A Critical Appraisal of Models of Public Understanding of Science: Using Practice to Inform Theory

Chapter · January 2010

DOI: 10.4324/9780203867631

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Part I

Merging Theory and Practice

Models and Frameworks

Chapter 1

A Critical Appraisal of Models of Public Understanding of Science

Using Practice to Inform Theory

Dominique Brossard and Bruce V. Lewenstein

Complex scientific issues are an inherent part of modern societies and are continuously debated in the public sphere. Stem-cell research, biotechnology, and global warming—these all require regulations and, as a result, necessitate scientific as well as societal considerations. Subsequently, a basic understanding of these complex issues should be made possible for all individuals living in societies that value and respect their citizens' views. In these democratic societies, public understanding of science is central to sound processes for policy making related to controversial scientific issues.

Recognizing the importance of the ethical, legal, and social dimensions of new scientific developments, the federal government over the last 20 years has made outreach activities and public understanding of science a mandatory component of federally funded projects. The essential assumption behind these outreach projects is that greater access to information will lead to more knowledge about ethical, legal, and social issues, which in turn will lead to enhanced ability on the part of individuals and communities to deal with these issues when they encounter them. Over the same period of time, new concepts of "public understanding of science" have emerged in the theoretical realm, moving from a "deficit" or linear dissemination of popularization, to models stressing lay-knowledge, public engagement, and public participation in science policy making (Lewenstein, 2003). In the public arena, calls for "better science communication" are routinely heard.

The present study turns to the Department of Energy-funded educational projects related to the Human Genome Project, specifically the Ethical, Legal, and Social Implications (ELSI) component of that research program, to explore the ways that information about a new and emerging area of science—one that is intertwined with public issues—has been used in educational public settings to affect public understanding of science. We aim to use real-world settings to investigate if discussions taking place in the theoretical realm can be translated into practice. In other words, we will use a case-study approach as a basis to test theoretical models of science outreach in order to assess to what extent those models accord with real-world outreach activities.

This chapter is organized in the following fashion: after placing theoretical models of public communication of science in a historical and conceptual context, we will discuss the methods we used to identify and analyze real-world outreach activities as related to these models. We will conclude by discussing the lessons to be learned from our investigation and their relevance to science communication research, and by challenging a strict use of the current theoretical models in public opinion and public understanding of science-related research.

Theoretical Background

"Public understanding of science," or PUOS, is a relatively new field of scholarly inquiry that has developed since the 1980s. PUOS-related projects can roughly be placed in two broad categories: (1) projects that aim at *improving* the understanding the public(s) have of a specific area of science; (2) projects that aim at *exploring* the interaction of the public and science.

Recent efforts have focused on integrating these two by linking research findings with outreach activities. Such efforts have aimed at building conceptual models of public communication of science that could give a comprehensive view of the frameworks that are at play for research in the field, one implicit goal of which is to implement these models systematically in the practical realm of outreach.

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 19th century, the lack of intellectual public support for scientific ways of thinking and material public support for scientific work—the funds for research (Burnham, 1987; LaFollette, 1990). By the mid-1970s, these concerns led to efforts by the National Science Board that attempted to measure public knowledge of and attitudes toward science and technology (Miller, 1983a, 1983b). These surveys show that in 2002, only 10% of Americans can define "molecule," and that more than half believe that humans and dinosaurs lived on the Earth at the same time (National Science Board, 2002). 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% of the American public is scientifically literate, and only 20% are interested and informed. The rest, by formal definition, are "residual" (National Science Board, 1991, 1993, 1996, 1998, 2000, 2002).

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 (Royal Society, 1985; U.S. National Commission on Excellence in Education, 1983). 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) (Ziman, 1991, 1992). Vast and important projects to address science literacy have emerged, perhaps most notably the National Science Education Standards in the United States (American Association for the Advancement of Science, 1993; National Research Council, 1996).

However, scholars have identified a series of difficulties with the Deficit Model. Most notably, many of the questions are asked without providing a context (Wynne, 1995). In what situation with personal relevance, for example, does a non-scientist need to know the definition of DNA? Learning theory has shown that people learn best when facts and theories have meaning in their personal lives (Bransford, National Research Council Committee on Learning Research and Educational Practice, 2000); 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 (Fessenden-Raden, Fitchen, & Heath, 1987). In addition, the interpretation that labels many people "scientifically illiterate" or "residual," while based on good political theory, highlights the power relationships between those with the particular knowledge measured by the surveys and those without. There has been little attention to other forms of knowledge that may be relevant to individuals in their real, everyday lives (Irwin & Wynne, 1996). Another critique is that, after nearly 30 years of gathering data on the public understanding of science, and after many more years of active attempts to affect public knowledge, the numbers seem remarkably stable. Approaching the problem from the perspective of "filling the deficit" doesn't 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: the Contextual Model, the Lay-Expertise Model and the Public Engagement Model. These models are frameworks for understanding what "the problem" is, how to measure the problem, and how to address the problem. Next, we discuss the Contextual Model of public communication of science.

The Contextual Model

The Contextual Model 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 the Contextual Model has been applied is risk perception and risk communication (Krimsky & Plough, 1988; National Research Council (U.S.) Committee on Risk Perception and Communication, 1989; Slovic, 1987). The model acknowledges 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). The Contextual Model also recognizes the ability of social systems and media representations to either dampen or amplify public concern about specific issues (Kasperson et al., 1988).

Newer approaches to the Contextual Model 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" (Office of Science and Technology & Wellcome Trust, 2000). At the practical level, the 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 often come from personal or social settings in which drugs and addiction are common) (Baker, 1995).

The Contextual Model has been criticized for being merely a more sophisticated version of the Deficit Model: it acknowledges that audiences are not mere empty vessels but nonetheless conceptualizes a "problem" in which individuals respond to information in ways that seem inappropriate to scientific experts (Wynne, 1995). The Contextual Model recognizes the presence of social forces, but nonetheless focuses on the response of individuals to information; it highlights the psychological component 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 the 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. The Deficit and Contextual Models often seemed to equate "public understanding of science" with "public appreciation of the benefits provided by science to society" (Lewenstein, 1992). They did 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 (Hilgartner, 1990), sometimes in political opposition to labor or local interests. Since the mid-1980s, these researchers have stressed the importance of recognizing local knowledge and commitments to political inclusion and participation. From these concerns have emerged two new models: the Lay Expertise Model and the Public Engagement Model.

