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Modelos de comprensión pública: la política de la participación pública

*Models of Public Understanding: The Politics of Public Engagement**

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Resumen

En este artículo destacaré algunos supuestos subyacentes al nuevo lenguaje (y enfoque) que se utiliza en el ámbito de la comunicación pública de la ciencia –esto es, al lenguaje de la participación pública o apropiación social. Mi

Abstract

In this paper, I will highlight some of the assumptions underlying the new language and approach in the field of science communication, –that is, the language of public engagement or social appropriation. My goal is to show

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propósito es mostrar cómo una comprensión de las implicaciones políticas de los diferentes modelos de comunicación pública de la ciencia puede ayudarnos a negociar las relaciones de poder y autoridad que están en juego. El reconocimiento de la complejidad política del contexto de la participación pública puede ayudarnos a identificar las cuestiones académicas que es necesario investigar, así como las preguntas más prácticas que es necesario formular en la evaluación de eventos concretos, actividades, e instituciones.

Palabras clave: Comunicación pública de la ciencia, participación pública, apropiación social, implicaciones políticas.

how an understanding of the political implications of different models of science communication can help us negotiate the relationships of power and authority that are at stake. Recognizing the political complexity of the public engagement context can help in identifying the scholarly questions that need to be explored, as well as the more practical questions that need to be asked in evaluations of particular events, activities, and institutions.

Key words: *Science communication, public engagement, social appropriation, political implications.*

I'm really delighted to be here at this meeting on challenges in science communication. I'm particularly excited to talk here at a meeting where we're looking at the challenges in science communication research. I think we have a whole series of them. Let me try to describe several of them, and the ways they link to each other.

I think that the first challenge we face in our field is that it's still new, and many people come to the field with relatively simple notions of what it's about. There's a tremendous amount of fascinating research going on. I had the privilege of publishing some of it when I was editor of *Public Understanding of Science* and now Martin Bauer gets to oversee it as the new editor. But if you're trying to understand the overall framework of the field, it can be hard to get the overviews that can introduce people to framework for understanding the questions being asked by the state-of-the-art work that appears in the journal.

To meet that challenge, we need to have some common scholarly vocabulary. But that's a challenge, too, one that is complicated even further by the language barrier. I, of course, think in English and most of you are thinking in Spanish. Moreover, the labels that get used in English don't necessarily

translate directly into Spanish. Even if they do translate directly, the words probably have different meanings when put together into certain phrases.

For example, I usually talk about «public understanding of science». When I first entered this field 25 years ago, many people referred to «popular science» or to «popularizing science». In French and Spanish, people referred to «vulgarization» and «divulgación». And there was then, and is still today, a lot of discussion of «science literacy». In India, where I visited for the first time a few weeks ago, the term «scientific temper» is part of the national constitution, listed as one of the fundamental duties of the citizen. In the scholarly community, we have moved on to other terms. Many of us discussing these issues refer to «public engagement in science» or to «*culture scientifique*» (in French). That reference to culture shows up frequently. In Korea and China, for example, many of my colleagues refer to «science communication and science culture» (all in one phrase). Our meeting today is talks about the «promotion of scientific culture». In Latin America, the term «social appropriation of science» has been used a lot, pointing to the way that broader culture incorporates science.

Interestingly, the City of Arts and Sciences here in Valencia is part of that attempt to link science with the broader culture, since it explicitly combines science and art. I'm looking forward to my visit there.

This new language tries to suggest that science is not something pushed onto an unwilling public, but instead is something that the public desires and eagerly takes up. That is a noble belief, and one that I do believe in myself. But as a scholar, I am deeply aware that different people use these terms in different ways. In this paper, I will highlight some of the assumptions underlying the new language and approach –that is, the language of public engagement or social appropriation. In particular I will try to show that many people (especially within the scientific community) who have taken up this new language do not understand the deep political implications of these new terms. In particular, they do not recognize that public engagement or social appropriation imply giving the public authority over science. Put another way, «promotion of scientific culture» will not necessarily lead to the results that scientists expect.

So my title really should be: «The politics of talking about "engagement"». My goal is to show how an understanding of the political implications of different models of science communication can help us negotiate the relationships of power and authority that are at stake. Recognizing the political complexity of the

public engagement context can help in identifying the scholarly questions that need to be explored, as well as the more practical questions that need to be asked in evaluations of particular events, activities, and institutions.

