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Talking about Nanotechnologies: Experiences of public dialogue at CSIRO

Fiona Solomon*, CSIRO; Evie Katz, CSIRO and La Trobe University; Roy Lovel, CSIRO; Wendy Mee, La Trobe University; Australia.

Abstract

Nanotechnologies are already used in everyday products and are predicted to become widespread with enormous impact on our lives. There are calls for regulation of these new technologies and greater public debate about their potential social implications. Our social research group in CSIRO has initiated some public dialogue activities with the aim of improving the governance of technological development. Two public workshops and a set of interviews with key informants were conducted in 2004 and are described in this paper. While the response of our participants has been positive, the work has not yet met our original goals of influencing CSIRO's nanotechnology research planning. The reasons for this are not easily resolved, however the next stage of our research will focus on encouraging nanotechnologists to reflect on their practice and the broader social context of their work.

Introduction

One of the hottest fields in scientific circles at present is nanotechnology. In 2004, the US Government spent more than US$960 million on nanotechnology research and development and other countries are also investing heavily (National Nanotechnology Initiative, 2005). Australian federal and state governments, combined with private organizations, are devoting in the order of A$100 million towards nanotechnology research (Invest Australia, 2004). At the same time, well-informed apprehensions (for example, Joy 2000) about the escalating pace of scientific advance are pointing to the urgent need for new approaches to their social evaluation and guidance (Grove-White et al, 2000). The recent Prime Minister's Science, Engineering and Innovation Council report on Nanotechnology recommended that public awareness activities and debate on its ethical and social implications should be carried out alongside the technical research (PMSEIC, 2005).

The 'nano' in nanotechnologies refers to the nanometre (10^{-9}), that is, one-billionth (0.000000001) of a metre. By way of comparison, the width of a human hair is approximately 80,000 nanometres. A nanometre-sized particle is smaller than a living cell and can be seen only with the most powerful microscopes available today. Nanotechnologies are thus materials and capabilities developed at the nanometre scale. By working at this tiny scale, technologists can engineer materials and ultimately devices from the bottom up, in contrast to traditional industrial processes. Because nanotechnologies are largely classified by the *size of materials* being developed or used, nanotechnology products may have little in common with each other. In this sense, nanotechnologies are best seen as enabling technologies that may cross all industry sectors and scientific disciplines. Consumers are unlikely to buy a

nanotechnology product *per se*, but rather will buy or use a product developed or enhanced through a kind of nanotechnology (PMSEIC, 2005).

Nanotechnologies may be applied in health, energy, housing, clothing, agriculture and environmental areas. They are already used in familiar products such as computer hard-drives, cosmetics and sunscreens, burns and wounds dressings, coatings for easier cleaning glass, catalytic converters in cars, longer lasting tennis balls and stain-free clothing. In the next few years, it is expected that new products such as solar cells in roofing tiles and advanced drug delivery systems will become available. Over the next ten to twenty years, predictions tend to focus on pervasive computing devices and military and defence applications (National Nanotechnology Initiative, 2005).

Since the range of science and potential areas of application are so incredibly diverse, in our work we try to use the plural term *nanotechnologies* to remind ourselves that 'nanotechnology' is not easily categorised. This in itself, combined with the historical gap between technologies and social research, presents many challenges for 'talking about nanotechnologies'.

Why talk about nanotechnologies?

It is well accepted that new technologies can have profound impacts on our lives: in fact this is often their purpose. However there can be unpredicted consequences within, and more often beyond, the original design of a technology. The most cited contemporary example is the pervasive influence of computing technologies on and in our lives, well beyond their initially conceived application as centralized data crunchers to be used mainly by big governments. A less well known, but equally significant, example is technical improvements in sewing thread which has had a huge impact on our standard of living by making clothing cheaper and more durable.

These two examples highlight how predicting future impacts of technologies can be highly unreliable. Debates on emerging technologies tend to be based on our current world view and often focus on the more radical or 'spooky' types of products and outcomes. In the case of nanotechnology, this has included on the positive side 'no-cost manufacturing' and on the negative, visions of the world being turned into 'grey goo' by self-replicating nano-machines. Overall, it appears likely that nanotechnologies will provide technical solutions to a range of significant (and insignificant) problems, but the history of technology suggests they are unlikely to fulfil any grand utopian dreams. However, sometimes what seems to be rather mundane or generally accepted at the time can have the most profound social and other impacts in the long term.