The Lay Expertise Model

The Lay Expertise Model begins with local knowledge, sometimes called "lay knowledge" or "lay expertise" (Wynne, 1989). 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. Basing their analyses largely on case studies (Irwin & Wynne, 1996), 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 (Wynne, 1996). 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 (Ellen & Harris, 1996). 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 knowledge as expertise in its own right (Centre for Study of Environmental Change, 2001; Grove-White, Macnaghten, Mayer, & Wynne, 1997).

Like other models, the Lay Expertise Model is subject to criticism. In particular, it privileges local knowledge over 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 (Labinger & Collins, 2001). It 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 than specific educational or informational approaches.

More recently, a Public Engagement Model, which does not solely rely on lay expertise but rather aims to integrate citizens' views in public policy debates, has been put forward as the most appropriate framework for public communication of science.

The Public Engagement Model

The Public Engagement model focuses on a series of activities intended to enhance public participation in science policy. These activities include consensus conferences, citizen juries, deliberative technology assessments, science shops, deliberative polling, and other techniques (see, for example, Hamlett, 2002; Wachelder, 2003; International Science Shop Network, 2003). The public participation activities are often 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 (Sclove, 1995), although the exact nature of this empowerment has yet to be clearly defined. 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 (House of Lords, 2000; Miller, 2001). Moreover, the Public Engagement Model appears to be similar to more established techniques such as public meetings and public hearings, although formal discussion of these links has not taken place (McComas, 2001).

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 participation, however, 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 (Dornan, 1990; Jasanoff, 1997). Still, the Public Engagement Model can 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.

In sum, the driving force behind these four theoretical models is different. As illustrated in Figure 1.1, two of the models thrive at *delivering information* to the general public or to a specific group (Deficit and Contextual Models), while the other two are about *actively engaging citizens* with science (Lay Expertise and Public Engagement Models). Although some overlap can be identified between the Contextual and the Deficit Models on the one hand, and the Lay Knowledge and Public Engagement

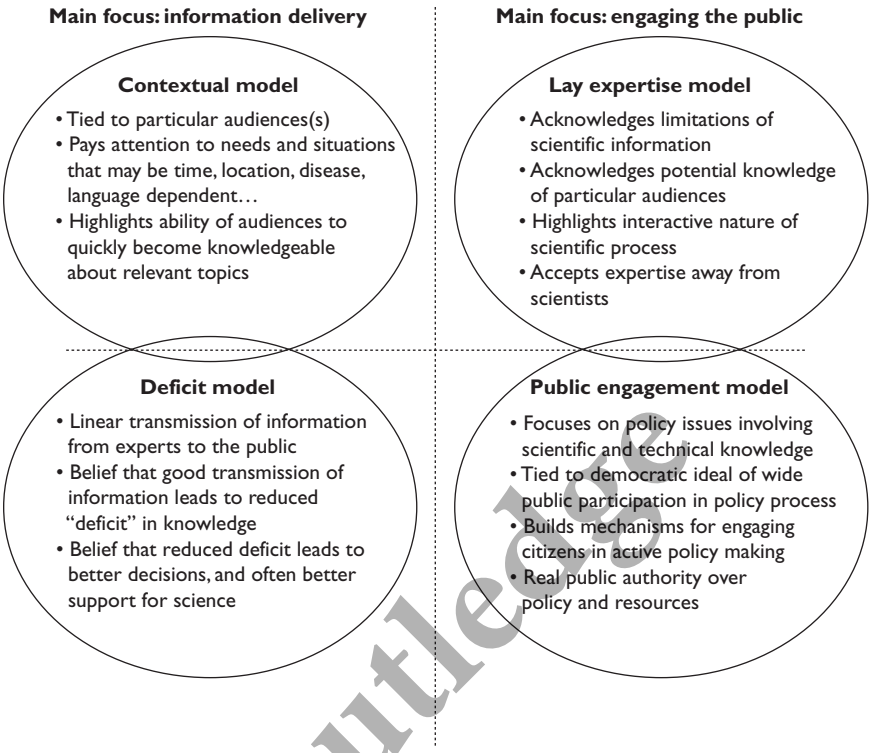

Figure 1.1 Conceptual Models of Public Understanding of Science.

Models on the other, the Deficit and Contextual Models as described in the literature are conceptually distinct from the two other models presented in this chapter and described succinctly in Figure 1.1. In other words, the literature tends to describe these models as mutually exclusive and to present them as the backbone of different research and outreach paradigms of public communication of science.

In the present project, we will test whether actual outreach can be mapped onto these models as described schematically in Figure 1.1, or if other models need to be defined in order to capture the reality of practice. We will therefore use a case study method as a way to rebuild or improve theory (Burawoy et al., 1991), with the overarching goal to inform future science communication research. To do so, we will rely on a specific context: the ELSI Outreach Programs related to the Human Genome Project.

Case Study: The ELSI Outreach Programs Related to the Human Genome Project

Genomics is a good example of a context for which advances in science have implications for individuals and society at large and have to be taken into account at the policy level. Studies of ethical, legal, and social issues related to genomic research have therefore been integrated into the Human Genome Project (HGP) since the earliest days of the project at the beginning of the 1990s. Coordinated by the U.S. Department of Energy and the National Institutes of Health and concluded in 2003, the HGP aimed to:

> 1) identify all the approximately 20,000–25,000 genes in human DNA; 2) determine the sequences of the 3 billion chemical base pairs that make up human DNA; 3) store this information in databases; 4) improve tools for data analysis; 5) transfer related technologies to the private sector; and 6) address the ethical, legal, and social issues (ELSI) that may arise from the project.
>
> (U.S. Department of Energy, 2008)

Three to 5% of the Humane Genome Project's annual budget was therefore devoted to "public understanding of science" studies, under the umbrella of the Ethical, Legal, and Social Implications (ELSI) Programs of the National Human Genome Research Institute of the National Institutes of Health, and of the Office of Biological and Environmental Research of the U.S. Department of Energy (DOE). As part of the educational component, a significant portion of DOE-ELSI funds were dedicated to public outreach projects, with the underlying goal of promoting public awareness and ultimately public discussion of ethical, legal, and social issues surrounding availability of genetic information (D. Drell, personal communication).

