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Chapter One

Rethinking Public Knowledge of Science: The Process of Crafting the Concept of "Science in the Service of Citizens and Consumers"

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Introduction

The *Science and engineering indicators* (hereafter *Indicators*) is a massive compilation of data that is assembled by the staff of the United States National Science Foundation (NSF) and published biennially by the National Science Board (NSB). Chapter Seven of the *Indicators* is titled "Public attitudes and understanding". When the 2010 edition was being prepared, some members of NSB criticised the item on public knowledge of evolution: "Human beings as we know them today developed from earlier species of animals". This item, they asserted, failed to distinguish between *knowledge of* evolution and *belief in* evolution (Bhattacharjee 2010). A person could know that scientists say that humans have evolved, but still disagree with the scientists; in that case, which is sometimes detected in survey research, the interviewee knows how evolution is presented by scientists or the authors of textbooks, but at the same time he or she does not believe in evolution. In the view of some members of NSB, the wording of the item on evolution captured *belief in* evolution when it should have captured *knowledge of* evolution instead.

After a series of communications were exchanged between NSB members and NSF staff, it was agreed that the conceptual framework for public knowledge of science, as reported in Chapter Seven of the *Indicators*, ought to be reexamined. A workshop at NSF was planned to reevaluate the conceptual framework in October 2010, with a follow-up workshop to devise methods to implement the recommendations of the first in November 2010. The authors of this paper participated in the first workshop, and some members also contributed to the second workshop. Here we describe the process of: (1) examining the former conceptual framework; (2) suggesting a different framework; (3) clarifying the implications of the second framework; (4) observing how the second framework was incorporated into documents of the National Science Board; and (5) observing how the second framework was reported in science media.

The topic of public knowledge of science deserves a rich interdisciplinary approach. The participants for the workshop of October 2010 had expertise in science communication, science policy, science education, informal science education, survey design, learning-and-cognition, science-and-culture, and other related areas. That way the group could look critically at public knowledge of science from multiple relevant perspectives.[1]

From Civic Scientific Literacy to "Science in the Service of Citizens and Consumers"

Why should the National Science Foundation measure public knowledge of science, and why should the National Science Board publish this information? These were the initial questions that the workshop considered. The workshop participants noted that NSF and other governmental science agencies have a legitimate interest in knowing how the public examines scientific evidence, how the public reasons about evidence and how it uses evidence to make judgments either as individuals or as communities. In the words of NSF's (2003) strategic plan, one of its objectives is to

> promote public understanding and appreciation of science, technology, engineering, and mathematics, and build bridges between formal and informal science education.

For purposes of conceptual clarity, the workshop participants used the term “public knowledge of science” for three reasons. First, there was concern that the expression “public *understanding* of science” has acquired a highly charged negative connotation in both the research and the policy communities as a result of criticism of projects conducted earlier under that title. This problem arose after the Royal Society presented its 1985 report, *Public understanding of science*, also known as the Bodmer report (Royal Society 1985). This document has been widely diagnosed as a plan in which scientists talk, members of the public listen and then the public uncritically supports government funding of scientific research. An opposition to that plan quickly crystallised, as represented in Brian Wynne’s (1992) paper, “Public understanding of scientific research”. There, the author asserted that the Bodmer report was motivated by scientists’ selfish fear of losing public support for science. In the words of Wynne (1992, 42), this reflected “the social neurosis of science over its authority and public legitimation”, in which the work of scientists is not vetted by the public. Wynne (1992, 37) writes that “problems in public understanding of science reflect problems in the representation, organisation and control–the broad political culture–of science”. This and other critiques have painted the Royal Society report as misguided and unrealistic. We note that Sir Walter Bodmer recently defended the report, saying that critiques have oversimplified its conclusions (Bodmer 2010).

Second, the conceptual framework to be reevaluated, public knowledge of science, is often identified with the term “civic scientific literacy”. If hypothetically the workshop was to recommend a different conceptual framework, then the themes of the new framework would lead to a new terminology. Third, “understanding” can include both the scientific knowledge that the public possesses and the attitudes, values, concerns, perceptions and other factors that shape public interpretations of that knowledge.

