Models of public communication of science and technology

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ABSTRACT: Science journalism, science museums, community outreach programs about science – all these forms of "public communication of science and technology" have a long history. But little is understood about the systematic differences between the goals and possibilities of different kinds of projects. This article identifies four key models that have been used to describe public communication activities: deficit model, contextual model, lay expertise model, and public participation model. It also identifies problems both within the models and with attempts to fit all activities into this particular set of models. It suggests both new areas for research and new possibilities for outreach.

For more than fifty years, scientists, policymakers, journalists, museum curators, and others concerned about the relationship of science and broader publics have worked to improve "public understanding of science." Activity in public communication of science and technology is vigorous: journalists exploring every topic from astronomy to zoology, museum curators developing new exhibitions and museum-based outreach projects, community organizers including science education in after-school and enrichment programs, television and radio producers creating both science minutes and weeks-long documentary series, web-producers including science on a wide range of sites, and scientists themselves increasingly seeing public communication as an appropriate use of resources of time and money[1-3].

But whether all that vigorous activity is being "successful" is less clear, in part because there is no consensus about the goal, about what constitutes improved public understanding of science. For almost as long as organized activities to promote public understanding have been underway, scholars in various disciplines have been exploring what "public understanding" means, what the goals of various public communication activities are, who is being served (or missed) by these activities, and what constraints affect public understanding of science [4-7]. In particular, a tension often exists between idealistic visions of education and more targeted goals of increased funding, changed policy, or adherence to particular public health recommendations [8-11].

This essay presents a framework for looking at public communication of science and technology, and especially for understanding the motivations, strengths, and challenges associated with different approaches. My goal is not to judge any approach, but rather to understand how different perspectives on public communication of science and technology can lead to different activities and achievements.

The deficit model

Not surprisingly, most discussions of public understanding of science emerge from within the scientific community itself. The primary concern there has been, since at least the middle of the nineteenth century, the lack of intellectual public support for scientific ways of thinking and material public support for scientific work – the funds for research [12, 13]. By the middle 1970s, these concerns led to well-designed surveys fielded for the National Science Board that attempted to measure public knowledge of and attitudes towards science and technology [14, 15]. These surveys show that only 10 percent of Americans can define "molecule," and that more than half believe that humans and dinosaurs lived on the Earth at the same time [16]. Combining these factual questions with ones about the process of science and the institutional place of science has yielded measures of "science literacy" that show, depending on the year and the particular method of interpretation, that only 5 percent of the American public is scientifically literate, and only 20 percent are interested and informed. The rest, by formal definition, are "residual" [16-22].

Studies such as these – along with anecdotes common among the scientific community about the public's inability to understand even basic ideas of probability, skepticism, and evidence – have led to cries about the lack of knowledge, and then to new programs for providing information to fill the gap of knowledge [23, 24]. This approach has become known as the "deficit" model, since it describes a deficit of knowledge that must be filled, with a presumption that after fixing the deficit, everything will be "better" (whatever that might mean) [25, 26]. Vast and important projects to address science literacy have emerged (often by linking science literacy concerns to national goals of technological innovation and economic development), such as the National Science Education Standards in the United States [27, 28] and similar national curriculum revisions in other countries.

However, scholars have identified a series of difficulties with the deficit model. Most notably, many of the questions are asked without providing a context [5]. Learning theory has shown that people learn best when facts and theories have meaning in their personal lives [29]; for example, research has shown that in communities with water quality problems, even people with limited education can quickly come to understand highly complex technical information [30]. But in what situation with personal relevance, for example, does a nonscientist need to know the definition of DNA? In addition, the interpretation that labels many people "scientifically illiterate" or "residual," while based on well-established political theory, highlights the power relationships between those with the particular knowledge measured by the surveys and those without (as a practical matter, the best predictor of performance is usually the number of science courses taken in college). There has been little attention to other forms of knowledge that may be relevant to individuals in their real, everyday lives [7], such as trusting in the judgments of family members or clergy, or valuing the knowledge of nature acquired by local hunters or fishermen. Another critique is that, after nearly 25 years of gathering on the public understanding of science, and after many more years of active (and often excellent) attempts to affect public knowledge, the numbers seem remarkably stable. The percentage of the public "correctly" answering a series of factual questions has not changed in 25 years (although the last few years do seem to show an up-trend, it's not clear if that trend is real or merely an artifact of measurement or natural cycles [22]). Despite all the vigorous activity in public communication of science and technology, defining and approaching the problem from the perspective of "filling the deficit" doesn't seem to have reduced the perceived problem; the deficit model does not seem to have been a successful approach.

As a result of these concerns, at least three other models have been developed in response to the deficit model: a contextual model, a lay-expertise model, and a public participation model. These models are frameworks for understanding what "the problem" is, how to measure the problem, and how to address the problem.