The nano-scale science and technology research that CSIRO is currently undertaking would probably be seen by many people as fairly unproblematic, mundane even. It includes biocompatible materials that allow contact lenses to be worn longer, self-extinguishing nanocomposites for use in fire retardants, and nano-filler toughened laminates for structural applications (Invest Australia, 2004). In collaboration with University of Technology Sydney, CSIRO has built an architectural model of the 'NanoHouse' to

showcase how new energy efficient nanotechnology products, such as paints, lighting and solar cells, might be used in a domestic environment (University of Technology Sydney, 2004). These sorts of nanotechnology products are fairly simple, familiar and ostensibly similar to non-nano-engineered versions already commonly in use.

However, this idea of nanotechnologies as familiar, simple and 'just like nature' probably has much in common with scientists' perceptions of biotechnologies when they were in their early stages of development in the 1970s and 1980s. History has shown that the general public ended up disagreeing with this assessment and when biotechnology products began to appear on the market, there was a significant backlash. As it happens, many scientists were concerned very early on about the potential pitfalls of biotechnologies and were proactive in putting in place internal systems of industry and institutional self-regulation to monitor and control R&D. But the emphasis on self-regulation, while important, was ultimately insufficient as it took place in the absence of broader public dialogue and debate (Reynolds, 2003).

The social context of nanotechnologies

In a report commissioned by the UK's Economic and Social Research Council (Wood et al 2003), it was noted that nanotechnology may be the first example of a technology that has drawn a backlash prior to its emergence. These authors note that in much of the literature to date, the 'radical' rather than 'realistic' perspectives dominate the debate. The overwhelmingly positive or negative interpretations of the technology have lead to associated implications for the role of social science. In positive readings of nanotechnologies, it is argued that social science research should be oriented towards overcoming barriers or public fears. In negative readings of nanotechnology, it is argued that social science research should focus on addressing a democratic deficit in science and technology policy and development. Unfortunately, both of these readings limit the role for social and community specialists to facilitating the interface between science and the public.

Wood et al argue that the social science agenda for nanotechnologies needs to be conceived more broadly than the public-science interface. They propose three main themes:

- Governance of technological change, including (but not limited to) the incorporation of concerns and perceived needs into the process of technical development. This would include greater understanding of the drivers and processes of decisions at the various choice points in the social process of technological development.
- Social learning and how we evaluate risks and opportunities under uncertainty; identifying conflicts of interest; and limits of the nation state as a regulator.
- Equity and economic divides. Nanotech investment for products for the rich; whether nanotech will cascade into beneficial applications for developing world. (Wood et al, 2003)

Our efforts to date in CSIRO have concentrated mainly on the first theme, that of governance of research planning and technical development (though the second and third themes are implicated in this).

Considering the broad social context of technologies while they are being developed, and with a view to influencing their development, is in practice still rather new. In the case of nanotechnologies, we can fairly safely assume that their social implications will be complex and sometimes unpredictable for a range of areas, including:

- Health
- Employment and education
- Consumption of resources
- Social equity (haves and have-nots)
- Local and national economies
- Control and ownership of matter and production
- Social relationships and culture
- Privacy and security
- Governance and the role of governments

For example, will nanotechnologies address or perpetuate consumerism? Might a nano-rich and nano-poor develop, entrenching or worsening social inequities? Will nanotechnologies lead to a de-materialisation of the economy, and what sort of implications could this have for resource-dependent countries? Can life and matter be patented and owned by corporations? How are nanotechnologies to be monitored, especially if they are invisible, movable or self-replicating? If nanotechnology is a new frontier, then who will be the "sheriffs"?

Such questions are significant, but current systems of governance of technological development rarely include such considerations. Where social outcomes are noted in science and technology planning, it is usually as unproblematic positives likely to arise from a program of promising research, rather than as issues open to debate. However, Langdon Winner argues that technical decisions are ultimately also social and political decisions: they are choices about power, liberty, order and justice, and hence the kind of world we will create (Winner, 1986). In the case of nanotechnologies, which appear to herald a range of new products and processes from improvements in the familiar to the development of far-reaching innovations, there is then much to consider. For CSIRO, as a partly publicly-funded institution, we believe there is a special responsibility to facilitate a genuine dialogue about technology and its governance, as well as its risks and its social outcomes.