According to grounded theory, case studies can form the basis for the development of general theories, the researcher approaching the case studies with no preconceived ideas of what they might encounter (Babbie, 2001; Strauss & Corbin, 1990). They can also be used to identify "theoretical gaps and silences" in existing theoretical frameworks (Burawoy et al., 1991, p. 10). Following this approach, our study will analyze the DOE-ELSI outreach projects to explore the following research question: Based on an assessment of how real-world outreach activities accord to the theoretical models, how can these models be refined?

Methods

Our preliminary step was to identify the projects funded by DOE-ELSI that had an outreach component (DOE-ELSI-funded programs were not exclu-

sively outreach-related and could also tackle the following domains: privacy and fair use; clinical integration; and genetic research (ERPEG, 2000)). To do so, we downloaded from the DOE-ELSI website the abstracts of the 94 projects presented in the Human Genome Program Contractor–Grantee workshops in 1994, 1996, 1997, 1999, and 2000 (workshops IV to VIII; abstracts of projects funded prior to 1994 were not available). We then performed a content analysis of these abstracts to determine (1) the nature of the project (educational or other); (2) its primary intended audience; (3) the primary public communication of science model into which the project conceptually fitted; and (4) the main communication medium used for outreach in the project (for detailed methods, see DOE-ELSI, 2003).

To explore our research question, and based on the results of the content analysis, we selected from the educational-focused subsample five case projects that matched the following criteria: (1) the outreach project had an adult lay population as target audience (in other words, projects targeting professional groups were to be excluded since our goal was to discuss issues raised by public understanding of ethical, legal, and social issues related to genomics research in everyday life, i.e., outside a professional context); (2) the outreach project loosely fit within one of the four theoretical models of public communication of science presented earlier; (3) each outreach project selected used a different communication medium; (4) the selected project was completed, in order to be able to compare objectives and outcomes.[1]

Each of the five selected case projects was thoroughly analyzed (for detailed methods, see DOE-ELSI, 2003). First, we conducted 21 semi-structured interviews with project leaders and selected audience members. In this type of interview, the interviewer has a series of specific questions to be raised during an informal conversation with the interviewee (Leech, 2002). We analyzed the content of all outreach document drafts available following a chronological timeline, in order to identify if the project goals had evolved overtime. We also tracked and examined evaluative research that might have been performed on the project, and analyzed the final report submitted to DOE-ELSI officers. When applicable, we tracked public use of Web documents related to the project. Finally, we analyzed the final outreach materials used by each project to reach the target population (book chapters, articles, conference proceedings, emails, etc.) in order to identify the content themes tackled through the project.

Results and Discussion

In accordance with DOE-ELSI's stated goal of promoting education for genetic information-related issues, the majority of the 94 1994–2000

DOE-ELSI-funded projects had an educational component (76 of the 94 funded projects).

Among these 76 outreach projects, 23% were geared toward a youth audience, and/or specifically high school students. The same percentage of projects was geared toward professional groups (excluding teachers). Roughly 20% of the projects were designed for a general adult audience. Only 2.7% of the outreach projects targeted low-literacy adults. In line with conventional wisdom, a majority of the outreach projects (76%) fell within the Deficit Model. Roughly 20% loosely followed the Contextual Model. The "Lay Knowledge" and "Public Engagement" models were the main frameworks used by only 5% of the projects, respectively.

As a next step, and based on the above results, we chose five outreach case projects for in-depth analysis. Table 1.1 below presents these five projects and outlines the public communication of science model they seem to follow, their primary target audience, their main communication medium, and the project timeline. The following sections will discuss each of these projects in detail.

Table 1.1 Projects Selected for In-depth Analysis and Related Characteristics

Projects selected for case study	*Public communication of science model**	*Target audience**	*Main communication medium*	*Timeline*
The Geneletter	Deficit model	General public	Web newsletter	1996–1999
Challenges of Genome Research for Minority Communities	Contextual model	Minorities, mainly the African American community	Conferences	2001–2002
A Question of Genes	Lay knowledge model	General public	Television documentaries	Aired November 1997
The Hispanic Radio and Science Education Outreach	Contextual/ public engagement models	Hispanic community	Radio programs	1996–1999

Note
*As defined in the initial description of the project; these might have evolved over time.

Project 1—Deficit Model: the Geneletter

Case Background

Supported by DOE-ELSI funds from 1996 through April 1999, *Geneletter* intended to reach a broad public audience by reporting on scientific, ethical, legal, and social aspects of genetics through a Web-based newsletter. The idea of Phillip Reilly (Director of the Shriver Center at that time, and co-PI of the project with Dorothy Wertz), was that whoever used the Internet for public education about genetics and ethics would have power over public education. *Geneletter* published 10 issues on its site at www.geneletter.org, from July 1996 to February 1999. After that period (and ending with the DOE funding), the *Geneletter* was turned over to GeneSage (a California-based Internet start-up, aimed at genetic professionals) in return for a $20,000 donation to Shriver Center.

Each issue of the *Geneletter* included one or more of the following types of pieces: updates on scholarly conferences (5% of total pieces); updates on community events/community education/websites of interest (2.3%); book reviews (8%); new articles (79%); and case studies (5%).

A content analysis of the 196 pieces published between July 1996 and February 1999 confirmed that *Geneletter* addressed a wide range of issues, in line with the DOE-ELSI research agenda. Roughly 20% to 25% of the new articles had as main focus respectively "ethical issues," "legal issues," "social issues," and "scientific issues," indicating that the *Geneletter*'s content was in line with its stated objective.

Geneletter editors kept records of Web traffic statistics. According to the *Geneletter* final report, the average number of hits on the *Geneletter* webpage per day between September 18, 1996 and October 26, 1999 was 1,857. Starting with the March 1997 issue, which contained articles on the ethics of cloning, readership shot up to an average 5,000 site visits per week and remained there until the site was transferred from the Shriver Center in October 1999. The average user session lasted 7 minutes. The audience was broad, including a range from sixth-graders to college graduate individuals. According to the co-PI of the project Dorothy Wertz, "no visible difference in knowledge was apparent between the groups, as shown by the types of questions asked through e-mail or chatbox" (D. Wertz, personal communication).

