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PEP/IS

A New Model for Communicative Effectiveness of Science

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Public engagement with a problem or an issue relative to science (PEP/IS) is suggested as an alternative and complementary model for understanding the communicative effectiveness of science. PEP/IS is conceptualized as the process of individual and collective problem solving in relation to science and exemplified with South Korean exploratory data. Finally, further steps for improving PEP/IS and related research capability are suggested with communicative effectiveness being anticipated.

Keywords: *communicative effectiveness; consequentiality; engagement; PEP/IS; public; public understanding of science; problem vs. issue; impression; reflexivity*

Scientific knowledge and its applications are exploding. They represent significant evidence of human civilization, especially the progress of the 20th century. It has been argued that we should understand science and appreciate its value so that we might attain a citizenry of the age of science (Cohen 1952). There is a sense that everyone should learn about science—somehow. Educational and awareness initiatives to produce learning, flourish around the world (Schiele 1994). However, public knowledge about science, its processes and products, is lacking. Is understanding of science also lacking?

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Science learning programs typically take the point of view of a message sender (scientist, teacher, or journalist) and the perspective of learning theory (McGuire 1985). Message receivers are conceived of as attending with interest to the message, comprehending its content, and then—perhaps—adopting a positive attitude toward science that will be reflected in subsequent actions. This is the dominant communication strategy and the reigning behavioral theory (e.g., Bauer, Durant, and Evans 1994).

The communication strategy and behavioral theory are incomplete. Public science–relevant communication is not limited to receiving messages from or about the science establishment. And message receivers do more than learn. They form impressions, for example, and may use them (as understandings) as a basis for action. Also, those impressions may not have their origin in received messages. Problems may evoke them, as people look about for solutions (and may have an exaggerated notion of science's ability to furnish them). Conversation with others, perhaps those facing the same problem, adds more to the communication picture, and inevitably to related behaviors (other than learning).

In all this—impressions and learning, problems encountered, collective behavior—we see a complement to the message and/or learning picture of the public's understanding of science. And we see the need for a model that conveys these additional considerations, which adds to our conceptions of public and understanding.

In principle, we can not avoid facing problems as long as we live in this "indeterminate" universe. To survive in it, we must engage with the most urgent problems by starting to transform them into problematic situations and trying to solve them (Dewey 1938). Some problems, unemployment for example, are more individual, whereas others, global warming for example, are more collective. A problem such as the energy shortage can be either, depending on what persons see about it. If they see it relative to paying the sharply increased gasoline price, it might be an individual's problem; if they see it relative to lack of the world's fossil fuel resources, it might be a collective problem.

Solving the problem of energy shortage could bring up the issue of constructing a nuclear power plant, which also tends to engage us highly. However, the issue usually pertains to controversy over solutions to the problem rather than the problem itself (Carter, Stamm, and Heintz-Knowles 1992; Kim, Carter, and Stamm 1996). So, we might get to engage by review with the initial problem of energy shortage via the issue, given more informative communication.

Whatever (individual or collective) problematic situation we begin to engage with, the process of problem solving is not simple from problem definition to solution. We often leave the problematic situation without paying further attention to it, trying to define it, and/or making efforts to construct its solution. The full process of engagement for problem solving is enormously demanding. If the problem is collective, problem solving needs collective engagement. Thus, we see the importance of the process of engagement behavior.

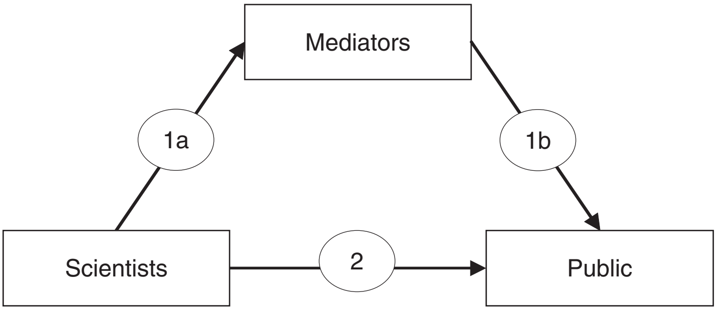
Science seems to lend itself to problem solving. For example, the problem of energy shortage seems to need scientific knowledge and research from many disciplines (e.g., physical, environmental, and economic sciences) to define the problem and construct its solution. Here, we look at how the public is likely to relate to science, that is, the potential of public engagement with a problem or an issue relative to science (PEP/IS). This view may shed new light on how to improve communicative effectiveness of science. It may also explain why "direct" dissemination of scientific information to the public struggles to improve public understanding of science (PUS) or scientific literacy, which is the traditional criterion for science communication with the public.

