Commentary

Dialogue on Nanotech: The South Carolina Citizens' School of Nanotechnology

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Abstract: Theory and experience emphasize that science communications between experts and nonexperts should be dialogue, not monologue. This principle guides a nanotechnology outreach program at the University of South Carolina which enables the participants to express their values and concerns to experts, and to question them. It is intended that the knowledge and confidence generated by this program will enhance the participants' ability to have active and constructive roles in nanotech policy.

Introduction

In December 2003, the U.S. National Science Foundation convened a workshop on societal implications of nanotechnology. Three troubling themes arose: (1) that public awareness of nanotechnology was almost nonexistent; (2) that polarizing visions of nanotech were well established, and would dominate the ideological landscape in lieu of balanced or centrist visions; and, (3) that communications regarding nanotechnology must not be one-way messages from experts to nonexperts, but should be dialogues in which nonexperts can question the experts and express their values and concerns.

A group of researchers at the University of South Carolina has been concerned about technological determinism, i.e., that nanotechnology might change our lives without any consideration for the values or concerns of consumers, nonexperts, or other stakeholders. The themes of the NSF workshop inspired members of this group to create a dialogue-based outreach program, the South Carolina Citizens' School of Nanotechnology (SCCSN).

This program should be understood in light of the history of the role of nonexperts in science policy. In the American experience, John Dewey argued that when citizens think scientifically, democracy and science benefit each other [1]. But this requires a well-informed citizenry. Jon D. Miller has measured scientific literacy across three decades, and his results show that it is consistently very low [2, 3]. There are some exceptions and improvements, but we conclude that it is unlikely that large proportions of Americans will be well informed about nanotechnology [4, 5, 6, 7, 8, 9].

At the same time, four observations point to constructive roles for nonexperts in science policy. First, stakeholder democracy indicates that for any given issue, some people will decide to become active [10, 11, 12], even if most are uninterested and inert. Secondly, studies show that nonexperts can acquire and comprehend scientific knowledge when they have to in order to participate in science policy [13, 14].

Third, informal science education is especially effective because it is self-motivated [15]. Miller has noted that this is one of the most powerful sources of scientific literacy, and it is easier to experiment with than other variables [3]. Experiments with informal science education include science cafés, mini medical schools, and consensus conferences [16, 17, 18, 19].

Finally, those observations culminate in participatory democracy, i.e., cases in which nonexperts have active and constructive roles in science policy. Some examples are: local cases of public health or environmental threats; patients' families organizing to support medical research; AIDS activists improving biomedical knowledge in epidemiology and clinical trials; and laypersons steering the board that created regulations for research on recombinant DNA in Cambridge, Massachusetts.

Nanoliteracy & the SCCSN

The University of South Carolina group has a vision we call "nanoliteracy," a condition in which:

- People who are interested in nanotechnology are reasonably informed about it, are aware of a spectrum of views, and can learn more on their own; and,
- Stakeholders are confident they can participate in shaping nanotech policy, even if they do not have expert scientific credentials; and,
- Societal questions are integrated into discussions about technical change, so the technology is not isolated from society.

This raises the question of implications and interactions. Government agencies speak of the societal implications of a new technology, but this usually means that the technology arrives, it changes society, and the change is understood after the fact. We prefer not to passively accept this. Instead, nanoliteracy means that one can understand nanotech now, before it causes major disruptions, so that people can advocate beneficial changes. Thus we speak of societal interactions with

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nanotech, meaning that nanoliterate stakeholders make decisions before technological change becomes a fait accompli [20].

The SCCSN is our premier program for nurturing nanoliteracy [21, 22, 23]. Our model has these elements:

- A package of readable articles gives the participants background and confidence to question the speakers.
- The speakers are faculty experts who are adept and comfortable in speaking with nonexperts.
- There are numerous opportunities for the participants to pose questions and comments.
- To ensure a friendly atmosphere for questions and discussions, enrollment is limited to fifty or less.
- The program is open to revisions and improvements as suggested by the participants.