Users' feedback was made possible through two channels: a chatbox and direct emails to the editors. The chatbox did not prove to be effective at promoting discussion, as numerous technical problems were encountered and only 200 items were posted in 3 years. As pointed out in the *Geneletter* final report, "it appears that although people were eager to seek information from the editors via email, comparatively few were eager to 'chat' about issues related to genetics."

Indeed, users did ask a wide variety of questions through the "Letter to the Editor" feature, i.e., emails. The editors received over 800 inquiries through this medium. A content analysis of a random sample of 177 emails sent to the editors produced the following results: 21% expressed support for the *Geneletter* webpage and 24% were related to education (i.e., school project, course content, graduate work). However, 12.4% addressed a theme not related to *Geneletter* content. As noted by Dorothy Wertz, "readers' queries focused on popular science issues (cloning, Jurassic Park) rather than on ethical concerns" (D. Wertz, personal communication).

Whenever possible, the editors made a point of answering readers' queries. Many of the emails, however, asked very broad questions (and were therefore hard to answer, according to the editors) such as "Tell me everything you know about the Human Genome Project." One may therefore wonder to what extent the content of the *Geneletter*'s articles was appropriate for the knowledge level of a fraction of the readership.

The initial project ended with DOE-ELSI funding in October 1999. *Geneletter* resumed its publication in February 2000, with a new editor, Paul Billing, and with financial support from GeneSage, Inc. *Geneletter* had lost a lot of readership by then, but eventually got back on track. *Geneletter*'s targeted audience shifted to primary-care physicians. Articles were written by staff and freelance writers, and the format of the letter changed. According to Dorothy Wertz, the quality of articles varied. Sixteen issues were published between February 2000 and May 2001 (one per month). The project ran out of funds in January 2001, and the last four issues ran previously used material. Dorothy Wertz did want to insure the continuation of the project as it was initially set up (and geared toward a broad audience), but was unsuccessful at getting *Geneletter* back to the Shriver Center.

Case Study in Relationship with the Theoretical Models

Geneletter essentially followed the Deficit Model, at least in principle. *Geneletter* aimed to increase public understanding of ethical, legal, and social issues related to genomics, the editors defining the themes to be covered and addressing a broad range of ethical, legal, and social issues related to genomics research. No specific audience was targeted, the editors aiming to reach all interested individuals. This approach seemed to be successful: (1) readership of the newsletter was broad, and included a range from sixth-graders to college graduate individuals; (2) the site had 5,000 visits per week (after March 1997), the average user session lasting 7 minutes, a reasonably high number for a specialized newsletter; (3) the themes raised by the readership in the "Letters to The Editor" were in line with the content of the articles posted online. However, the content of the emails did raise the question of the level of information that should be provided to a broad audience.

Still, although at first glance *Geneletter* broadly followed the Deficit Model of public communication of science, it did provide information in context, which critics often claim deficit approaches do not attempt to do. Most of the articles (particularly those using a "case study" format to address ethical issues) provided information in a clear and simple way and made this information as relevant as possible to readers' lives. In other words, *Geneletter* displayed some characteristics usually not outlined in theoretical accounts of Deficit Model approaches and were actually in line with the Contextual Model.

Another feature of the project illustrates that the Deficit Model label does not accurately describe the *Geneletter*. Project leaders and readership did interact through emails, and readership was, to some extent, encouraged to "engage" with science, to use the project leaders' own words. As pointed out earlier, "engagement" and public empowerment are the main goals of the Public Engagement Model. We did mention earlier how this term is conceptually vague, because it can range from sparking interest among the public, to engaging citizens in decision-making procedures related to science. Although obviously we do not know to what extent *Geneletter* did spark public participation in decisions related to scientific issues, the project does suggest that the boundaries between the Deficit model and the Public Engagement models may not be as drastic as sometimes described in academic realms.

In sum, the analysis of the *Geneletter* shows that the Deficit Model does not fully capture the reality of this type of outreach. A project that, at first glance, might have appeared to be a traditional deficit approach had characteristics that made it fit in several theoretical models.

Project 2—Contextual Model: "The Challenges and Impact of Human Genome Research for Minority Communities Conferences"

Case Background

The National Educational Foundation of Zeta Phi Beta Sorority, Inc. received support from DOE-ELSI to sponsor conferences specifically geared toward minority communities. Five major conferences took place between 1999 and 2001 in New Orleans, Philadelphia, Atlanta, and Washington, DC, three of them funded by DOE-ELSI.

The conferences broadly aimed to involve minorities with science and genetics. The goals were to provide minority community members with information about the Human Genome Project and to find out minorities' concerns related to current genomic research. The conferences also aimed at getting minority college students interested in the areas of genetics, biotechnology, and related sciences.

We focused our in-depth analysis on the Philadelphia (July 7–8, 2000) conference. Leaders of the conference were Issie L. Jenkins, Esq., Zeta Foundation chair and Kathryn Malvern, conference project director. A planning committee developed the program for the conference. An advisory council (composed of around 25 representatives from minority organizations, governmental agencies, health organizations, churches, and educational institutions) provided feedback during program development and was in charge of information dissemination to communities.

According to Jenkins,

> the committee advisory groups [were] very instrumental in identifying people in that community who could be a part of the program … and in raising questions that might be of interest to them so that [they] might be included in the program.
>
> (I.L. Jenkins, personal communication)

They were also instrumental in getting community members to attend the conference because community leaders, such as ministers, could encourage individuals to attend who might otherwise be left out of the process.

The conference combined experts' presentations and panel discussions, workshops, and public discussions. Organizers succeeded in creating a very mixed group of presenters (researchers, DEO representatives, private researchers, sociologists, anthropologists, educators). According to the organizers, general scientific information and terminology (e.g., genes, proteins) was first provided in order to make the presentation of the Human Genome Project—and its potential benefits and ethical, legal, and social implications—easier to understand. Follow-up workshops covered a variety of topics related to minorities and genetics and aimed at producing a list of concerns and recommendations. Handouts and free copies of the book *Your Genes, Your Choices: Exploring the Issues Raised by Genetic Research* (Baker, 1997) (both provided by DOE) were made available to conference participants. The conference proceedings were posted online on the DOE-ELSI webpage.