First, we review how PUS, the traditional perspective, has been treated in previous studies. Second, we explicate PEP/IS conceptually. Third, we illustrate how PEP/IS has guided a survey in South Korea. Finally, we suggest some practical steps to take in accomplishing PEP/IS, mainly in regard to communicative effectiveness.

PUS Reconsidered

The dominant concept of PUS takes basically the information provider's point of view, according to Kim et al. (1996). It concerns the scientist's sufficiency of scientific knowledge relative to the public's deficiency of it. This is also called the deficit model: that the public lacks scientific knowledge and appreciation (Wynne 1991; Ziman 1991). The public is implicitly expected to equip itself with scientific literacy, the major components of which are a basic scientific vocabulary, and some level of understanding of scientific methodology and of scientific (and technological) impacts on society (Miller 1983). These are assumed to be useful and necessary for a citizen to cope with daily life in modern society, mainly for decision making (e.g., on policy issues), rather than problem solving, by individual or collective means. Thus, the flow of scientific information will be basically unidirectional from the scientist to the public, which is illustrated in Figure 1 as the unidirectional information flow model.

Figure 1
The Unidirectional Information Flow Model



The information flow from scientists to the mediators (Path 1a), mainly the mass media, has been studied mostly in terms of media portrayals of science. Nelkin (1995), for example, argued that the American press showed a remarkable consistency in portraying science as magic, as a revolution, and as a solution. Also, Dunwoody (1986) found the media much less critical in their coverage of science than in coverage of other topics, perhaps because of their dependence on one another and scientists as their information sources. Science coverage in newspapers has steadily increased but not changed much in terms of content. Content is mostly health-related topics, with some natural sciences (Pellechia 1997). Typically, coverage is bits and pieces, lacking methodological details and contextual factors (Burnham 1987; Evans et al. 1990), perhaps because media aim to "celebrate" scientific findings with "wonder and application appeals" while their sources aim to "validate" their observations of "facts" (Fahnestock 1993, 20). Yet scientists often deeply deplore inaccurate or omitted media coverage of science (Pulford 1976; Tankard and Ryan 1974).

Information flow from the mediators, mainly mass media, to the public (Path 1b) stipulates that the public can and does consume key content in media portrayals of science and technology . . . somehow. This content includes knowledge of and attitudes toward science and technology. Studies show that print media are the major source of the public's health information (Meissner, Potosky, and Convissor 1992) and appreciation of energy conservation (McLeod, Glynn, and Griffin 1987). Television, newspaper, and interpersonal channels contribute positively to understanding of global warming causes, effects, and solutions, but each to understanding of a different aspect (Stamm, Clark, and Eblacas 2000). Nisbet et al.'s (2002) analysis of the National Science Board's (NSB) *Science and Engineering Indicators 1999* report finds that viewers of television, unlike readers of newspapers, have lesser knowledge of and greater reservations about science. And the NSB's 2004 report (National Science Board 2004) shows that the American public continues to learn about the latest developments in science and technology primarily from television (44 percent), with print media (16 percent), and the Internet (9 percent) far behind. Irrespective of a particular medium's role, the public's exposure to science and technology through mass media is still assumed to be quite omnipotent, directly enhancing much knowledge of and positive attitudes toward science and technology (Miller 1986, 2004; Nelkin 1995). However, as we review below, there is little evidence to support this assumption.