The workshop participants were charged to reevaluate the conceptual framework for public knowledge of science, but not the influences that shape interpretations of knowledge. Those other influences are interesting and important, but the problem at hand was public knowledge of science. Furthermore, a reevaluation should think about the future: how can a conceptual framework improve the process of measuring and reporting information for the 2014 *Indicators* and beyond?

The first order of business of the workshop was to examine the history of measuring and reporting public knowledge of science. Dr Robert Bell of the Science Resources Statistics Division at NSF (subsequently renamed as the National Center for Science and Engineering Statistics) presented this history from an administrative perspective, after which the workshop participants discussed the contributions and conceptual framework of Dr Jon D. Miller, who established a framework known as civic scientific literacy (CSL) in 1983, with various revisions since then (Losh 2006).

Miller's framework was anchored in John Dewey's theory of liberal democracy, particularly Dewey's 1934 essay on "The supreme intellectual obligation" (Dewey 1981 [1934]; Miller 1983, 1987a, 2004). Here, Dewey argued that if citizens know how to think scientifically, then democracy will benefit from good knowledge combined with good decision-making processes. According to Miller's (1983, 29) account,

> In a democratic society, the level of scientific literacy in the population has important implications for science policy decisions…any measures we can take to raise this level…will improve the quality of both our science and technology and our political life.

None of the workshop participants opposed civic scientific literacy *per se*. Nevertheless, they identified two reasons to develop an updated conceptual framework. One is that the former vision has not been attained. It is possible that higher levels of scientific thinking might or might not affect democracy for the better, but there is little reason to be optimistic that the American public will achieve the levels of scientific literacy that Dewey and Miller hoped for. The civic virtue that Dewey envisioned included individuals voting and making personal decisions. Some readers might further infer that Dewey also called for the kinds of large-scale political grassroots organising that are required to support or resist a particular science policy. Even so, telephone surveys have not captured that latter possible dimension of civic scientific literacy. It can be recognised that large-scale political activism is now a common feature of public scientific controversies in creation-evolution disputes, AIDS/HIV policy, environmental issues, and other topics. That level of activism on scientific topics proceeds with or without desirable levels of scientific literacy. A conceptual framework for public knowledge of science should reflect the reality that scientific knowledge is acquired and deployed, not only in voting in elections and referendums, but also in additional styles of civic engagement.

The second reason for reevaluating the conceptual framework of civic scientific literacy is that this vision frames the person in the public as a micro-scientist. That is, it identifies some of the knowledge that working scientists possess and then measures how much of that knowledge non-scientists possess. Consistently the answer is that most of the public possesses miniscule quantities of scientific knowledge, leading to stories with titles like "America's scientific illiterates" (Russell 1986), "The dismal state of scientific literacy" (Culliton 1989), and "The scientifically illiterate" (Miller 1987b). The workshop did not challenge the validity of these reports.

What should be the standard of acceptable civic scientific literacy? Sometimes it is said to be the ability to read the "Science" section in the Tuesday edition of the *New York Times*. Why? If a citizen accepts that scientific information passively or uncritically, is this an acceptable form of civic scientific literacy?

The workshop participants agreed that decades of data collection from surveys of civic scientific literacy have enabled high-quality longitudinal research. Long-term trends can be identified and analysed. Likewise, comparative research is made possible. Public knowledge of science in the United States can be weighed against the same in other nations and perhaps insights can be derived from that kind of comparison. This kind of analysis is already made possible for K12 science education, e.g., in the *Science framework of the 2009 national assessment of education progress* (NAGB 2009). It would be regrettable if the longitudinal and comparative value of that information was diminished.

Following that conclusion and with the benefit of the participants' expertise in science communication, science policy, science education, informal science education, survey design, and other related topics, the workshop explored ways to improve the conceptual framework by incorporating recent thought about relations between the science and the public. One insight that was especially salient is that persons in the public have different reasons for acquiring scientific knowledge and using it (e.g., Bell *et al*. 2009; Shen 1975; Toumey 2006; Wickson *et al*. 2010).

Sometimes a person is in the role of an information consumer and so wants the kind of practical knowledge that enables one to comprehend the ingredients in a food label, or to know how to take antibiotics without developing antibiotic-resistant bacteria. Other times a person is in a civic role and needs scientific knowledge in order to have an active and constructive role in a science policy decision-making process. If a nuclear reactor is planned near one's home, what knowledge will a person need to weigh the benefits and the risks, and then to participate in supporting or opposing the construction of the reactor? In a third situation, a person might feel that science is interesting and learning about science is enjoyable. Unlike the reasons of the consumer or the citizen, this motive has merely the pleasure of learning about science. We can call this public knowledge of science for its own sake and we can note that by acquiring it, people are connected to a shared view of how the natural world works.