Despite all the problems of labels, I am going to introduce a new one. I like to refer to «public communication of science and technology». Building on the work of one of my own professors, the astronomer Benjamin Shen, I like to think of public communication of science and technology as serving three needs: personal needs, civic or national needs, and cultural needs. The personal needs are things like health, computers, and all of the particular technical skills one needs for a job in the modern world. The civic need is for informed citizens in a democracy. Those of us who believe in democracy deeply believe that the more people who understand issues like global climate change, genetically modified foods, the pricing of pharmaceuticals, the environmental implications of fishing and farming and forestry policies, the interrelationships between local geography, agricultural capabilities, economic needs, and national security –all of these issues will be better handled by representatives who are elected by citizens who can voice informed opinions about how they would like their governments, grocery stores, and community organizations to handle the compromises that are necessary in the real world for dealing with these complex issues.

The final need, cultural science literacy, is one that isn't talked about enough. Public communication of science and technology serves our need to think about science and technology and innovation as core elements of our culture. We need to know about science, technology, and innovation because they are what defines us as humans. Just as we believe that everyone should know something about art and music because they are expressions of our human spirit, so we also need to know something about science and technology because our ability to create these understandings of the natural world and to use those understandings for innovations to serve the world is one of the supreme achievements of the human mind.

Many other lists of the goals of public communication of science and technology have been proposed, but I think most of them can be boiled down to this list of three. When you combine these needs, you recognize the complex relationships among them. Balancing these needs is never easy. That's what politics does: it is the process of reconciling our competing needs. I don't mean politics in the dirty, corrupt sense of saying anything to get a vote. Instead, I'm referring to politics in the noble sense, politics as

the process of bringing together a community into a shared set of goals. Since the needs served by public communication of science and technology or public understanding of science or social appropriation of science and technology –whatever you want to call it– are so complex, that means that public communication is inherently a political process.

As with any political process, public communication of science and technology will therefore involve compromises, winners and losers, questions of power and authority, efforts to identify experts in the non-experts, and all the other factors that we see in any political context. You see this especially in developing countries; at meetings I've attended in the last year in Colombia and India, one of the main issues has been the question of elites, the power they hold, and how to use that power to address the common problem in developing countries of large gaps between the rich and the poor.

One key element of politics of course, is the local culture. Unfortunately, I know little of the culture of Spain, and nothing of the culture of Valencia. So, in what follows, I will refer primarily to politics of public communication of science and technology in the United States. I hope that in the discussion we will be able to link some of my observations to the political cultures here and elsewhere.

In the United States, various activities associated with public understanding of science are motivated by the institutional needs of different groups. For example, magazine publishers and website producers are trying to drive readers to their products so that advertisers will be rewarded by purchases from those readers and viewers. Scientific societies, such as the American Association for the Advancement of Science and the American Chemical Society, are trying to influence the allocation of resources to science in general, and sometimes to their particular scientific discipline. They are also trying to ensure that the educational system continues to produce new recruits for their fields, whether those are people with strong backgrounds in mathematics, deep understanding of the natural world, or facility with using highly advanced computers. Government agencies are trying to be sure that they have the expertise they need to carry out their obligations, as well as trying to influence citizens to support increased allocations to their budgets (they are, after all, bureaucracies, and the primary function of a bureaucracy is to extend its own life).

Given these institutional needs, it is not surprising that the term «public understanding of science» usually means «public appreciation of the benefits

that science provides to society». I don't disagree with that meaning, but I think it's very important for us to understand that these innocuous terms like «public understanding» or «public engagement» actually represent the interests of particular institutions or particular sets of people. These are *political* terms, which have meanings that go beyond the simple meaning of the words.

Thus if we are to understand how public engagement in science and technology can serve society, we need to understand the politics of the institutional and social relationships that are involved in the process of public engagement.

In the political world of public communication of science, there are four models at work. The deficit model and the contextual model both focus on delivering information to people. The lay knowledge and public engagement models are sometimes called dialogic or interactive models –they focus more on the interaction between different publics and the scientific community that is trying to provide information.