The failure of the expected effects from unidirectional information flow through mediators has led, out of desperation, to "direct" efforts to diffuse scientific information to the public (Path 2). Numerous initiatives to facilitate that flow have been introduced by scientific communities, governments, parliaments, nongovernmental organizations (NGOs), and lay publics in Europe and the United States (Clark and Illman 2001; Edwards 2004). Recently a new term *civic scientist* has arisen on the political agenda, courtesy of former U.S. President Bill Clinton's science advisor Neal Lane (1999). He asked scientists to step into their communities to engage in active communication with citizens so that those citizens might know and appreciate science better.

This path was initiated in the United Kingdom as early as 1985. The Royal Society published a report titled *The Public Understanding of Science*, in which it stressed that the public's scientific ignorance might arouse fear and disfavor of science (Bodmer 1985). The report's outcome was the creation of COPUS, a tripartite committee from the Royal Society, the Royal Institution, and the British Association for the Advancement of Science, which focused on improving public understanding of scientific efforts. Ten years later, a U.K. Office of Science and Technology report went further, strongly recommending that scientists should specify their past and future communication activities with the public in their research proposals to get public funds (Wolfendale 1995). Fifteen years after the Bodmer report, the U.K. House of Lords (2000) report, *Science and Society*, continued to call for more dialogue, discussion, and debate between scientists and the public. Finally, more than one half of British scientists were found to have participated in at least one activity a year to communicate their research to the nonscientist public (Wellcome Trust 2001).

In spite of many efforts to bring scientists and the public closer together via communication, mediated or not, unidirectional information flow seems inadequate or incomplete for the problem (Miller 2001). The measurement of PUS began to be conducted as early as 1958 by the University of Michigan Institute for Social Research, and from 1973 and regularly from 1979 with Jon Miller's efforts by the U.S. National Science Board under the name of *Science Indicators* (later: *and Engineering*). And it was also assimilated into the U.K. survey in 1988 (Durant, Evans, and Thomas 1989), and thereafter in Eurobarometer surveys. However, their findings continue to show the "deficit model" to apply: The public has a low level of understanding of science.

The typical PUS measurement consists of three major sectors: the public's interest in science; the public's knowledge of scientific content (vocabulary, concepts, and methods); and the public's attitudes toward science in general, the impacts of science, the scientific community itself, or a policy issue regarding science (Bauer et al. 1994; Miller 1998, 2004; Pardo and Calvo 2002). This measurement approach corresponds with a tradition in social science research on learning that posits a correlation among interest, knowledge, and attitude (e.g., Petty, Ostrom, and Brock 1981; Taylor 1998). However, PUS studies have usually found high interest and low knowledge, along with varied attitudes: "curvilinear" attitudes (Bauer et al. 1994, 180), "chaotic" attitudes (Durant et al. 2000, 149), or "ambivalent or critical" attitudes (Pardo and Calvo 2002, 157) in relation with knowledge.

How low is knowledge? The proportion of scientifically literate adults has been estimated at twelve percent (1995) for the United States, ten percent (1992) for Britain, eight percent (1992) for Denmark and the Netherlands, five percent (1992) for the European Union, four percent (1989) for Canada, and only three percent (1991) for Japan (Miller 1998; Miller and Pardo 2000). According to Miller's (2004) recent analysis, it now reaches seventeen percent (1999) for the United States, mainly due to a general expansion of college education and its science courses. Still, only 13 percent of adults knew that a molecule is composed of atoms, even though both are popular journalistic terms. However, Americans had very high interest in scientific discoveries and new technologies, highly positive attitudes toward science, strong support for the government's investment in basic research, and high regard for the scientific community.

These irregular, and unexpected, relationships among interest, knowledge, and attitude bring the theory and methods of PUS communication and assessment into question. PUS researchers, however, seem to hold to the belief that the basic concepts and their relationships are still valid, despite invalidating observations. Factor analysis shows that the items used to survey the public were found to share no significant dimension. As one possible solution, Pardo and Calvo (2002) argued that new items should be systematically introduced to obtain internal consistency of their constructs. Alternative PUS measures were suggested to include knowledge of the activities of the scientific institution such as teamwork, mutual criticism and checking of scientists, attitudes toward the nature (independence, autonomy, objectivity, policy neutrality, etc.) of science, trust in science, and efficacy on science policy, or even political knowledge (Bauer, Petkova, and Boyadjieva 2000; Kallerud and Ramberg 2002; Sturgis and Allum 2004).