In addition to considering the reasons *why* people acquire scientific knowledge, it is worth realising that there are *different kinds* of knowledge and that some kinds will serve one purpose while others serve another. The consensus of the workshop was that there are three principal categories of scientific knowledge that can serve persons in the roles of information consumers, citizens, and the curious:

1. *Factual scientific knowledge* gives one a vocabulary of scientific information and scientific conclusions about the empirical world. For example: What is an atom? What is a species? What is a vitamin? What are genetically modified organisms? What are stem cells? In addition to knowledge that might be conveyed as definitions, it also includes natural and technical processes: What is adaptation, and how does it work? How does a solar cell work? How does a nuclear power plant work?

2. *Knowledge of scientific processes and standards* enables one to comprehend intellectual practices such as experimental design, naturalistic explanation, sampling and probability, and so on.

3. *Institutional scientific knowledge* enables one to know how scientific institutions operate. This includes peer review; the adjudication of scientific claims; the funding of scientific research; how science identifies and prioritises emerging issues; how scientific advice is used; processes of making science policy; and so on.

From those considerations comes the core of a conceptual framework for measuring and reporting public knowledge of science in the *Indicators*:

> In order to place science in the service of citizens and information consumers, the concept of public knowledge of science refers to: (a) factual scientific knowledge; (b) knowledge of scientific processes and standards; and (c) knowledge of how scientific institutions operate. It equips persons in the public for: (1) active civic engagement in scientific issues, including organised efforts to support or oppose specific science policies; and for (2) using scientific knowledge for practical decision-making by individuals; and for (3) a better scientific understanding of the world.

In addition, the process of measuring and reporting public knowledge of science continues the long-term responsibility of collecting data which enables high-quality longitudinal and comparative analysis.

This conceptual framework can be envisioned as a three-by-three matrix. The horizontal dimension represents three purposes for acquiring knowledge, and the vertical dimension depicts three kinds of knowledge content. One can then categorise items to be measured according to which purpose they serve and what kind of content they represent (Table 1.1).

		Purposes of public knowledge of science		
		Civic engagement with science	**Practical/ individual decision-making**	**Cultural curiosity about the scientific worldview**
Content	**Factual knowledge**		How should antibiotic medicines be used?	What is an electron?
	Processes and standards	How is probability relevant to a particular issue?		Principle of naturalistic explanation
	Institutional knowledge	Why does nano-technology receive government funding?	Which experts and institutions can I trust?	

Table 1.1. A 3x3 matrix of Purposes and Content showing how certain kinds of knowledge fit into cells

For example, the principle of naturalistic explanation would belong in the row for scientific processes and standards and the column for scientific understanding of the world. It would also go in the column for the civic purpose of public knowledge of science in the case of a policy controversy about evolution and creationism. But it is not necessarily urgent for it to be in the column for the practical purpose of serving consumers. One can imagine how a person who wants to understand the label of ingredients on a food package does not particularly need to invoke the standard of naturalistic explanation. It is noted that some items to be measured can go in more than one column and more than one row.

This matrix can be further understood by focusing on one particular theme. In this case, we place nine kinds of knowledge about medications into the matrix (Table 2.2).

		Purposes of public knowledge of science		
		Civic engagement with science	**Practical/ individual decision-making**	**Cultural curiosity about the scientific worldview**
Content	**Factual knowledge**	Who funds research on Drug X?	What are the risks of Drug X for me and my family?	How do drugs work?
	Processes and standards	What standards are used to evaluate Drug X?	Have financial interests affected safety testing of Drug X?	How do scientists develop drugs?
	Institutional knowledge	How can non-experts affect research and regulation of Drug X?	How can I evaluate conflicting reports about Drug X?	What is the social history of research on Drug X?