What has CSIRO done so far?

CSIRO is Australia's Commonwealth Scientific and Industrial Research Organisation. As an organisation that is partly publicly-funded, CSIRO is focussed on providing new ways to improve quality of life, as well as the economic and social performance of a broad range of industry sectors through research and development. It has divisions such as Molecular Science, Industrial Physics, Textile and Fibre Technology, and Manufacturing and Infrastructure Technology, among others, who are involved in nanotechnology research. CSIRO's environment/agricultural divisions, such as Land and Water, and Sustainable Ecosystems, tend to recognise the social context of their work and have research groups

which carry out social and economic research. CSIRO's technology divisions, however, by and large do not take this approach. The authors of this paper are part of one of the exceptions, a social research group at CSIRO Minerals, one of the technology divisions. Along with several CSIRO nanotechnologists, our group identified an opportunity to work together as a first step towards an ideal of more integrated research programs. Our initial goals were to explore ways for social issues to influence nanotechnology research planning, and to scope a broader social science agenda for nanotechnologies within CSIRO. During 2004 we carried out interviews with thirteen key informants and conducted two public workshops on nanotechnologies: one in Bendigo in regional Victoria, and one in Melbourne.

The first public workshop in Bendigo brought together nanotechnology specialists, academics, industry and government representatives, and people living in a regional community to learn about and discuss some of the applications and possible implications resulting from nanotechnology research and development. Using a key informant approach, we identified likely participants in target stakeholder groups and then contacted them by telephone. The workshop and aims of the project were explained, and people invited to participate and to suggest others who they believed could make a valuable contribution to the day. These contact names were collected and the final selection of participants was made with the aim of maximizing the diversity of participants across the stakeholder groups. In total, 22 people attended the day.

The purpose of this first workshop was to listen to and analyse public input, in order to begin the process of shaping an ethical and ecological framework with which to evaluate research decisions within CSIRO around this emerging technology. In general, the Bendigo workshop participants highlighted issues related to regional economic development and public health and safety. Overall, they wanted CSIRO to:

- Demonstrate that it takes the issue of public participatory processes seriously, by being more proactive in conducting and funding effective public communication and participatory research activities,
- Foster an understanding of and commitment to the needs and priorities of rural and regional Australians, and
- Address issues arising from the potential conflict between matters of public interest and those of commercial confidentiality. (Mee et al, 2004)

A simple checklist for community issues was developed for CSIRO scientists as a result of the first workshop. At this stage, it is not yet being used by nanotechnologists in their research planning processes or to reflect on issues in existing projects.

The next activity, the key informant interviews, was designed to assist in scoping the second workshop. The interviews explored what we saw as five key contexts of nanotechnology development: commercialization, environmental impact, regulation, social impacts, and ethics. We chose interviewees according to their knowledge of and experience in one or more of these contexts. Interviewees came from government departments (Federal and State), universities, CSIRO managers, manufacturers, and civil society non-government organizations (NGOs). The interviews raised the following key issues:

Commercialisation	▪ Nanotechnologies encompass several disciplinary areas so to commercialise the research, considerable coordination and cooperation is required among the relevant scientific disciplines, the different tiers of government and government agencies, as well as with industry. ▪ Government funding appears to emphasise an emerging technology rather than an emerging industry. ▪ There is a potential conflict of interest between research done for commercial ends and public good research.
Environmental Impact	▪ There is uncertainty in the consequences of long term exposure and use of nanotechnologies. ▪ The health of the natural environment could be undermined by the lack of transparency in both public and private sector research on nanotechnologies and the pace of change. ▪ There is a possibility that the effects or impacts of some nanotechnology applications might not be reversible.
Regulation	▪ There is a need to review current legislation and test its adequacy for anticipating and dealing with the impacts of nanotechnologies and designate responsibilities for monitoring and implementation of regulations. ▪ Small firms manufacturing nanotechnologies may not have the financial or skilled resources to undertake full-scale audits on occupational health and safety, or environmental impacts. ▪ The concentration of ownership and control of these technologies is likely to be a major challenge for any regulatory framework and its effectiveness.
Social Impact	▪ Whether nanotechnology will create a new social divide or exacerbate an existing one, i.e. who will benefit from the uses of nanotechnologies, and are there groups who will be disadvantaged. ▪ Human health and safety with regard to body-related applications, as well as issues of privacy. ▪ Employment opportunities and impacts. ▪ Cultural factors such as perceptions of nanotechnology as ‘fiddling with Nature’.
Ethics	▪ The ethical principles that apply to nanotechnologies include informed consent, harm minimisation, the protection of vulnerable populations, and the precautionary principle. ▪ The convergence of nanotechnology with biological and informational technologies opens up new possibilities such as, for example, radical forms of human enhancement research, and this poses serious ethical questions. ▪ The ethical principle of transparency, needed to maintain public trust in science and technology research, could be challenged by other principles,

	such as privacy.

Table 1 – Five contexts of nanotechnologies

The second public workshop, the Melbourne Citizens Panel, sought to build on the first Bendigo workshop and the interviews described above, and consider a range of perspectives around nanotechnologies. Participants at the Melbourne Citizens' Panel were self-selected, made up of 22 people who responded to advertisements placed on online science forums, in an inner urban local newspaper, and on departmental noticeboards of universities, and the Council of Adult Education. The participants represented members of the broader community and included a number of people associated with civil society groups such as environmental and/or ethically oriented non-government organisations (NGOs).

The day was divided into morning and afternoon sessions. During the morning session, a panel of six invited speakers gave short presentations and answered questions and comments from participants. The exchange of views between the speakers and audience was lively, and on the whole conducted with goodwill and respect despite often differing positions and ideas in some areas. In general, the workshop participants were concerned about:

- Monitoring the health and safety of both humans and the natural environment, and those working with nanoparticles;
- Nanotechnologies developed for the purposes of war;
- Ownership and control of emerging technologies;
- The adequacy of current international regulation for nanomaterials;
- The social divides that nanotechnology might generate or exacerbate internationally as well as intra-nationally; and
- The ramifications of intellectual property laws both for Australia and for developing countries in light of what are likely nanotechnology impacts and paths of development.

In the afternoon, three small self-selected groups each played the roles of community, government and industry and developed a 'group' position in response to the hypothetical scenario: "What statement will Australia make to the United Nations Forum on Nanotechnology in 2005?" Each of the statements captured much of the feeling, intent and views of the three groups and showed how the workshop participants thought about and discussed issues from a range of perspectives (Katz et al, 2005).

Have these activities "worked"?

At one level, yes they have. The sorts of questions and insights emerging from the workshops and interviews are highly relevant for science and technology R&D. The range of technologies can make it difficult to have an abstract debate about 'nanotechnology', though some workshop participants believe strongly that they should be discussed in aggregate rather than case by case. However if nanotechnologies become widespread in a huge range of products, through nano-scale science in their

design or production, then it will be like talking about the pros, cons and regulation of 'technology': too broad a concept to be useful.

Overall, we have seen a lot of enthusiasm about the workshops and our research from the participants. A common piece of feedback has been "there should be more of this". There has also been plenty of interest internationally from others interested in the nanotechnology debates and/or initiating their own research programs. We have come to feel that, as social scientists, we are uniquely placed within an institution like CSIRO where we are able to access nanotechnology research that is being carried out in-house.

There is also reasonable enthusiasm from the nanotechnologists we have been working with. In particular, they appear to have enjoyed the public workshops which have given them an opportunity to present and discuss their work and are keen for more. However, we are starting to realise that for some, the understanding of public dialogue, and its intended effects, may not yet be as broadly conceived as our own. In particular, we sense that in some cases dialogue may be associated with 'education'. For example, the Australian Research Council Nanotechnology Network website focuses on public lectures and school visits to 'enhance public awareness' (ARC Nanotechnology Network, 2005).