No matter how we measure the traditional PUS notion, the findings seem to cast doubt on our expectation of effective unidirectional information flow from scientists to the public, and thus of more effective communication about science. If so, we might need to question the applicability of the concepts of interest, knowledge, and attitude, and of their hypothesized relationships, which for so long have been assumed to describe and direct human behavior.

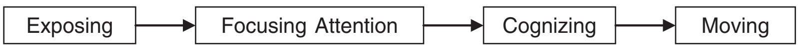
Conceptualizing PEP/IS

The bulk of research on PUS seems to have taken the traditional definitions of the public, understanding, and science; that is, the public was considered mostly as the aggregate of people, whether the attentive (interested and informed) public or the interested (but uninformed) one for scientific matters (Miller 1986); understanding primarily as knowledge preceded by interest and followed by attitude; science as scientific vocabulary, concepts, methods, impacts on society, policy issues, or even the scientists as workers. It is clear that we need to attempt a new broader conceptualization of those concepts, as we try to produce a new measurement tool.

The first concept that we should review from PUS is *understanding* because the others relate to it. Typically the concept of understanding is viewed as a product of behavior rather than as a process of it. Its usual measurement components, especially knowledge and attitude, are observed as postcommunication products, whether through mediators or directly from scientists. If defined as something else, understanding ends up seen as interpretation, various and often imprecise. Thus the question remains: What is the process?

In fact, PUS researchers have already raised the need to focus on the behavioral process involved in understanding. Miller (1998) urged us "to

Figure 2
A Processual Model of Behavior



learn more about the magnitude and dynamics of these [PUS measures] adult learning processes" (p. 221). Bauer et al. (1994) consider "the mode and the intensity of public debate" (p. 181) as crucial mediators. Ziman (1991) pointed out that "scientific knowledge is not received impersonally, as the product of disembodied expertise, but comes as part of life" (p. 104). Michael (1992), Irwin and Wynne (1996), and Wynne (1991, 1993, 1995), critical of traditional PUS research that "decontextualizes" the public's understanding, have argued that the public is highly reflexive, negotiatory, constructive, and reconstructive of science, based on its usefulness in context, not just taking what science imposes irrespective of social institutional factors. They stressed the public's "reflexivity" in every context but do not show its clear (e.g., sequential) structure. Emphases on process and potentially significant circumstances do not get us into explicating the process itself conceptually, however.

The concept of "engagement" in PEP/IS brings us closer to a perspective on behavioral process. It starts by taking the public's point of view (e.g., the information consumer's—but not solely as a communication receiver). This contrasts with the information producer's point of view, on which is based our traditional notion of science popularization, scientific literacy, or public understanding of science. Prewitt (1983) said that "the public probably knows more about science than scientists know about the public" (p. 63). Kim et al. (1996) considered PEP/IS to be the key to explicating the public's relationship with people, institutions, and policies of science.

Explicating the concept of engagement gets a hand from Carter's (1990a, 1990b, 2003) behavioral theory. It posits that behavior as process has a structure of its own, independent of, but interdependent with, a body. We can speak of the molecular structure of a behavioral step just as we can of a body. Behavior's molecular structure consists of various modes of relating, which would help us to specify what engagement might comprise.

A simple model of behavior's structural features (relatings) consists of four basic act components in sequence (Carter 1990a; Kim 2003), as in Figure 2.

Engagement could, but might not, carry on all the way through the sequence of those acts. For example, we make a minimal engagement through exposing ourselves to the environs. Further engagement takes place when we focus our attention on something in particular, which may or may not lead to cognizing (thinking).[1] Moves may or may not take us further into engagement. Full engagement is difficult for communicators to accomplish by themselves, however much they achieve exposure and focal attention to many (scientific) things. People think whatever they want to think about whatever they want to do. Then there are a variety of barriers, from timidity and ignorance to taxing and threatening circumstances, which stand in the way of productive moves.