Let's talk first about the deficit model. It emerges from the scientific community, which has a lot of political power, although they don't always realize it. For many years, going back to the beginning of the 20th century, the scientific community has been concerned about the lack of public knowledge about science and technology. The community has usually argued that more knowledge is better knowledge. In other words they believe that people have a deficit of knowledge, and all we have to do is fill the deficit. Then, everything will be better –whatever «better» means.

Typically the deficit model is associated with measures of scientific knowledge such as the science literacy surveys conducted by the National Science Foundation in the United States or the European Union's broader surveys of public knowledge and attitudes, which are actually modeled on the American surveys.

Since some of what I have to say may make it appear that I am critical of the deficit model, I want to be explicit that I believe that many excellent educational materials have been produced by people who follow the deficit models. Some examples: well-known books such as Stephen Hawking's *Brief History of Time* (which has sold more than 12 million copies worldwide), or the *Bill Nye –The Science Guy* television show. It was originally from the United States, but it has been shown around the world as wel– I was once at a game reserve in South Africa, hundreds of kilometers from any city, and the clerk at the hotel desk recognized Bill! I'm particularly fond of him, because he

graduated from Cornell University, where I work, and he comes back to visit regularly. Many institutions, such as aquariums and planetariums operate on the deficit model, delivering excellent information about the natural world to many different audiences.

Along with the deficit model comes the attempt to measure public understanding of science. These surveys have several parts, but typically the core of the survey is a series of questions about people's knowledge of particular areas of science and technology. The data shows very little change for most of the questions. About the same percentage of people –45%– over the 20 years can tell you that electrons are smaller than atoms. Many more –about 80%– can tell you that the center of the Earth is hot. But that still means almost 20% can't answer that question.

In the United States we have a particular problem with questions that involve dinosaurs or the age of the Earth, because fundamentalist readings of the Bible are so strong in our country. So, less than 50% of people know that the earth began in something called «the Big Bang» or that humans evolved from other species. About the same number believe that dinosaurs and humans walked on the earth at the same time. For those of you who know children's cartoons, I call this the «Fred Flintstone effect». (Well, maybe this isn't just a North American problem. Last year, when I asked someone in Colombia if people would recognize Fred Flintstone, he told me that people there used to play with Bam-Bam and Dino. I know he was just joking, but still…).

Questions about radioactivity, the speed of light compared to the speed of sound, and continental drift show the most knowledge –nearly 80% know that the continents move around on the planet's surface.

The lesson from this data is, I think, fairly clear. Despite 30 years of excellent efforts to provide information, driven by the political needs of the scientific community, there has been very little change in people's knowledge of science and technology.

This data is traditionally interpreted through a political science theory about «attentive» publics. According to this theory, first developed in the 1950s, there is only a small percentage of the public that is both *informed about* and *pays attention* to particular subjects. That group is called the «attentive» public. There is a second group that pays attention, but isn't very well informed. That group is called the «interested» public. The final group, and this is the label that is used in the theory, is called the «residual» public.

This data, and the accompanying theory, have some difficulties that need to be addressed. The first is the lack of context of the knowledge questions. Why, for example, would most people need to know the relative size of electrons and atoms? Why do they need to know whether dinosaurs and humans lived on the earth at the same time? Certainly there is no practical reason why you need to know the answers to those questions, although one could make an argument about the civic or cultural reasons for knowing that information. But still, the questions seem to come out of nowhere.

The more important problem is one that highlights the political aspect of the different models of public communication of science and technology. Labeling the different parts of the public as attentive, interested, and especially «residual» creates a clear hierarchy among parts of society. It clearly implies that people who are attentive are the best people, and it especially implies that the people who are not paying attention, who don't have knowledge, are the lowest kind of people. Another example of the political use of this data is the attempts to define people as scientifically literate or scientifically illiterate. Clearly in any kind of modern society, to be illiterate, is lower on the list of acceptable positions. Although I have not given details about how this data is used to label people as scientifically literate or illiterate, I can tell you that the definition is essentially arbitrary, and therefore demonstrates the power of those who have the ability to define who counts as literate or illiterate. This means that it is easy to misinterpret some of this data.