Table 1.2. A matrix of Purposes and Content focusing on questions about medications

The starting point of this conceptual framework is to ask what knowledge a person in the public needs, whether for civic engagement with science and science policy, or for making individual decisions about one's life or health, or for feeding one's curiosity about science. This starting point is different from that which informed the previous conceptual framework, when the principal effect was to measure civic scientific literacy as a proportion of scientific knowledge in general (and how little the public knows). The revised framework entails a series of consequences for how we think about relations between the public and scientific knowledge. The workshop participants noted that this was not the original intent of the framework of civic scientific literacy, which had a complex definition of scientific literacy that included both science process and science policy (Miller 1983). In practice, however, that framework was largely understood as focusing on the science content dimension. The revised framework, "Science in the service of citizens and consumers" (SSCC), entails a series of consequences for how we think about relations between the public and scientific knowledge.

A Conceptual Framework Based on Citizens' Needs

The public is not a homogeneous entity. There are various levels of formal education and multiple levels of encountering science through informal science education. Topics of interest will differ. Some people will be interested in nuclear power; others will concentrate on one disease or another; still others will be curious about the ethics of embryonic stem cell research; or what they need to know for a career in environmental management; and so on. Furthermore, some people will care about a given issue more than others. The first responsibility of those who disseminate public knowledge of science is to serve the segments of the public that want this knowledge. This takes precedence over an aspiration to deliver public knowledge of science to everyone equally, including those persons who do not particularly care about scientific knowledge.

Thus public knowledge of science is largely topical according to this framework. This can be contrasted with universal or timeless scientific principles. Topical knowledge does not arise from the same needs as the content in a science course or a science textbook. On the contrary, it arises when a citizen or a consumer is curious, concerned, alarmed, or excited about a particular topic. A resident of the Louisiana coast may want to know how the residue of the oil spill in 2010 can be made to disperse. The molecular structure of hydrocarbons is relevant at one level, but the resident probably does not want a tutorial on that. Instead, he or she wants to know which products will work, how quickly they will work and whether they will harm the coast.

Related to the topical character of public knowledge of science is the point that non-scientists can often acquire, comprehend and employ the relevant scientific knowledge when they have to. Self-motivated learning by adults has an impact almost as strong as formal undergraduate science courses (Miller 2004, 289-290). It is not expected that, during a controversy or a crisis, persons in the public will aspire to acquire knowledge equivalent to a degree in a scientific discipline. But these citizens do not need to become scientists with formal degrees in order to know what they need to know to have active and constructive roles in public debates that include a scientific dimension. This reinforces the insight that the starting point for public knowledge of science is the need of the citizen or the information consumer, rather than a microcosm of what a scientist knows. Consistent with this perspective, the workshop participants also recommended that periodically a topic of special concern in the United States, e.g., genetically modified crops, be featured in the *Indicators*, with a series of questions to gauge public knowledge of the subject.

Next, it is no secret that persons in the public, like persons in scientific communities, seek scientific knowledge from multiple sources. It is known from the 2012 *Indicators* that television and the internet are the two principal sources of scientific information for the American public, in equal proportions. Access to knowledge is not limited to a small number of authorities. When persons in the public acquire scientific knowledge from institutions and persons that are considered authoritative by the standards of scientific communities, those institutions and individuals are communicating in a very competitive marketplace where other sources claim to be equally authoritative.

The workshop participants understood that the new conceptual framework overlapped with civic scientific literacy in the data collection it recommended, but it would also be more encompassing than that earlier framework. By updating the framework to account for research and critiques generated in the last twenty-five years, the participants sought to retain the value of data collected under the framework developed by Jon D. Miller, while providing a more robust structure with new perspectives on public interactions with science. The new framework makes explicit some assumptions that were earlier implicit and it changes some of the emphases. By re-reading Miller’s work on civic scientific literacy over the past thirty years, one could find parts of the new conceptual framework prefigured there. The fundamental goal of collecting data on public knowledge of science, namely to serve government policy making, remains the same.

In addition to specifying these implications, the workshop of October 2010 made a series of recommendations about collecting data on public knowledge of science for the *Indicators*. These can be found in the workshop report, "Science in the service of citizens and consumers" (Toumey *et al*. 2010).

