshapes the world - the printing press, gunpowder, the cotton gin - but only in the twentieth century have these wonders united into a comprehensive system that seems to overtake us.

This view makes people passive about shaping it, and so promotes a dangerous apathy. It focuses minds on how to adapt to technology, not on how to shape it. Thus, it removes a vital aspect of how we live from our public discourse. This creates a pressing need for citizens who understand technological systems.

"The purpose of this understanding," in

the words of engineer turned historian Thomas Hughes, "is not simply to comprehend the impressively ordered, controlled, and systematized, but to exercise the civic responsibility of shaping those force that in turn shape our lives so intimately, deeply, and lastingly."

The key here, the take home message, when you engage K-12 students is this: Technical aspects cannot be construed apart from their social context. This is aptly captured by the great historian of technology, Lewis Mumford: "Railroads may be quicker than canal boats, and a gas lamp may be brighter than a candle," he said, "but it is only in terms of human purpose and in relation to a human and social scheme of values that speed or brightness have any meaning."

So, in reaching out to students, we should present the entire technical, social, political, economic, and cultural context of the things that surround us. This includes the innovators, inventors, engineers, entrepreneurs, and business people who make technology happen.

References

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[2] Pompilio, Natalie, J. Bewley. and J. Soteropoulos, "DNA test fraud is alleged in girl's saga - Correa allegedly tried to thwart state's procedure" *The Philadelphia Inquirer*, March 4, 2004.

[3] Simon, H.A. "Science Literacy as a Goal in a High-Technology Society", *The Tanner Lectures on Human Values* delivered at The University of Michigan November 11, 1983.

[4] Miller, J.D. and R. Pardo "Civic Scientific Literacy and Attitude to Science and Technology: A Comparative Analysis of the European Union, the United States, Japan, and Canada" in *Between Understanding and Trust: The Public, Science and Technology* (eds M. Dierkes and C. von Grote, Hardwoood, Australia, 2000 p. 81)