As I have noted above, the data is also troublesome because there is essentially no progress over the 30 years since the data was first gathered in the late 1970s, despite many years of excellent books, superb museum exhibits, stimulating and exciting television shows, newspapers, magazines, websites, interactive theater, traveling programs… still there has been essentially no change in public knowledge of science and technology. Moreover, there have been several studies which have shown that there is no correlation between people's levels of knowledge and their attitudes and actions with regard to science and technology. People with very limited knowledge of science and technology are often some of the most supportive of science and technology, and the most likely to use the products of science and technology.

These problems led to the development of a second model, the contextual model. The contextual model is very similar to the deficit model, except that it recognizes that public communication of science and technology takes place

in a social context. It recognizes that demographic characteristics, social settings, trust in institutions, and other factors can shape public knowledge of science and technology.

For example, a different set of data was collected in the United Kingdom around the year 2000. This data was collected and interpreted in a different way than the simple knowledge questions. It noted that people could also be assessed on whether they were concerned or unconcerned about the place of science in society. They could also be assessed on whether they were interested or not interested in the products of science, technology, and innovation. And in addition to those two criteria, they could also be assessed on their level of trust in the regulatory system –in other words, their level of trust in a major *social* institution. When these three characteristics are used to chart people, six different groups emerge.

The contextual model has been used in many ways to create communication programs that recognize the social context in which people deal with information. For example, in the United States, we have often been shamefully racist in the way we have dealt with the African-American community. In a very famous study, the Tuskegee study, that began in the 1920s and did not end until the late 1960s, a group of black men were allowed to have no treatment for syphilis, even after an effective treatment was discovered, in order to study the «course of the disease». The study was flawed in many technical ways, and yet those flaws were ignored because of the racist beliefs. One consequence of that study is that African-Americans in the United States today are still, nearly 40 years later, extremely suspicious of the medical community. So, if you want to provide medical information to the African-American community, you have to pay attention to their distrust, and plan your programs with that in mind.

Other kinds of contextual knowledge are simpler. Because of our large Hispanic population in the United States, many outreach projects now produce the materials in Spanish as well, as you can see from the biological sciences project on the right. And that understanding of our multilingual society has led to projects like one from the Centers for Disease Control in which information is made available in many languages.

Another aspect of the contextual model is to recognize the social setting in which public communication of science and technology takes place. If I take my son to the science museum, does he remember anything about how to achieve a balance between displacement and buoyancy in a large bucket

of water? No, of course not. He remembers that he spent a day with his parents, having fun. But if I take my *students* to the science museum, what do they think about? They want to know what they have to know to pass the test! So the context makes a big difference.

The contextual model also tells us something about what *not* to do. About 12 years ago, I visited the Indonesian Science & Technology Center in Jakarta. At the time, it was only two or three years old. It was before the overthrow of the dictator Suharto, and one of his good friends was the patron of the museum. As you can see, it was large and fancy. It was also empty. They had put so much money into the building that they left nothing for exhibits or education. I met the «director of education», who was a teacher at a local university –she worked at the science center only one day a week or so. But it was especially the exhibits that failed to meet the «contextual model». They were whatever exhibits the museum could get donated. One exhibit was apparently the previous year's trade show exhibit from a weapons manufacturer –it was all about the strength of the materials used in the manufacturer's missiles. The saddest exhibit was one about languages. It was a wonderful exhibit, all about how the sounds that animals make are different in different languages. So, in some languages, a dog says «bow-wow». In others, it says «woof»! In others it says «wow-wow». Unfortunately, none of the languages in the display were spoken in Indonesia. All the examples were in English, Spanish, Japanese, or Scandinavian or Middle-eastern languages. There was a tremendous missed opportunity there.

Still, the contextual model does have difficulties. It remains focused on delivering information, understanding «science literacy» as a problem that can be fixed by simply providing the right information to the right people in the right way. While the contextual model recognizes that different audiences may have different needs because of political or economic histories, it doesn't address the underlying causes of those different needs. It does not try to address the distribution of power in society, it does not address public participation, it is ultimately not about democracy.

That brings us to the «lay knowledge» or «lay expertise» model. In this model, it is less important to deliver information about technical subjects, such as stem cell research. Instead, one should put much more effort into acknowledging local knowledge, such as public understandings of ethical issues.