Measurement and Operationalisation of the SSCC Framework

Issues of measurement and item validity have not gone unattended in this fertile field of social science inquiry. And yet the renewed controversy over validity of the items used in the NSF surveys called for a careful examination of the quality and utility of the full set of public science knowledge items drawing on recent advances in survey methodology. The second workshop, on implementing the recommendations of the first (Guterbock *et al*. 2011), examined the measurement adequacy of the current NSF survey items themselves taking into account the newly defined SSCC conceptual framework. The workshop, convened by Thomas Guterbock on 12 November 2010, brought together a group of survey methodologists and substantive experts for the purpose of developing a set of specifications to identify the measurement qualities that would be desirable in the public science knowledge questions and to outline a protocol for creating additional questions and testing them. The workshop participants represented a wide range of expertise from the disciplines of sociology, communication, psychology, political science, and health policy, plus survey researchers and methodologists.

Considerable scientific attention has already been paid to the assessment of the measurement properties of the existing science knowledge items used for the *Indicators*. This existing instrumentation assessment work is of high quality and was of considerable value to the evaluation task. Nevertheless, the workshop found that further study of some of the survey items is warranted and some new items will need to be developed if adequate measurement of the new framework is to be achieved.

Since the SSCC framework is broader in scope than its predecessor, the current NSF survey items do not measure all its aspects. Both factual and process items are well covered by the items in current use by NSF. However, it was noted that no relevant questions exist in the category of institutional scientific knowledge. Examples of this type of knowledge might be items asking about the federal government's role in funding basic research, the role of universities, differences in credibility of independently funded research versus that funded by for-profits, and so on. Another topic of institutional scientific knowledge was the question of human subjects in research. While funding agencies typically have clear parameters for protecting human subjects, this may be unknown to non-experts. It would be valuable to know whether this form of institutional knowledge can be detected and measured in survey research.

A key aspect of the SSCC framework is the recognition that citizens use scientific knowledge for three different sets of purposes as was indicated in the three columns of the matrix shown above. As the workshop reviewed the existing survey items it became evident that they do not attempt to measure these purposes directly. The second workshop found that it would be relatively easy to develop new items that would directly measure whether a person deploys scientific knowledge in everyday life. For example, items could probe whether the respondent regularly consults scientific or technical sources or published data in making important consumer purchases. Other items could measure whether the respondent holds opinions on policy issues where science is relevant and whether she or he relies on science knowledge in forming such opinions. A third set of items could focus simply on the extent to which a person enjoys hearing or reading about scientific studies, or learning about science.

Three distinct “science-purpose” scales could be constructed from these items. Armed with these scales, researchers could then put to empirical test the assumptions that underlie the SSCC framework, i.e., that science knowledge actually *does* empower citizens or improve their lives by making them more able consumers, more effective citizens, or better able to comprehend the world.

Although the instrumentation workshop had the task of reviewing the public science knowledge questions as a whole, the workshop participants devoted some attention to the two items that had drawn criticism from the NSB when the 2010 *Indicators* was being prepared: the true/false questions regarding evolution of humans from lower forms of life; and the origin of the universe in the Big Bang. While these questions are stated as simple factual propositions without any direct religious content, it is clear that some respondents respond to the items based on religious belief systems to which they are committed. In particular, conservative Christians who hold the Bible to be inerrant would be reluctant to endorse these items as being “true”. The continued strength of conservative Christianity in the United States would then explain the lower scores on these items compared with other developed countries.

That presents an interesting problem. The evolution and Big Bang questions are different from the other knowledge items, but they also correlate fairly well with the other general-knowledge items. And so they function in part as measures of science knowledge, but they are also clearly picking up another dimension which may be personal commitment to religious belief. To derive the greatest analytical value from these items it would help to measure these two topics in terms of both knowledge and belief.

It was the strong consensus of the workshop participants that the notion of evolution is too fundamental and broad-reaching a concept in science to be left out of the set of public science knowledge indicators. Based on prior experiments conducted for NSF on variations of these items, the workshop suggested that they be modified into an “unfolding” or contingent form. Respondents would first be asked if the item were true “according to evolutionary theory” or “according to astronomers”. They would then be asked directly if they personally share each belief. That approach would have the virtue of clearly separating a respondent’s knowledge about what scientists believe from his or her personal beliefs.

The NSF public science knowledge items should be clearly focused on scientific knowledge. A change in measurement of the concept will not in itself resolve the debate over whether personal belief in human evolution is an essential part of scientific knowledge, or more generally whether science literacy necessarily assumes acceptance of scientific consensus as opposed to mere knowledge of that consensus. The suggested unfolding version of the questions will provide researchers with information that more clearly separates a respondent’s knowledge of scientists’ views from his or her personal agreement with those views, thus allowing for a more informed investigation of both aspects of public knowledge of science.

