THE STATE OF THE SOCIAL SCIENCE OF NANOSCIENCE

D. M. Berube, NCSU, Raleigh

Some problems are wicked and sticky, two terms that describe big problems that are not resolvable by simple and traditional solutions. They are steeped in uncertainties and function at scales, both temporally and physically, that are far beyond traditional attention. Advanced technologies can be associated wicked and sticky issues. Their hazard and risk profiles are generally unknown and regulating their integration into society demands high levels of trust in those marketing them. In addition, they are often associated with overclaims in terms of both their desirability and their drawbacks. Emerging and converging sciences and technologies like nanoscience and nanotechnology introduce a host of problems that if not addressed adequately may become wicked and sticky.

By and large the primary consumers of advanced technologies are governments, industries, and publics (this term is used to reflect that many different publics that make up the “rhetorical” public). The roles of publics in consuming advanced technologies involve but are not limited to electing and communicating with representatives in government who support budgets in turn funding research and development as well as purchasing, boycotting, and protesting the sale of products derived from advanced technologies. In addition, as members of the public sphere, publics are in a partnership with others, such as business and industry, to participate in a grand ecosystem commons that helps define what is and is not public property and is and is not public interest. Public participation in advanced technologies can be viewed as a public good. As advanced technologies become more integrated into society bot as consumables and as platforms for other technologies, publics are left to defer to others especially experts, and policy makers who may be expert, but more than not they are no better informed than the publics in understanding advanced technologies.

Nanoscience and nanotechnology, as science and technology, retain a complicated risk profile. Experts of all sorts testify as to nanotechnology’s public benefits as well as public costs and their testimony covers the breadth of concerns from ultra-conservative fears and reservations to bright-eyed hyperbolic claims of nearly indescribable benefits. Trying to determine how understood advanced technologies are by publics is under the purveyance of social scientists that have spent their careers studying trends.

This perspective piece does not take a position on this debate. Instead it attempts to explain why social science research associated with nanoscience and nanotechnology has a role to play in the development of nanotechnologies. It behooves us to base our public planning as something beyond intuition and

conjecture. Data-based social science has evolved over the last half-century to a point where marketing of a technology can be done with some assurance of confidence. Marketing does not mean mindless or conspicuous consumption. While much is marketed that does not have a true societal benefit, a lot is marketed which does.

Thanks to funding in the social science of nanoscience, there have been many peer-review publications, edited books, and white papers on the social science of nanoscience published in the 1990s to the present providing some insight into the public understanding of nanoscience and nanotechnology. Many of these works have found themselves published in the *Journal of Nanoparticle Research* as well as others such as *Science Communication*, *Public Understanding of Science*, *Risk Analysis*, *Science, Technology & Human Values*, *NanoEthics, Nano Today*, and even *Nature Nanotechnology*.

While some may argue that social science is underfunded in federal and private grant support, others have insisted it is waste of money. On balance, the expense of a social science research project is minute when compared to the investments made in science and technologies. However, without this research we guess what the public understands and wants and base our suggestions on "years of experience" when a more empirical approach might be both more amenable to our scientific colleagues in the natural sciences as well as subject to replication and verification. Before we invest fortunes into technologies the publics may not want or need, it is our duty as scholars to understand as well as we can their sensibilities.

Collecting data is the currency of experimental design in the natural sciences and contemporary social science research as well. The assumption bureaucrats and regulators are able to accurately predict what the publics want and need assumes exceeding high levels of competence on the part of the expert communities. While the publics have their own ways to discern interest and attention, there have been many examples where expert predictions have proved to be notoriously incorrect. We need to understand public needs and concerns and use the full realm of methodologies of the social sciences to determine what they may happen to be.

What have we learned about nanoscience and nanotechnologies from the small group of social scientists who work in this field? Initially, we learned the public knew very little about nanotechnology. We saw the application of psychometrics and cultural theory which has led us to conclude different categories of publics think differently about nanotechnologies. Initially, research was undertaken using surveys and focus groups, both of which have significant predictive shortcomings. Researchers have found correlations between perspectives on

nanotechnology and ideology, religion, and other societal variables. In addition, some researchers learned that cultural mindsets tend to be correlated with certain sensibilities about nanotechnology. For quite a while, we witnessed article after article corroborating these findings. But for very specific applications, the publics were and are less concerned about nanotechnologies than many other risks. The fundamental weakness in much of this research was that it did not explain why publics had the sensibilities they had about nanotechnology. Broad conclusions about communities and subcultures of publics provided little useful information for managers of science and technology in government and industry.