There was very little newspaper, television, or radio coverage prior to the conference, with advertising restricted to flyers and mailings. The organizers reached out to the community members by contacting organizations directly, and by providing them with materials and registration forms to give to their members. Kathryn Malvern reported the following story (K. Malvern, personal communication):

> So I was telling you the story about the judge in PA, she said, "Dr. Malvern, you are not going to get the Chinese community this time, because they are all focused on Chinatown." [The judge] said, "I will be the conduit," and she was for what was happening, and she would

> be part of whatever happened later. She was there at the conference, she had all the material.... So I am saying, you must have a true leader ... she has kept that community involved.

Attendance exceeded expectations. The conference was attended each day by 250 individuals representing, among others, minority organizations, civic groups, religious groups, leaders in health communication, local government officials, and students. Roughly three-quarters of the audience was composed of African Americans.

Some 55 attendees requested to serve as future community liaison coordinators, and signed up to be trained as such at the end of the conference. Participants were also asked to fill out evaluation surveys, which was done by 83 attendees. Of those, 88% felt the conference was very successful at imparting useful information to members of their groups (8.4% somewhat useful; 2.4% don't know), 67.5% felt they had learned a great deal about the science being done on the HGP (25% a little). Roughly 55% of respondents said that they learned a great deal about the ethical implications of the HGP, about the potential harmful effects of the HGP for minority groups, about the social implications of the HGP, and about the potential benefits of the HGP for minority groups (35% a little).

As far as attitudes toward the potential effects of the HGP, 48.7% felt that the benefits would be greater than the harmful effects, while 15.4% felt the harmful effects would be greater than the benefits; 80.8% were concerned about the availability of genetic information to employers; 79.7% were concerned about the availability of genetic information to insurers; 78.9% were concerned that HGP benefits would be available only to privileged groups.

The conference seemed therefore to have achieved the goal of informing its audience and raising awareness of the potential benefits and harmful effects of the HGP for minority communities. However, the percentages reported above should be interpreted with caution, because only 33% of the attendees (assuming that the same 250 people attended the conference every day) filled in the evaluation survey. The project did succeed in initiating the propagation of HGP-related information to minority communities beyond the conference itself. The fact that 55 of the conference attendees signed up to become community liaison coordinators demonstrates that the conference motivated some individuals to reach out to their communities, which was ultimately the goal of the conference.

Case Study in Relationship with the Theoretical Models

The project broadly followed the "Contextual Model" of public communication of science. As explained in an earlier section, according to this model, researchers identify populations that might have different underly-

ing attitudes and concerns related to genomics research without necessarily tying those groups to particular risk contexts or to levels of "science literacy." Outreach projects are then built in a way that is relevant to these audiences. The conference focused on minority needs and concerns.

What is particularly interesting is that the conference was used as a setting not only for the dissemination of relevant information, but also to find out the characteristics of the particular context at play. For instance, the Rev. Dr. Deborah Wolfe, a conference panelist, produced 14 questions for which she requested answers at the conference. As she put it:

> Since, as you know, I did not participate in bringing about this great discovery [the genetic code] and since I really know so little about the details of the study, all I can do as a teacher, as a preacher, as an interested citizen is to raise questions to you who are specialists.
>
> (Jenkins, personal communication)

The meetings with the community liaisons were also a place where specific minority concerns could be identified. Kathryn Malvern synthesized this point in the following way:

> You see, we don't necessarily know all minority issues. Take for instance the Hispanics, their morals and culture can be different and when we think in terms of something that happens in the community, we could think that it is negative when for them it is a positive thing. Therefore it is important to get their leaders involved, so that we can more easily understand [the context] and get into those communities.
>
> (K. Malvern, personal communication)

Philadelphia conference organizers and community liaisons did share the goal of providing useful information to their community through outreach. But as David Lieu (from the organization State of the Arts Inc. and one of the community liaisons) put it, "the challenge was that people [had] a different interpretation of outreach. Everybody was going towards a goal, but using different ways to get there" (D. Lieu, personal communication).

Not surprisingly, the project borrowed some features of the Deficit Model, by providing background knowledge a priori defined by experts. The goal was to help the audience grasp the basic scientific content needed to be able to constructively discuss ethical, legal, and social issues related to genomic research and its applications. As discussed previously, critics have argued that the Contextual Model is at best an "improved" Deficit Model, since it still posits expert knowledge to be the correct one and conceptualizes a "problem" in which individuals respond to information in ways that seem inappropriate to scientific experts. However, as our case

study points out, the community members themselves seek scientists' input, based on the assumption that some scientific knowledge was necessary for conference participants to be able to raise meaningful questions. In this case, the goal was not, as argued by critics of the Contextual Model, to fix lack of knowledge among lay publics, but rather to bring all audience members to a shared level of basic knowledge before discussing specific concerns. One may argue then that the conference was more of an "empowerment" tool, following the philosophy of the Public Engagement Model, since it broadly aimed to involve minorities with science and genetics. However, the goals of the organizers were very pragmatic and did not seem to have political motivations: to help minority members understand the science behind the genome project, to allow them to raise their concerns, and to get answers, if any, from a group of experts from various backgrounds.

Project 3—Lay Expertise Model: "A Question of Genes"

Case Study Background

On September 16, 1997, a special program developed with funds from DOE-ELSI, entitled "A Question of Genes: Inherited Risks," aired on national public television. Through case studies, this documentary aimed at exploring the dramatic social and ethical dilemmas raised by genetic testing, and at appealing to a broad audience. The general philosophy of the documentary was "to tell what the technology [meant], not what it [did]" (N. Schwerin, personal communication).

The project was developed at the initiative of the filmmaker Noel Schwerin, who had worked previously on science-related documentaries (for programs such as NOVA, in particular) and who performed all the background research necessary for the program. Schwerin then brought the project to an executive producer, Angier Production, to work on a proposal to be submitted to DOE.