The lay knowledge model was developed in the 1990s, about the same time that people here were starting to talk about social appropriation of knowledge. It came out of the recognition that the deficit model was privileging the knowledge and power of particular groups in society, and wasn't recognizing that in the real world, people look for information in situations in which they already have some knowledge. This model says that the local knowledge should be given more authority.

That's critical, to recognize the commitment to more authority. This model and the next one are not just about delivering information in better ways. They are about transferring authority to nonscientist publics.

I think it is easiest to understand the lay knowledge model by showing you the most famous case that led to its development. Much of this work was led by a British physicist who became a sociologist of science, named Brian Wynne, who works at Lancaster University. The case he followed involved sheepfarming in Cumbria, in the north of England, just after the Chernobyl nuclear reactor accident in 1986.

The accident happened at the end of April. By a few days later, the fallout cloud had drifted across much of Europe. As it passed over England, unfortunately, it rained. That rain deposited nuclear radiation on the hills of northern England, where one of the major activities was sheepfarming. Initially, the Ministry of Agriculture, Food, and Fisheries (MAFF), said that farmers didn't have to worry. But within days, it was clear that lambs who had grazed on the radiation-covered hills were themselves becoming radioactive. In June, MAFF imposed a 3-week ban on bringing lambs to market. More than a month later, the 3-week ban was extended indefinitely. Notice how often the ministry was changing the information it provided.

Initially, almost 9000 farms were affected. Although many farmers were able to bring their lambs to market later in the summer, 15 years later there will still a few farms that were considered contaminated. That's 15 years *after* a 3-week ban.

Also in the region is the Sellafield nuclear-reprocessing plant. The Sellafield plant used to be called the Windscale plant. In 1956, there was a major fire at the Windscale plant, which was the most serious nuclear accident before the 1979 Three-Mile Island disaster in the United States. But there had been a massive information cover-up at the time, leading to the government losing much of its credibility about nuclear issues, especially in this region. The problem was so bad that the plant had been renamed, in

part to try to make people forget about the fire. But this is the kind of region where families stay for generations, and those people have *local knowledge* –in this case, knowledge about what has happened in the past. So when the new problem came from Chernobyl, many local people were very suspicious about anything the government –including government scientists– said about nuclear contamination.

Meanwhile, information was coming from many, many sources. That information didn't always agree with each other. How could the local citizens decide who to trust? They had good reasons, historically, to not trust the government scientists, especially the ones who came from far away. So they were much more likely to trust locals, like the local agricultural extension agent or simply the information they heard at the market or the pub.

Moreover, the government scientists continued to act in ways that confirmed their *lack* of knowledge. They ignored questions from the local farmers about whether the radiation would be uniformly distributed or more concentrated in pools where the water collected as it ran down the hillside. They told the farmers *one* day before the weekly market whether they could bring their lambs to sell; but farmers needed *three* days to bring their lambs in from the hills where they roamed –the scientists were clearly ignorant about the important knowledge of how farming works. It turned out the scientists didn't even understand their own technical models– they didn't realize that the models they were using were based on soil in a different part of the country, and that's why the models were giving the wrong information.

But the biggest problem was that the scientists continued to insist that they had the correct information, even when it was completely obvious to the local citizens that the scientists' knowledge was wrong.

The idea of the value of local knowledge is not just about the possibility of mistrust of knowledge that comes from distant experts. Nor is it simply about the local nonscientists misunderstanding the information that the scientists were providing (using something like «deficit model» techniques of handouts and lectures). Rather, the idea of lay knowledge highlights that local communities have collective knowledge that they have developed over many years and on which they can rely. That knowledge is actively constructed by the community as it brings information from many sources to address their problems.

Local knowledge doesn't have to be about controversies. For example, consider a program called «Project PigeonWatch». The program has ordinary citizens in big cities observing pigeons and providing information to scientists

about the color differences and behaviors among pigeon communities. The scientists use this information to address questions about genetics and color distribution. In this case, the scientists use local knowledge of where the pigeons are and the work of local communities to gather data.

The PigeonWatch program is just one of the many «citizen science» projects operating around the world now. Citizen science projects are all about harnessing local knowledge, to help scientists with hundreds or thousands of eyes and hands that can help define scientific problems and gather data. In some citizen science programs, the citizens are just data-gatherers for the scientists. But in the best citizen science programs, the participants themselves help define the scientific questions, and have complete access to the data that is collected by volunteers from around the country or even the world. So those citizens can themselves do the analyses that interest them. The Laboratory of Ornithology, at my own university, has been one of the major developers of citizen science –you can go to their website to get more information on how to create your own citizen science project or join an existing project.