Next, we began to see experimental designs employed to test samples of publics by restricting the variables that might be influencing indices of public understanding. Often employing convenience samples in educational settings, these conclusions were touted are more predictive than the surveys and focus group findings.

Simultaneously, some researchers employed scraping methods, such as content analysis, to examine how media was covering nanotechnologies. Other social scientists did much the same to study funding, scholarly production, and patent generation trends within and between countries. In turn, this work fueled some rhetorical claims about national prominence and economic competition, for better and for worse, in the developing field.

Other social science experts took some very different ethnographic perspectives focusing instead on interactions in the labs as well as policy development. Since nanoscience was fundamentally cross-disciplinary, there were some unique opportunities to see how scientists worked with other scientists. Indeed, some researchers began to study how social science and natural science expertise worked at odds or cooperatively in these environments. Another group concerned themselves with governance issues to determine how to move regulation as an ongoing process rather than a consequence of planning shortcomings.

If we return to the first line of this piece, we may want to conjecture whether the future will be populated with issues that may be wicked and sticky or not. With the advent of technological convergence and deep ecosystem analysis of the profound changes ushered in by globalization, it seems easy solutions to easy problems may be a historical artifact. Complexity and uncertainty have begun to dominate the lives we live and how we interact with technologies of all sorts including nanotechnologies.

What should be on the social science of nanoscience agenda in the first quarter of the 21st century? There are at least six priorities for the social science of nanoscience and nanotechnology.

1. First and foremost, we need to understand why publics cognize nanotechnologies the way they do. Rather than understand “what” public feel, we need to move to “why” publics feel the way they do about nanotechnology. This involves the functions of attitudes and beliefs and their interaction which may help us predict behavior. By and large, these are experimental designs rather than surveys.
2. Second, the interaction between governance and publics needs to be understood in cross-national settings. Paths of interaction between regulators, researchers, and consumers need to be modeled to enable the construction of predictive and evaluative algorithms. We need to understand the cross-national macroeconomics of advanced technologies and the roles played by government and industry in research and development.
3. Third, promotion of science and technology remains controversial yet with the extensive delay in return on investment, some common investment in new technologies may be inevitable. It is time to begin to gather data on how productive funded research has been in moving nanotechnology forward.
4. Fourth, it would be useful to comprehend how different players interact in laboratory and commercial settings by continuing to embed social sciences and the public into places scientists and engineers work. This organic work may provide information that we can use to address a whole gamut of wicked and sticky problems we may come to confront.
5. Fifth, it might be important to attend to if not re-examine what we know about media as the internet and its social/digital nature continues to mature. Information availed to publics about advanced technologies, including nanotechnology, are found in online public forums rather than in traditional media settings. This trend will continue as media moves from its traditional print and video formats to digital formats.
6. Sixth and finally, it might be time for government and industry to commit itself to developing data based expertise in communicating risks of all sorts to publics. This starts with organized databases/clearinghouses of information between public, academic, government, and industry source. This effort would encourage experimental research in communicating risks before crises are upon us. Risk communication is much less expensive, in pecuniary and a host of other terms, than crisis communication.

In addition, societal issues include environmental health and safety, many articles on the production of nanoparticles and their fate have been published. Given the growing production figures, there will be increasing interests in how nanowaste affects publics and how policy makers and regulators may approach

its disposition. Predictably, studies over the profiles of nanoparticles and nanosystems on environmental health and safety will continue and it becomes more important that parallel research continue to be undertaken to estimate exposure and dosage issues.

This opinion piece has been driven from a comprehensive review of the literature in the social science of nanoscience and nanotechnology. The statements made above and the conclusions I have drawn are mine and do not reflect those of other coordinating editors or others associated with the Academies. Strong social science articles about nanoscience and nanotechnologies are welcome in our journal and will be subject to rigorous peer review regardless of the recommendations.

— Dr. David M. Berube