Two types of outreach materials were developed in the context of the project: first, the documentary that was aired on national television, and second, a website developed concurrently to provide additional information and links relevant to the topic at hand.

The documentary provided a series of seven profiles, or case studies, of people "like you and me" that had had to deal with issued related to genetic testing in the course of their lives. The filmmaker had the individuals directly share their personal experiences—there was no narrator. As Schwerin put it: "I believe that they are the experts… They had the real data" (N. Schwerin, personal communication).

The seven profiles presented in the documentary were given equal weight, although they did not all present the same point of view. The goal

was to get the audience to think about the issue and the ethical implications of such situations, while presenting only the science that was needed to understand the case study. Schwerin pointed out that it was often "tricky to give just enough information as not to get confused" (N. Schwerin, personal communication). In some cases, the individual recounted his/her experience and provided necessary scientific information. In others, a doctor or expert presented relevant background information. In some instances, additional information was provided at the end of the case study through a scroll-down text.

The seven case studies were also presented on the website related to the project, giving interested viewers the opportunity to find out more about the issues at hand. Video clips with audio were posted for each case study—users could also read transcripts of the scripts. Each case study was also accompanied by a link to an educator's guide specific to that topic, as well as links to a discussion forum. Users could post comments and questions to the discussion forum from September 16 to October 13, 1997. During this period, users were able to interact with a panel of participants from the TV program, which included physicians, patients, and researchers.

It is hard to assess the size of the audience that viewed the program when it aired on national television, although it did have the potential to reach millions of individuals. It seems reasonable to assume that the audience was typical for such TV shows broadcast on PBS in the late 1990s. PBS reached at that time 90 million viewers a week, an audience that reflected the U.S. population in terms of race/ethnicity, education, and income (PBS, 2009).

The educator's guides (provided through the website) were distributed to 66,000 professionals in genetics, ethics, biology, public health, and related fields. Results from a bounced-back survey card (223 responses) provided with the educator guide indicated that 63% of the respondents were professors or teachers. Additionally, the website had 40,000 hits in its first 3 months, very high traffic for such a show. Some evaluation of the TV program was provided through the bounce-back survey cards and through phone interviews with a sample of those who had been provided with the education guide (94 interviews). Respondents, overall, gave very positive feedback on "A Question of Genes," 92% of the respondents indicating that the program was excellent. More than 85% of the respondents indicated that they had or would use "A Question of Genes" as an educational resource; 92% videotaped the program for future use; of those, 80% said that they would recommend it to their students.

The timing of the project was perfect for the format used in the program. Since media coverage about these issues was still minimal, people were more genuine and more eager to share their experiences. According to Schwerin, "it was an amazing opportunity to find out how people felt about these issues" (N. Schwerin, personal communication).

As shown by the evaluation data and the press coverage, "A Question of Genes" was a highly successful documentary that won several awards. Not only was the documentary used as a TV program and discussed through the website; anecdotal evidence shows that it is also in demand for use in high schools and other educational settings. Schwerin has been invited to talk about the film at the University of California at Berkley and Stanford University, and a screening of sections of the film were shown at a meeting of the American Association for the Advancement of Science, for an audience of bioethicists.

Case Study in Relationship with the Theoretical Models

"A Question of Genes" exemplifies how the Lay Expertise Model for public communication of science can be used in an outreach setting. As we discussed earlier, proponents of a lay knowledge approach argue that communication activities need to be structured in ways that acknowledge information, knowledge, and expertise already held by communities or individuals about science and technology issues they face. Despite criticisms of this model, this case study demonstrates that it might be a good way to approach issues that do have high relevance in people's lives and that might provoke strong feelings. In other words, as Schwerin argued, having "real people" explain how they dealt with genetic counseling will explain "what the technology means, not what it does." If this is the goal of the outreach, a "lay knowledge" approach might be the way to go.

In line with the conclusions reached for the other projects, this case study also reveals some overlaps between the theoretical models we presented earlier, by fostering participants' engagement with science. Showing overlap between the lay knowledge and public engagement models, the TV program led viewers to go to the website and to get the educators guide, likely in order to use it in other settings. The project also provided the scientific information necessary for the audience to be able to understand the case studies. In that sense it did share some of the characteristics usually attributed to the "Deficit Model" of public communication of science. Finally, the project displayed some characteristics of the Contextual Model, in that it paid attention to the needs of particular audiences, the people for whom genetic counseling might be particularly relevant. By emphasizing what the technology meant and what it did, i.e., by focusing on attitudes rather than on knowledge, the project successfully went beyond the Deficit Model.

Project 4—Contextual/Public Engagement Models: "The Hispanic Radio and Science Education Outreach"

Case Background

In 1998, the Self Reliance Foundation (SRF), a nonprofit organization connecting Hispanics in the United States with informational resources, got 3 years of funding from DOE-ELSI to develop a series of radio shows focusing on the HGP, its scientific, medical, and ELSI implications, and complementary outreach projects. The shows were to be broadcast on the Hispanic Radio Network (a Spanish-speaking radio network). The overall goal was to "help inform the Spanish-speaking population in the U.S. about the HGP and its ELSI implications, and motivate them to access the resources available for further education and information on these issues" (Self Reliance Foundation Robert Purcell, personal communication).

From February 1998 to February 2000, the project developed more than 75 brief (1–2-minute) radio programs that were broadcast on three radio shows of the Hispanic Radio Network: 30 programs through "Fuente de Salud" (carried by 36 station affiliates); 10 programs though "Planeta Azul" (carried by 96 station affiliates); and 10 programs through "Saber is Poder" (carried by 31 station affiliates). These programs covered the following themes: Hispanic individuals involved in aspects of genome research and its implications; economic implications of genome science; bio-industry involvement in the genetic revolution; and encouragement of Hispanic students to pursue science and biotechnology careers. The project also developed three hour-long shows for the radio talk show "Mundo 2000" (carried by 17 affiliates), in which Spanish-speaking experts in genetics discussed a number of issues and answered audience questions.