Looking to the research agenda ahead, the November 2010 workshop expressed concern that some of the current NSF survey items have been developed for use only in face-to-face interviews (although older items were developed for oral administration via telephone). The workshop recommended that a telephone-friendly version of current and proposed new items be developed, so as to allow more frequent and widespread testing of items by researchers who wish to expand, explore and validate the SSCC approach. The current survey vehicle for the NSF items is the General Social Survey (GSS): a biennial, NSF-funded, face-to-face survey known for the quality of its probability-based, large national sample. If research in this area is to develop at the needed pace, it will be necessary to collect a great deal of new data. A telephone version of the items would facilitate more rapid, more frequent and affordable data collection by multiple research teams to supplement and inform continued data collection via the GSS.

If the current measures are to be improved and the SSCC framework is to realise its full potential, there is thus much methodological work–

qualitative, quantitative, and experimental–that will need to be completed in the next few years. The second workshop provided NSF with a number of action and research recommendations, including a call for additional funding for research on public attitudes toward science.

SSCC in the Considerations of the National Science Board

The products of the two workshops were presented in a pair of reports in November 2010 (Toumey *et al.* 2010) and January 2011 (Guterbock *et al.* 2011). The first report was disseminated for the benefit of the November 2010 workshop, organised and chaired by Thomas Guterbock. Subsequently, Dr Myron Gutmann of NSF presented an oral summary to the National Science Board at its meeting of December 2010 and then he presented a written summary to NSB at its February 2011 meeting. The written report was later incorporated into the minutes of NSB's May 2011 meeting as an Appendix. In a one-page article in *Science* in July 2011 (Bhattacharjee 2011), the Chair of the NSB subcommittee for the *Indicators* affirmed that NSB is "revamping the survey" of public knowledge of science in accordance with the two workshop reports. The 2012 *Indicators* included a sidebar in Chapter Seven, which alerted the reader to the work of the two workshops in 2010, along with changes that will become manifest in the 2014 *Indicators* (NSB 2012). Together these developments indicate that the two workshop reports are being institutionalised for the benefit of future editions of the *Indicators*.

SSCC in Science Media

Another series of developments occurred in other venues. Chris Toumey had a two-page synopsis of the SSCC report published as a commentary in *Nature Nanotechnology* in January 2011 (Toumey 2011). Toumey and graduate research assistant Colin Townsend also disseminated the workshop results in presentations at the Society for Applied Anthropology (Seattle WA, April 2011), the Conference on Science and the Public (Kingston upon Thames UK, July 2011), and at North Carolina State University (Raleigh NC, January 2012).

The article in *Science* from 22 July 2011 (Bhattacharjee 2011) contained three statements that Toumey and Guterbock considered misleading, namely: (1) a statement that the SSCC report intended to "downplay" measures of public knowledge of evolution; (2) an accusation that the members of the National Science Board had been acting from religious motivations when they called for a re-examination of the conceptual framework for public knowledge of science; and (3) that changes were recommended because Americans were not scoring high enough on measures of civic scientific literacy.

In response, Toumey and Guterbock wrote a letter which appeared in *Science* on 7 October 2011 (Toumey and Guterbock 2011). Their letter refuted each of those three misleading statements from the July article. On the first point, the authors quoted from the first workshop report:

> The workshop participants strongly feel that the NSB, the NSF, and the *Indicators* cannot retreat from controversies about important scientific concepts. Evolution is a cornerstone of Biology. Measures and reports of public knowledge of science in the *Indicators* and elsewhere need to explore knowledge of evolution.

Their letter added that the SSCC report recommended expanding measures of knowledge of evolution by including adaptation, natural selection and speciation; also, the topic of evolution should not be limited to human evolution.

> The evolution of plants is germane to questions of genetically modified organisms, for example, and microbial evolution is relevant to our use of antibiotics and vaccines.

In summary, "These recommendations do not downplay evolution, as Miller suggests. Just the opposite–they enhance and expand measures of public knowledge of evolution".

Regarding the second and third statements, Toumey and Guterbock (2011) countered that "We see no evidence that the NSB members were motivated by religious reasons", and, "There is no truth to the allegation that we and our colleagues made those recommendations 'because Americans are not scoring high enough'."