As identified by Wood et al (2003), a narrow conception of dialogue limits the role of social research to the interface between science and the public. However it is upstream in the governance of technological development within CSIRO that we are hoping to have an impact. Unfortunately, we feel that the nanotechnology research that is taking place within CSIRO is largely still insulated from the public dialogue we are trying to create. It has been nearly two years since we started working together and we had hoped (naively perhaps) to have made more internal progress, as a result of our external activities.

As we write this paper, we are preparing for the next stage of our research: to bring the issues and insights of our work so far to a broader group of CSIRO nanotechnologists than have participated to date. In developing our approach, we find ourselves again reflecting on some of the theoretical issues that we feel underpin our research.

What have we learned and what's next?

The main issue appears to be an epistemological one (how do we know what we know). One important contribution from the sociology of scientific knowledge literature is the recognition that it is not only scientific practices and cultures which are inherently social, but so too is the knowledge produced within such domains. We (as social scientists) understand technology development and change as a social process, but scientists on the whole see it as a rigorous exercise in discovery and ingenuity. In this latter interpretation, there is often little room for social questions and public input that does not fit the scientific method.

One conceptual solution is that scientists and their scientific communities and institutions need to be located within society. Rather than conceptually separating scientists and scientific organisations as outside 'the public' (a simplification we can be guilty of too), we should place scientists as part of the public just as the so-called 'lay' or 'general public' are. Dietrich and Schibeci (2003) use the term 'interested publics' to collectively refer to not only scientific 'experts' but also 'lay unrecognized experts' including government, non-government, industry and community-based groups, along with general community members. Methodologically, the issue then is not simply one of bringing together 'the public' and 'scientists' in order to foster a dialogue between two separate spheres. Instead we should investigate ways to bridge knowledge divides and find grounds for consensus across conflicting values that necessarily exist within a broadly-conceived 'public'. This approach is far from straightforward and mirrors seismic shifts in the perceived role and practice of scientists.

The context of science and technology has changed, and there is now greater scrutiny, scepticism and a sense of risk associated with it. It seems likely that government and public demands for greater accountability are set to strengthen in publicly funded and also commercially-driven science and technology. Such demands are linked to broad shifts in modern society commonly identified with a loss of trust in public institutions and the weakening of collective sources of meanings and certainty. This has been talked about in terms of the 'risk society' (Beck 1992), and partly characterized by deep structural states of risk and fear in relation to new technologies (Lash and Szerszynski 1996). A related conceptualization is that of 'reflexive modernization', where increasingly opportunities, threats and ambivalences fall to the individual to resolve or make sense of (Giddens 1990). Such developments not only affect the general or lay public; we are all caught up in the implications of this form of reflexivity.

At CSIRO, this has resulted in some scientists becoming more open to 'outside' perspectives as a way of managing their own perceptions of 'risk'. However *a priori* dichotomies, such as objective/subjective and natural/social (Mercer, 1996), still dominate to the extent that we sometimes find ourselves using them as an explanatory device with scientists. Negotiating a less dichotomous approach, with scientists who are often deeply committed to a particular worldview (e.g. realist or objectivist) is one of the challenges of this work. The next stage of our work will focus on encouraging nanotechnologists to reflect on their own values, assumptions and the practice of their science.

Conclusion

Nanotechnologies are developing apace and are already available in the marketplace in a range of products. As the cloning debate should have taught us, the discussions over nanotechnology should begin sooner rather than later, because as the debate grows more intense and as the science approaches feasibility, it becomes more difficult to think carefully about the issues involved. (Reynolds, 2003)

In 'talking about nanotechnologies', we believe we have made a positive start with several public workshops and a number of interviews with key informants. There appears to be interest in the process

of dialogue and external participants are keen to see that their perspectives and concerns are responded to. Our vision is of a more integrated, participatory or democratic technology development approach, but this may be slow to achieve in-house with its strong traditions of scientific ascendancy. There is a challenge here for us as social scientists to negotiate our own position as part of a set of 'interested publics' and the expectations that are placed upon us.

A range of CSIRO scientists have participated enthusiastically in the workshops to date and have contributed to our research activities. However, we are finding that nanotechnology 'at the bench' appears to remain somewhat quarantined from what we at least see as its broader social context. As our aim is to affect the governance of technology development and change, our next stage of research should see us attempt to tackle these issues more directly.

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