But citizen science projects are not just about birds or the environment, and they are not just in the United States. There are many lists of citizen science projects on the web, in many countries. There are projects about astronomy, the weather, biodiversity, water quality, air pollution, climate change, and so on. Last year, two writers at scidev.net, which is a site for science journalists in the developing world, wrote an article highlighting the possibilities for using citizen science to empower people in the developing world to use science for their own benefit.

Still, the lay knowledge model has its own problems. Just because people think they know something, that doesn't mean their knowledge is correct. If you tell people that smoking will frequently lead to lung cancer, they may respond: «No, that's not true. My uncle Jose smoked like a chimney for all his life and lived until 92». That is local knowledge, but it is not reliable knowledge about the natural world. Even people who support citizen science worry about whether the information that nonscientists gather will meet the methodological standards of professional science. (So far, the data shows that citizen science data is very good. The very fact that there are so many people collecting data means that incorrect data becomes a statistical anomaly).

The lay knowledge model also suffers because *scientists* don't trust it. To accept the validity of lay knowledge is to give up the power and technical

control that scientists believe that they, as experts, should be the ones to have. And many of us would agree with them. When I get on my plane to go back to the United States, I do not want an amateur fluid dynamicist to have designed the wings on the plane.

Finally, although the lay knowledge model can be used to describe citizen science, the overall lay knowledge model doesn't really give us suggestions for how to improve public communication of science and technology. It tells us what can go wrong, but how would we design a program at the planetarium or develop a story if we are a science journalist to highlight local knowledge? The nature of local knowledge is that we don't know what is needed until the moment that the knowledge is brought to the discussion, so it is hard to plan actions based on local knowledge.

This leads to the final model, called the public engagement model. This is the model that often generates the most excitement in the policy community today, because it seems to offer a way to get people excited about science.

«Engagement» is often described as something like «educational involvement» –using hands-on or interactive exhibits to get children and adults «engaged» in the learning process.

But this is not what scholars meant when they developed the public engagement model. They were much more focused on the process of *political* engagement, on finding ways of bringing citizens more actively into the process of making decisions about science policy issues. They applied the label of public engagement to activities such as consensus conferences or citizen juries. These activities involve having nonscientists gather information or hear testimony about the technical, social, legal, political, ethical, and other aspects of issues such as genetically-modified foods, coca-eradication programs, nuclear or solar energy production, or anything else that involves science, technology, or innovation in a social context. Then that jury or conference makes a recommendation.

Many of the original public engagement activities were developed in Denmark. There, the recommendations were a formal part of the public policy process. The report of a consensus conference was required to be sent to Parliament. Parliament might choose not to accept the recommendations, but they had to do actively. They couldn't just ignore the report. This meant that the citizens who participated in public engagement activities were truly exercising the power that they have in a democratic society.

The real political innovation of these kinds of public engagement activities is to turn power and authority about science policy over to nonscientists. To many scientists, that is a scary possibility, and every time I hear scientists talk excitedly about public engagement, I think they probably do not understand the deeply radical political position that it represents. The term «public engagement» has been misused, because in its pure meaning, it is very politically subversive.

Now, I do have to say, most of the public engagement activities that have been implemented are much more interactive and dialogic than deficit model activities, but they fall short of the political upheaval that I believe the term was meant to describe. Many activities are like this one, which provides information about genetic testing and then gives people the opportunity to express their opinion. But there is no formal link to the political process, no way for the engagement to necessarily lead to real action.

Similarly, when public discussions have been held about GMOs or genetic enhancement or any other issue, those discussions are rarely linked to the policy process. Consensus conferences have now been held in many countries around the world, and I have yet to hear of one that has led to a change in policy. Indeed, a couple of months ago I was in Denmark, and my colleagues there questioned whether, even in the ideal case, the consensus conferences have actually led to substantive changes in policy or the direction of science.