The contextual model

The contextual model (or models) acknowledges that individuals do not simply respond as empty containers to information, but rather process information according to social and psychological schemas that have been shaped by their previous experiences, cultural context, and personal circumstances. One common area in which a contextual model has been applied is health communication, where practitioners have long understood the complex relationships between the information presented by health-care practitioners and the understandings taken away by patients both at the individual level and at broader public health campaign levels [10, 11]. A related area with well-developed use of a contextual model is risk perception and risk communication [31-33]. Contextual models acknowledge that individuals receive information in particular contexts, which then shape how they respond to that information. Personal psychological issues may affect the context, such as stage in life or personality type (fearful, aggressive), as may the social context in which information is received (a trusting relationship with an old friend versus a confrontational relationship with a distrusted employer, for example). Contextual models also recognize the ability of social systems and media representations to either dampen or amplify public concern about specific issues [34]. Newer approaches to contextual models have attempted to use modern marketing segmentation approaches to identify populations with differing underlying attitudes toward science, without necessarily tying those groups to particular risk contexts or to levels of "science literacy" [35]. At the practical level, a contextual model provides guidance for constructing messages about science relevant to individuals in particular contexts, such as using messages about addiction and brain structure as a vehicle for teaching reading to low-literacy adults (who may come from personal or social settings in which drugs and addiction are common) [36].

Contextual models have been criticized for being merely more sophisticated versions of the deficit model: they acknowledge that audiences are not mere empty vessels but nonetheless conceptualize a "problem" in which individuals respond to information in ways that seem inappropriate to scientific experts [5]. Contextual models recognize the presence of social forces, but nonetheless focus on the response of individuals to information; they highlight the psychological components of a complex social psychological setting. The recent use of marketing and demographic approaches has also raised concern that contextual model research is intended as a tool for manipulation of messages to achieve particular aims; the goal might not be "understanding" but "acquiescence."

In response to deficit and contextual models, researchers expressed concern that perspectives for exploring public communication of science and technology were too tied to the interests of the scientific community, which almost by definition constitutes an elite group in society. Deficit and contextual models often seem to equate "public understanding of science" with "public appreciation of the benefits provided by science to society" [6]. They do not adequately address the social and political context in which the powerful social institutions of science use "science literacy" as a rhetorical tool to influence funding and policy decisions [37], sometimes in political opposition to labor or local interests. Since the mid 1980s, these researchers have stressed the importance of recognizing local knowledges and commitments to political inclusion and participation. From these concerns have emerged two new models: lay expertise and public participation.

The lay expertise model

The lay expertise model begins with local knowledge, sometimes called "lay knowledge" [38].[1] This is knowledge based in the lives and histories of real communities, such as detailed local farming or agricultural practices, or historical legacies such as the cultural heritage of African Americans for whom the Tuskegee syphilis experiments are a real antecedent to contemporary opinions about trust in scientific medicine. The lay expertise model argues that scientists are often unreasonably certain – even arrogant – about their level of knowledge, failing to recognize the contingencies or additional information needed to make real-world personal or policy decisions. Although some researchers view attention to lay expertise as a subset of a contextual model [39, 40], I believe it should be seen as distinct. Unlike contextual models, which assume the value of scientific knowledge but recognize the complexity of delivering it, a lay expertise model assumes that local knowledge may be as relevant to solving a problem as technical knowledge. Basing their analyses largely on case studies

[1] A brief note to avoid terminological confusion: Burns et al. (2003) have recently used the label "contextual model" to refer to what I call the "lay expertise" model; they do not separately break out what I call the contextual model. Their work provides another attempt to make sense of the complex literature on public communication of science and technology.

[7], proponents of a lay knowledge approach argue that communication activities need to be structured in ways that acknowledge information and knowledge and expertise already held by communities facing scientific and technical issues [41].

While ideas about indigenous knowledge systems in developing countries have not been central to the intellectual development of the lay expertise model, they clearly fit comfortably with that model, as they emphasize the importance of knowledge and expertise that is held and validated by social systems other than modern science [42]. However, unlike approaches to indigenous knowledge systems that attempt to use modern science methods to verify traditional beliefs, the lay expertise model is explicitly targeted to valuing local knowledges as expertise in their own right [43, 44].

Like other models, the lay expertise model is subject to criticism. In particular, it privileges local knowledge over the reliable knowledge about the natural world produced by the modern scientific system. For that reason, it can be called "anti-science," and certainly proponents of local knowledge approaches have been targets of some of the virulent "science wars" disputes of the 1990s [45]. Scientific experts exist because some knowledge is more difficult to get and maintain; a gap of expertise is a natural outcome of an advanced and specialized society. The lay expertise model is clearly driven by a political commitment to empowerment of local communities. It is also not clear how a model of public understanding based on lay expertise provides guidance for practical activities that can enhance public understanding of particular issues, although it does suggest that activities designed to enhance trust among participants in a policy dispute are more important that specific educational or informational approaches.