For example, during the first round (Spring 2004), the participants heard much about the scanning tunneling microscope, the atomic force microscope, and electron microscopes. They were extremely curious to see these machines in operation, and so suggested adding a lab tour. This was done in the second round and thereafter: the group visited the Electron Microscopy Lab and a Chemistry lab with an STM. They saw the imaging of nanoscale materials and surfaces (ranging from 30 to 0.27 nm) in real time, and the faculty explained the instruments. For nonscientists, this was a rare and exciting insight into the workings of nanotechnology.

Currently, each round consists of six presentations, once a week, supported by a package of readable articles, plus a lab tour, and a roundtable discussion at the final session. The SCCSN benefits from a structure of topics and readings in which societal issues are as prominent as the scientific information [11, 20, 24], but its special strength is the ethos of dialogue that shifts the focus from the speakers to the participants. This is expressed six ways:

- Participants pose questions and comments during the presentations;
- A thirty-minute discussion period after each presentation generates more dialogue;
- Some participants talk with the speakers face-to-face after the formal program concludes;
- Some participants later join the speaker and the organizer at a coffee house;
- Each round concludes with a ninety-minute roundtable discussion with all the speakers, with a participant serving as the facilitator; and
- Some participants have on-going contact with the speakers, usually by email.

We give two examples of creating dialogue. In Fall 2004, Robert Best spoke on nanomedicine. He had a well-developed powerpoint presentation, but on the evening of 20 October we could not get into the computer because C. Toumey could not find the password. So Best delayed his formal presentation, and he began by soliciting questions from the participants. This had an excellent effect: it was clear that the evening would be driven by their concerns, not his conclusions. His talk still had a structure which moved from topic to topic, but it was flexible and participant-friendly, resulting in ideal dialogue between participants and expert.

In a second example, the initial presentation of the fourth round (Fall 2005) was Davis Baird's fifty-minute historical introduction to nanotech, during which participants asked 24 questions. Many professors would feel that this was an annoying number of interruptions, but D. Baird and C. Toumey saw it as an excellent indication that the participants knew that they too were principals in this outreach program. During the same round, participants suggested adding an eighth session, the roundtable discussion. This was another successful exercise in dialogue, and has been incorporated into subsequent rounds.

Compared to other forms of informal science education, the SCCSN is more intimate than a mini medical school, more formal than a science café, and, with its background readings, it provides more depth of content than the other two forms. It can also co-exist with those other formats, and in fact a group of SCCSN participants organized a science café for Columbia, South Carolina, in July 2006.

Metrics and other indicators

Preliminary metrics from baseline and end-point tests of nano-knowledge and attitudes show that participants' knowledge changes markedly. Examples are:

	Baseline	Endpoint
Recognizing the importance of the STM for nanotechnology	32%	100%
Recognizing that the fullerene molecule is made of carbon	53%	94.4%

Even more important, however, are changes in participants' confidence. They report becoming more confident about: (1) explaining their positions on nanotech; (2) understanding a newspaper article on nanotech, and (3) speaking publicly at a hypothetical community meeting on nanotech policy.

A second line of investigation consisted of a record of participants' questions and comments, from which themes were identified by J. Ryan Reynolds during SCCSN.4 (Fall 2005). There were 46 participants, and the average attendance was 28 participants. Three themes emerged from that work:

Gender and Nano-Curiosity : was there a relation between gender and the questions asked by participants? The proportion of males to females was approximately 3:1. An average 15.4 questions per session were asked by males, compared to only 2.2 from females. The questions were separated into technical (n = 36, e.g., "Could assemblers be reprogrammed to disassemble?") and social (n = 52, e.g., "I'm concerned that nanotechnology will benefit only a select group of people."). Women asked one technical question and 11 social, while men asked 35 technical and 41 social. This is not a simple bifurcation of males asking about science and females asking about social issues: there was a strong preference for social questions by female participants, yet the male participants exhibited a balance of the two concerns.