A personal history of engagement can be quite a bit more complex, as cognitions along with memory come to affect later exposure and focal attention—as well as moves. Also, engagement has quality and quantity. An important part of that quality is whether it comes about with other members of the public, as it might by conversation or discussion, such that coexposure, cofocal attention, and others are not mere aggregate notions, but collective ones.

The difficulty of engagement is deplored in many arenas. For example, Paisley (1998) identified at least forty-five topical literacies in journals, including sexual or historical literacy and computer or statistical literacy. They all claim a share of public attention and understanding. Bennet (1998) pointed out the sharp decrease of civic engagement with institutional politics, notably elections. He attributed it to increased economic pressure and individualized lifestyles, whereas Cappella and Jamieson (1997) saw it as due to media cynicism toward government and politics.

Constructivism in education typically reflects students' difficulty of engagement in learning, especially of science and mathematics (Matthews 2000; Phillips 2000). For example, a constructivist perspective suggests a "problem-centered learning" model in which a task regarding science or mathematics is faced by student groups and solved by their cooperative communication under a teacher's minimal facilitation (Wheatley 1991). All this seems to imply the importance of engagement but fails to show the process of it.

The second concept that we should review is *public*. It is, first of all, ambiguous. It might indicate an aggregate of individuals, a collectivity concerned with a common problem, or a collectivity concerned with a common issue. The first, an aggregate of individuals, is our ordinary (and dictionary) meaning of *public*. The second and third collectivities differ because they presage the possibility, if not the existence, of people coming together in their relating to scientific matters. Indeed, in the collectivity cases, engagement to produce the collectivity itself has to occur along with, if not before, engagement with their concerns. That is to say, a sequence of coexposing, cofocusing attention, cocognizing, and comoving, which is an extension of

Figure 2, might produce a certain level of collectivity and of collective engagement (Kim 1999, 2003).

Mass media seem to be quite effective for coexposing, less so for our cofocusing attention. Yet Chaffee and Schleuder (1986) found that media "exposure" does not increase knowledge; however, media "attention" does help it a lot. When the media are effective in bringing about cofocused attention to a common problem, as for example, the war in Iraq, we begin to see collective engagement with that agenda, a variety of cognitions, and some moves being made. However, this is a scattering of engagements, even on events of great importance.

The public is clearly not a monolithic behavioral entity, so we had best start with engagement as an individual challenge and take it from there, keeping in mind the potential for two kinds of collectivities. Constituting an engaged public will differ according to whether there is a common problem or a common issue. Cognizing, especially, will differ. "Issues" usually imply alternatives, and decision making. "Problems" might not have any solutions (hence alternatives) yet. Relevant communication must take note. Engagement may already be farther down the road for issues than for problems. Purely informative content could well be lost on those dealing with issues. Partisanship, re issues, puts people on the move.

The frequent mention of the issue-oriented public as an ideal collectivity (Blumer 1966; Carey 1995), and in conjunction with the concept of the public sphere (Habermas 1992), seems to be inferior to a problem-solving public that involves collective constructive engagement for problem solving (Kim 2003). However, in any case, it becomes important to construct the public as a collectivity, not an aggregate.

Third, we should review the concept of *science*. It looks too broad and abstract to secure validity. Just what is the public supposed to relate to? An establishment? A method? Only rarely might the public try to be directly engaged, possibly only if pressed to take a test in school. And in that case, public understanding of science may be an impossible communication goal in the first place. This seems to require us to look for a different direction for engagement relative to science, to come back to a behavioral perspective taking the public's point of view. We might better ask: How and how far can we take individual and collective engagement with respect to science?

Problem solving is supposed to be the most prominent and basic condition for all kinds of life to survive and advance in this indeterminate, partially ordered world (Carter 2003; Dewey 1938). As we face a problem, we must engage with it. When we are exposed to many problems at a time as in our daily life, we must select the most urgent one, focus our attention on it (Carter et al. 1973), think about it, and make moves to solve it. Similar engagement can apply to issues, whose resolving might best be pursued by first reviewing the problem solving that has got us this far. Premature decision making is all too frequent.