That leads to the difficulties. First is the terminological one - by «public engagement», do we mean educational engagement or political engagement? Second is that even the political engagement model tends to focus on the process of getting citizens involved in policy, and doesn't address how those citizens will get the content knowledge that they need. Finally, consensus conferences *may* work when you have a small, homogenous country like Denmark. Imagine trying to set up a conference of 25-30 people in Spain, or Italy, or in any developing country such as Brazil or India – how would you get a good representation of the entire country? It's very difficult to scale these activities up to a large population, have them be truly interactive and participatory, and still somehow have a coherent outcome.

And, of course, there is the political issue that I have already stressed so much. True public engagement activities are not just about hearing local knowledge and getting the opinions of local communities. They are about transferring political power and authority. Is that something scientists, or

government agencies, or industrial leaders, are willing to do? People sometimes call for a revolution in social power. But revolutions are violent, dangerous things. Yes, the world is sometimes a better place after the revolution. But in the revolution, some people win and some people lose. Sometimes they lose badly, losing not just power, but wealth and possessions and even their lives. So I do not expect that the transfer of political power that is presented by a true understanding of the public engagement model is likely to happen easily.

So how do I bring these models together? As I said at the beginning, the four models really fall into two groups: the transmission model and the engagement model. As I went through the models, I hope you saw that when I described their strengths and weaknesses, they all have both. The transmission models, especially the contextual model with its understanding of how you have to tailor a message for a particular audience, really gives us excellent opportunities for creating wonderful ways for people to learn what they want to know. And the engagement models help us understand how and why people would *want* to be trying to appropriate information, what a world of social appropriation of knowledge would be like.

But the models all also have flaws.

And so I think, in the real world, public communication of science and technology needs to combine the models. If we truly believe in democracy, then we have to move towards real public engagement models. But in order for those public engagement models to work, there must be a great deal of transmission of information lying underneath them.

This, I think, is what we should mean by «public engagement» or «social appropriation» of science. It would be an entirely different talk, but my former student Dominique Brossard and I have tried to apply this kind of thinking to looking at projects funded by the «ethical, legal, and social issues» program of the U.S. Human Genome Project. We have found that you can only understand those programs if you understand them as combinations of all of these models. Similarly, I've seen work from Ana Maria Navas, from Sao Paulo, about the science communication policy of Brazil. She has found that even though the government policy is to move away from the transmission model towards the engagement model, in reality the projects they support continue to depend heavily on the transmission model. So, as we move forward, we must find ways of revising these theoretical models to reflect the real world of public communication of science and technology.

To close, I want to return to my son at the science museum. He's lucky, because he has a father who likes to spoil him. He had a longstanding interest in elephants, because his first stuffed toy was an elephant. He carried it with him everywhere until he was about 7 years old. So we would take him to the zoo, and give him elephant books. When I had a chance, I would introduce him to exciting science popularizers like Bill Nye the Science Guy (the really small kid is my 3rd son –I haven't shown you any pictures of my oldest). In 2002, when I had a meeting in South Africa, I brought him with me– he got to see elephants and a total eclipse of the sun and hold an elephant gun that our guards shared with him. Many people would bring him elephants from around the world, so that his collection fills an entire bookcase in his room.

But despite all this science information, he really didn't think of himself as a scientist. He's really interested in politics, and travel. He's been studying Spanish, and during high school thought he might try to become a diplomat or a businessman traveling between the United States and Latin America. But then a funny thing happened. In his final year of high school, he discovered that biology comes easily to him, and he became involved in a research project on elephant conservation in Gabon, in Africa. (He didn't get to travel there – he just helped enter the data back at Cornell).

And so, about a year ago, he started college at Tufts University in Boston, which has an elephant as its mascot. Just two weeks ago, he declared his major as international relations with a concentration in environmental issues, so that he can be involved both in the science and the public discussions. So he would be active in both transmission *and* engagement.

To conclude: One of our greatest challenges is to recognize the political nature of communicating science with different publics. Politics means power and authority are at stake. So, when people start talking about specific models of how to go about communicating science, we have to be aware of the political implications of those models. I think an important direction for science communication research in the future must be to find new ways of combining these models, using them as tools for exploring the political aspects of science communication. As we learn more about the politics, I think we will be better placed to understand the interaction of science and culture, which ultimately should be our goal.

Thank you very much.