Growing Sophistication : there were some very sophisticated questions at all sessions, but the proportion of simpler questions diminished across eight sessions. From the first session: "are all atoms the same size?" From the last session: "If we could build a particle accelerator on the nanoscale, it seems we could build a very good one due to increased surface area." This may be partly because the topic of the first session was an introduction to nanotechnology, while the topics of the later sessions were more sophisticated. If so, the participants' questions and comments kept pace with the development of the session topics.

Prominence of Health and Medicine : the session on nanomedicine had the largest number of questions (n = 25), and additional questions on health and medicine arose at other sessions. This was clearly the most prominent theme of all. This corroborates survey research which shows that the most important benefit of nanotech is expected to be medical applications [4, 5].

Our third set of indicators comes from A. Aggelopoulou's debriefing of faculty who had spoken in the first five rounds. Eleven of the thirteen speakers were debriefed, including two who had spoken in all five rounds, and three who had spoken in four of the five. This group comprised six chemists, two philosophers, and one each from English, Art and Genetics.

Had their experience with the SCCSN changed the direction of their research? Only one answered affirmatively: a philosopher said he was more concerned than before about the participants' interest in near-future commercial products. The sense of this is that products like cosmetics and nano pants seem trivial, but this is how consumers will encounter nanotech in the near future. In addition, he noted the participants' interest in Drexlerian nanobots. Although he considered them unrealistic, it impressed him that nanobots were prominent in the participants' views.

A chemist had an interesting reaction to that question: although the SCCSN had not changed the direction of her research, "the participants' insistence in knowing how the various aspects of my research are important and relevant has forced me to face the same questions."

Almost all of the speakers said they had changed the ways they present their research to make it more accessible to nonexperts. Most were surprised and impressed that the participants were well informed, reasonable and articulate. They appreciated that the participants were enthusiastic about nanotech, but were concerned about their high expectations, and were bothered by the participants' interest in nanobots and grey goo.

Finally, they noted the participants' strong curiosity about medical applications.

The future of the SCCSN

The experience of executing five rounds gives us an opportunity to use the SCCSN as a platform for experimenting with informal science education. We can try new ideas within a reliable program.

The round for Fall 2006 (SCCSN.6) includes an experiment in generating policy recommendations. P. Hamlett and others have emphasized that consensus conferences and citizens' juries generate better policy recommendations than focus groups or survey polling because the former give people plenty of time and opportunity to investigate and discuss a topic [16, 25]. The latter are quick snapshots of public opinion, with little or no learning or deliberation. Considering that each round of the SCCSN is an eight-week process of learning and dialogue, it is worth asking whether this process can generate policy recommendations.

For SCCSN.6, the participants are asked, when they enroll, to react in writing to a pair of policy questions: (1) how to balance concerns about privacy with changes in the quality of biomedical information that come from nanomedicine; and (2) whether appropriations to the USC NanoCenter from the state government should specify research directions, or defer to the scientists in the NanoCenter.

At the third and eighth sessions, the participants will face the same questions again. Then a group of participants will synthesize their reactions into a set of policy recommendations, possibly including a minority report.

This way, the participants will have multiple opportunities to deliberate, plus three opportunities to put their views in writing. While there are differences between this process and a consensus conference, we anticipate that it will generate well-informed recommendations from stakeholders that are approximately as credible as those generated from a consensus conference.

Meanwhile, the staff of the SCCSN recognizes three additional areas to develop. We hope to increase the ethnic diversity of the participants so that more nonwhite people will participate. Next, we are curious to know whether science museums can build nanoliteracy on the SCCSN model. Finally, we feel intuitively that the SCCSN model could serve other scientific topics besides nanotech, and we would like to see this tested. Currently we are seeking support to explore these areas.

Conclusions

We emphasize that the South Carolina Citizens' School of Nanotechnology is not a one-way transmission of information from experts to nonexperts. On the contrary, it is a dialogue in which scientific knowledge intersects with laypersons' values. Both are intensely important. It is our hope that the SCCSN will lead to participants making active and constructive contributions to nanotech policy that are infused with both good science and articulate expressions of concern about the future of nanotechnology.

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