Finally, the report of the October 2010 workshop received a very kind appreciation in the magazine of the British Science Association. Under the title "Knowledge should be of practical value", Anjana Ahuja (2011, 29) noted that "the concept of scientific literacy is changing–and…it desperately needs to change". Ahuja paraphrased the workshop report with these words:

> Instead of measuring how much scientific knowledge nonscientists can muster, and then lamenting the paucity, why not reframe scientific literacy in terms of a need-to-know basis instead of an ought-to-know basis?

The SSCC framework, wrote Ahuja, will “allow people to dig deep into the science that affects their lives”. The result, she said, will be that people will make better use of science in their lives: more parents will vaccinate their children; more people will take their entire course of antibiotics; more people will understand an allegation that light bulbs cause cancer; and so on. Ahuja’s article was unexpected praise of the workshop report, and the participants could not have asked for a more favourable endorsement.

Conclusion

For the process of measuring and reporting public knowledge of science, the revised conceptual framework described here has a clear and distinct starting point: what kinds of scientific knowledge do people in the public need for purposes of civic engagement with science and science policy, and for purposes of making individual decisions about one’s life and one’s health, and for purposes of feeding a person’s curiosity about science?

Furthermore, the revised framework reveals a series of insights about relations between the public and scientific knowledge: the public is far from homogeneous in its relation to scientific knowledge; public knowledge of science tends to be topical rather than nomothetic; and many persons in the public have a considerable ability to acquire, comprehend and employ scientific knowledge when they need to even if this ability is often underestimated.

The transition from “civic scientific literacy” to “science in the service of citizens and consumers” has a certain value: the audience for the two workshop reports is not a small community of academics unattached from the importance of public knowledge of science. On the contrary, the audience comprises three constituencies: (a) the staff of the National Science Foundation, who are charged with measuring public knowledge of science for the *Indicators*; (b) the members of the National Science Board, who are ultimately responsible for the content of the *Indicators*; and (c) policy makers, researchers and others, who use the *Indicators* as a trustworthy reference work.

And so this framework for putting science in the service of citizens and consumers reflects the ways that non-scientists acquire scientific knowledge and make use of it. This reorientation will shape Chapter Seven of the *Indicators*. If indeed policy makers use the *Indicators* when they think about science, then this new conceptual framework can bring new information and new purposes to discourses about a profoundly important topic: whom does scientific knowledge serve, and how does it serve them?

Notes

1. Participants in the October 2010 Workshop on Public Knowledge of Science (with field of expertise), included: John Besley, University of South Carolina (science communication); Meg Blanchard, North Carolina State University (science education); Mark B. Brown, California State University–Sacramento (science policy); Michael Cobb, North Carolina State University (science policy and survey research); Elaine Howard Ecklund, Rice University (science and culture; religion and science); Margaret Glass, Association of Science & Technology Centers (informal science education); Thomas Guterbock, University of Virginia (survey research methods); A. Eamonn Kelly, George Mason University (learning and cognition); Bruce Lewenstein, Cornell University (science communication); Chris Toumey (organiser and chair of the workshop), University of South Carolina (anthropology of science, especially public scientific controversies). Participants in the November 2010 workshop on implementing the recommendations of the first workshop, included: Nick Allum, University of Sussex (survey methods, public understanding of science); John Besley, University of South Carolina (science communication); Frederick Conrad, University of Michigan (survey methods); Allyson Holbrook, University of Illinois at Chicago (survey methods); Scott Keeter, Pew Research Center (survey methods); Susan Losh, Florida State University (Educational Psychology and Learning); Jeff Mondak, University of Illinois at Urbana-Champaign (political science); Bryce Reeve**,** University of North Carolina – Chapel Hill (psychometrics, quantitative psychology)**;** David Sikkink**,** University of Notre Dame (sociology of religion) ; Sally Stares, London School of Economics (social measurement, public perception of science); Roger Tourangeau, University of Michigan and University of Maryland (survey methods); Chris Toumey**,** University of South Carolina (anthropology of science); Tom Guterbock (organiser and moderator), University of Virginia (survey methods). In addition, the two workshops benefited greatly from the services of graduate research assistants Debbie Rexrode (University of Virginia) and Colin Townsend (University of South Carolina).

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