The public participation model

Because of the importance of social trust as an issue in policy disputes about scientific and technical issues, a "public participation" or "public engagement" model has emerged, focusing on a series of activities intended to enhance public participation and hence trust in science policy. These activities include consensus conferences, citizen juries, deliberative technology assessments, science shops, deliberative polling, and other techniques [46-49]. The public participation activities can be driven by a commitment to "democratizing" science – taking control of science from elite scientists and politicians and giving it to public groups through some form of empowerment and political engagement [50]. Not all activities envisioned by supporters of public engagement necessarily require turning over control; in the United Kingdom, the public engagement model is sometimes called the "dialogue" model and is intended to highlight the importance of seeking public input into science issues, without necessarily yielding control [51, 52]. Moreover, the public engagement model appears to be similar to more established techniques such as public meetings and public hearings, although discussion in the literature of these links has taken place only rarely [53, 54].

Because the public engagement model, like the lay expertise model, carries with it a commitment to a particular stance about political relations, it can be criticized for addressing politics, not public understanding. Proponents of public engagement activities, however, often deny that their approaches share any common critique of science; in addition, some proponents counter that the deficit model and contextual models are equally political, for they link the "problem" of public understanding to individuals rather than social relations [55, 56]. The public engagement model can also be criticized for focusing on the process of science and not the substantive content (though some public engagement activities, especially consensus conferences, do commit significant resources to education), for serving only small numbers of people, and sometimes for having an "anti-science" bias.

Where to from here?

Clearly, these models provide only a schematic tool for understanding public communication of science activities. In practice, many activities combine elements of the different models, for example by including information about basic scientific issues in the background materials for public engagement activities such as consensus conferences [57, 58]. Recent analysts have attempted to re-analyze or re-design the survey work that is at the core of the deficit model, seeking new understandings in light of critiques of the deficit model [59-65]. Moreover, as Steve Miller has suggested (personal communication, 1 May 2003), the value of the deficit model can be rehabilitated by a shift from the "moral pressure/you *have* to know this" approach to a "softer/you might want to know this" approach (as in, "You might want to consult the WHO website on SARS before traveling to China"). Thus one important task is to further refine the models, understanding the relationship between idealized visions of what "public understanding of science" activities might be and what they actually are [6, 58, 66]. A particular element of this task will be to better integrate understandings from health and risk communication into broader models of public understanding of science and technology.

A related task is to expand the vision of what public communication projects can be imagined, and to understand how those imagined projects relate to existing projects. The clearest example, perhaps, is the proliferation of "citizen science" projects (also known as "student-science partnerships"), in which students and amateurs become deeply engaged in providing data both for the professional scientific community and for their own use; these projects often combine education, research, and a degree of entertainment or family outing [67]. Although environmental monitoring (such as Project GLOBE, www.globe.gov) and bird-watching (such as Project FeederWatch, www.birds.cornell.edu/pfw) are some of the most prominent of these new citizen science projects, their antecedents go back more than a century, to weather-gatherers, star-watchers, and Christmas bird-counts [68-70]. Are these projects attempts to fill the deficit? To create public participation in science? To help people bring local knowledge to solve local problems? The answer, of course, is "yes." But the currently existing models of public communication do not address these multiple, overlapping goals.

Another task: Because of the recent emphasis on "public engagement" in the language of both researchers and project designers, the community needs to understand better what that language might mean. Many types of engagement can be envisaged, for example: engagement in making or shaping science policy, engagement in making personal health decision, engagement in producing scientific knowledge (such as the citizen science projects noted above), engagement in particular areas of scientific knowledge (learning to love birds, amateur fossil-hunting, extensive plantings and gardenings, star-watching, etc.), and finally participating in or demonstrating "scientific thinking" (also called inquiry, critical thinking, disciplined thought). Some of these types of engagement can be accomplished as an individual, others require group or public activity. At least for the group (public?) engagement activities, a simple list of the "elements of engagement" that might be measured or observed might include, for example: group size, the number of people involved, the degree of deliberation that a group provides (ability to express a position or opinion), the existence of strength of attitudes expressed by the group, the ability to take action (and the actual activity of doing so). Many other issues can be elaborated.

The list of future directions can be expanded, no doubt. The key conclusion is: we need more research on public communication of science and technology. We need more understanding of the goals and accomplishments of particular kinds of public communication activities – understanding that can be achieved, in part, by acknowledging which of the models described above are at work in any particular public communication project, and which public communication activities don't fit any of these models. Such research will contribute to better knowledge of how knowledge (science) operates in society, as well as serving the practical needs of those concerned with "improving public understanding of science" – whatever that might mean.

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