An 800 telephone number was listed at the end of the radio programs. A bilingual operator would answer the call and use a database of over 15,000 local organizations, ranging from health clinics to science museums, to provide additional referral information. The goal of the 800 number was to link people to information sources useful to their needs. Finally, the project used the syndicated newspaper column "La Columna Vertebral," syndicated in 82 Spanish-language newspapers, to provide information about genomics and its implications.

Although no data are available concerning the audience for DOE-funded programs, general information about the syndicated programs is: "Fuente de Salud" reaches an estimated 48.9% of the Hispanic population of the United States, "Planeta Azul" 86.4%, "Saber es Poder" 46.2%, and "Mundo 2000" 20.9%. The column reaches 2.5 million readers overall.

In 2001, SRF started to broaden its outreach to involve a greater mix of components. Its new philosophy was to use the radio program to get people interested in a specific topic, and help them follow up on their

interests. One of SRF's most recent projects is "Celebre la Ciencia" (celebrate the science), which is funded by the National Science Foundation. For that project, SRF tries to combine traditional media (radio, newspapers, etc.) and high-profile events, like community festivals. Information on why science is important and how families can get involved is presented in the media, with examples of science museums, zoos, and other family-friendly settings. In recent years, SRF had six science-related organizations represented at the Mount Pleasant festival in Mount Pleasant, MD. Notices were posted on the radio, and local TV news programs announced the event.

Case Study in Relationship with the Theoretical Models

The project clearly fits into the Contextual Model of public communication about science, because it was specifically geared toward the Hispanic population and tailored to their needs and attitudes. Because Hispanics made up 12.5% of the population in 2000, and were the fastest growing minority in the United States (U.S. Census Bureau, 2006), the project intended specifically to reach and inform that audience. According to the organizers, data had also shown that a significant fraction of this minority felt discriminated against by the U.S. health-care system. Radio seemed an appropriate medium since it appears that most of the Latino population has good access to it—greater access than lower-income African American families (Arbitron, 2005).

The project also had a public engagement component. The purpose of using the toll-free number was to promote a self-informational process for the audience of the radio shows. The SRF clearly intended to go beyond informational engagement, as the follow-up projects demonstrated, by promoting active participation of Hispanic families in science activities, such as the ones displayed in science museums, and therefore increase general interest in scientific issues and, potentially, policy-making involvement. In short, the project clearly did not fit exclusively into one of the theoretical models as presented in the academic literature.

Conclusion and Lessons for Research Agendas

The goal of the present study was to assess whether theoretical models routinely discussed in the public communication literature are a good reflection of outreach efforts in the public realm. Our objective was to use practice to inform theory and to identify areas of research that should be integrated in new agendas for science communication research.

Our analysis of specific outreach projects related to the ELSI of genome research showed that although the scholarly literature tends to present the theoretical models outlined in our first section as incommensurable and as reflecting different research and outreach paradigms, practice is likely to be

more pragmatic, with projects adopting parts of each model to suit different contexts. We found that a "contextual project" does attempt to provide information and to promote understanding of a scientific issue. It can also aim more particularly at shifting attitudes toward using scientific knowledge, rather than at specifically increasing knowledge. Alternatively, a project that fit the "lay knowledge" approach did display characteristics compatible with the "public engagement" model, by actively encouraging participants to seek more information about genetic counseling and by encouraging involvement in science.

In sum, we argue that theoretical approaches to public communication of science do not capture the complexity of the reality of informal science education projects. Our somewhat limited analysis (we focused on five projects) did unveil an overlap between models traditionally presented as incommensurable in theoretical discussions. Projects tended to use mixed approaches that blended models, rather than gravitating toward any one well-defined framework.

Figure 1.2 presents the public communication of science models as experienced in the outreach settings. All outreach projects tended to use the Deficit Model approach as a backbone, even if they seemed to follow other theoretical approaches. Contextual projects aim not only at increasing knowledge, but also at discussing the audience's attitudes toward science and scientists. Public engagement with science was fostered at different levels: (1) through a simple interaction between citizens and scientific experts; (2) through the empowerment of citizens to voice their viewpoints; and (3) by providing real public authority over policy.

Several of our findings have important implications for science communication research. First, our analysis highlighted the importance of defining the public(s) of interest for any type of communication effort (and by extension any type of science communication research context). This might at first glance seem like a given, since as discussed previously, theoretical models do acknowledge that science audiences differ on a number of characteristics and do give different weight to these audiences. But it is important to reiterate that a crucial element of science communication resides in the level of commitment of the publics under consideration. Not all citizens want to be involved in science decision making, nor should they be; nor do all scientists want to participate in the communication of science. In short, research should not rely on a priori characterizations of science audiences and should carefully assess all contexts of inquiry.

Second, all case studies shared the goal of communicating accurate scientific information to an audience (whether this audience was the general public or a specific group), even when lay expertise or public engagement were put forward as the focus of the project. However, although all project organizers acknowledged that an understanding of scientific concepts was a prerequisite to any type of discussions about the ELSI of genomics research,

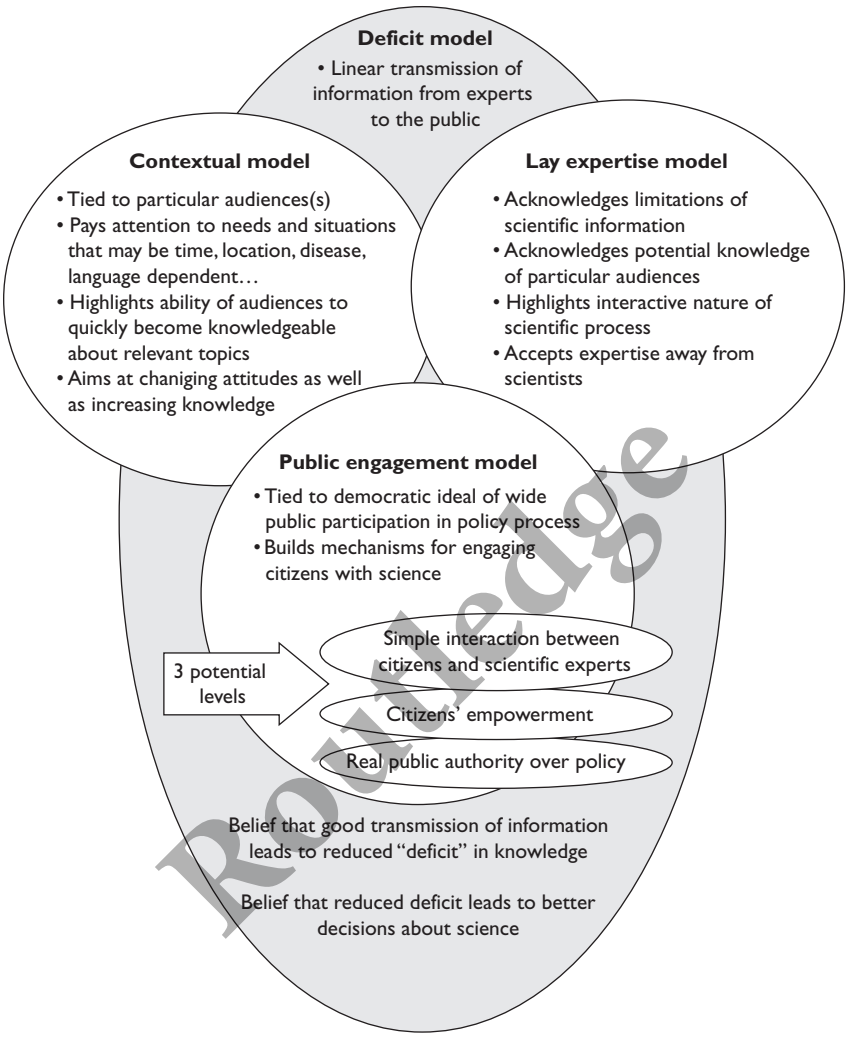

Figure 1.2 Public Communication Models in the Outreach Setting.

there was no consensus among project organizers about the level and type of knowledge to be fostered. In fact, this was reflective of the lack of consensus at that time about what constitutes an "adequate" knowledge of genetics, a point that was brought up in 2000 by the ELSI Research Planning and Evaluation Group (ERPEG). The ERPEG report noted, "a major gap in DOE-ELSI education and resources portfolio is the absence of studies that examine basic issues such as what each audience (students, teachers, nurses, judges, lay public) actually needs to know about genetics and ELSI" (ERPEG, 2000).

This conclusion, reached in 2000, is still valid today and has implications for science communication research agendas. We live in a world in which "scientific citizens," to borrow a term coined by Alan Irwin (2001), are increasingly expected to express viewpoints on a variety of controversial topics having technological dimensions (such as stem-cell research, biotechnology, nanotechnology, biofuels), while what constitutes scientific literacy and how to measure it is still under debate. Understanding this dynamic should continue to be a major priority of research agendas in science communication (for a recent discussion on scientific literacy, see Brossard & Shanahan, 2006).

More broadly, the relationship between levels of understanding of technological innovations and public attitudes toward these issues should also continue to be analyzed. Recent research has shown that levels of knowledge do indeed matter, but in a more complex way than previously thought. Individuals are likely to use their existing knowledge to form attitudes, but will tend to interpret scientific information differently by relying on pre-existing value predispositions as filtering tools (Brossard, Kim, Scheufele, & Lewenstein, 2008; Ho, Brossard, & Scheufele, 2008). Most of the research exploring the link between knowledge and attitudes has traditionally been performed in predominantly quantitative methodological settings, while relying on measures of knowledge that were for the most part conceptualized by experts. This line of research would benefit from insights provided by the Lay Expertise Model, while integrating qualitative and quantitative methods of inquiry. In a nutshell, we should develop measures of scientific knowledge that take into account relevance and context (time and place) and that relate to a specific objective, and we should continue to research scientific literacy and knowledge-production mechanisms. This will be made possible by building bridges between research paradigms.

Third, our analysis highlighted a concept often put forward in recent debates related to public communication of science, the notion of "public engagement." What is "public engagement" in the context of science-related activities, and what type of engagement can these projects reasonably aim at increasing are both questions worth asking in science communication research. Although educators (and outreach specialists) might conceptualize "engagement in science" very pragmatically as "interest" and "involvement," academics and policy makers tend to give the term a political dimension. The analysis of our case studies demonstrates that citizens can be engaged in science (and ultimately in science policy) at different levels. First, individuals can engage in a simple interaction with experts to discuss scientific issues and their ethical implications (e.g., *Geneletter* emails). Second, individuals can be empowered through different public participation processes (e.g., "A Question of Genes" project; the minority conferences). Third, citizens can be given authority for decision making about science policy. In this case, scientific experts are to some

extent disempowered. This form of engagement is the one traditionally put forward through the Public Engagement Model. Although it is encountered in some public communication of science instances (e.g., consensus conferences), we did not identify it within the DOE-ELSI educational portfolio. This is interesting considering the fact that wide public engagement is the ultimate goal in current discussions related to nanotechnology and other controversial innovations.

As science communication researchers, we need to acknowledge that citizens can indeed become engaged, but not always when we want them to (for a discussion, see Brossard & Shanahan, 2003). Research on public engagement in science within different contexts (conceptualization and operationalization) should therefore be one of our priorities. Political science has for decades examined the concept of public engagement. Here again, science communication research will be fruitful if it builds bridges between different research paradigms.

Finally, science communication research should focus on interpersonal processes. The minority conferences used in this chapter relied on community opinion leaders to build effective communication contexts and on different discussion settings to foster dialogue and shared understanding. Methodologically sound research on the role of interpersonal discussions in science communication is yet to be published, although it has been the focus of numerous research studies in other fields of inquiry. The role of opinion leaders in science communication is also ripe for focus in our field.

In sum, theoretical perspectives in science communication research need to take into account the permeable boundaries between theoretical models and continue to reach toward other fields of inquiry. Practice may be achieving what academics and researchers still need to accomplish: breaking down the walls that separate paradigms and building bridges between them where useful and effective.

Acknowledgment

This material is based upon work supported by the U.S. Department of Energy under Grant No. DE-FG02-01ER63173. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the U.S. Department of Energy.

Note

1. It should be noted that no formalized sampling methodology was applied to the selection of the case projects, since we were not aiming to generalize conclusions to other projects.

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