Engagement with problems or issues looks to be a good bet to bring about engagement with science because ordinary persons or society tend to consider and (currently) demand science as providing practical or useful benefits via problem solving (see Lubchenco 1998; Pielke and Byerly 1998). Michael (1992) and Wynne (1989) showed that a public's problematic situation makes a difference in that public's engaging with science. For example, UK Cumbria sheep farming after the Chernobyl fallout was found to let those farmers be highly engaged (reflexively) with scientific knowledge in their problem-solving context. However, citizens volunteering in a radon survey for the home rarely engaged with science. The so-called science shop activity in which the university helps community problem solving was also found to be productive, as the university and the lay communities could reformulate the latter's original problem into a shared problematic situation (Irwin 1995; Zaal and Leydesdorff 1987). Recently, Karl and Turner's (2002), Lee and Roth's (2003), and Roth and Lee's (2002) studies show that community engagement with local problems (e.g., on creek watersheds) could be critical to bringing collaborative problem solving with relevant scientists. In short, Grote and Dierkes's (2000) critique of traditional PUS points out that "it is the contexts of use that enable a public to take an active part in constructing the relevance of science and technology and in using them" (p. 354).

The act of cognizing in the process of engagement is particularly pertinent because one of its functions is to produce an idea via relating (Carter 1978; Carter and Stamm 1993, 1994; Kim 1986). Relating a problem or an issue to science should be a central act of cognitive engagement. This kind of cognizing seems to be the key to producing a useful level of public understanding of science. It provides identification and attributions of significance. If we have not succeeded in this engagement act of cognizing, beyond the prior acts of exposing and focusing attention, we may have accomplished nothing of PUS—unless it be by accident.

The PUS knowledge-attitude view rests on learning as the dominant behavioral process for achieving understanding and support. However, the major cognitive product of this newly conceptualized PEP/IS is likely to be closer to an "impression" of science. This impression, if it is not merely identificatory, originates from its consequentiality as seen by the public (Carter et al. 1992).

The impression, an idea, consists of an association between science and some other element(s) evoked in relation to it. The element could be an object, attribute, or value that the public relates to science. The relation for constituting the association can be inside-outside (e.g., spatial, logical inclusion), before-after (e.g., temporal, sequential, logical sufficiency), similarity (e.g., equal), or difference (e.g., opposition), to take the most common cognitive relations that contribute to making ideas (Carter 1992; Carter et al. 1992; Kim, Choi, and Jung 2000; Kim, Hong, and Park 2003).

This impression, an ideational product, differs from knowledge, attitude, and image that neglect our self-informing or self-instructing capability. It is often spontaneous; being consequential it will be salient; it is very situational; and, it is quite capable of eliciting and directing a move.

Using this conceptualization, Kim et al. (1996) constructed and experimentally tested the new PEP/IS model of measuring the public's engagement with problems and issues relative to science in Seoul, South Korea, and in Seattle, Washington, United States. Then, Kim, Lee, and Hong (2002) and Kim, Park, Park, and Hong (2003) conducted two further national surveys of Korean adults (in 2001) and Korean youths (in 2003) for suggesting policy implications to improve PEP/IS in Korea via communicative effectiveness. This article covers part of those results.

Measures of PEP/IS

To demonstrate an alternative and a complement to traditional PUS measurement, we have extracted parts of two national surveys done with adults and youths in South Korea.[2] We see how differently and how far Korean youths and adults took (or could take) individual or collective engagement with major social problems or issues[3] relative to science. We explore the following three questions:

1. Do Korean youths and adults have the same kinds and levels of "attention-focused" engagement with major social problems or issues? Might they develop a collective public by cofocusing attention on the same problems or issues?
2. Do Korean youths and adults advance to "cocognizing" engagement with the same problems or issues on which they respectively cofocused attention? Do problems or issues on which they cofocus attention match those which they think science should solve or resolve?

3. What impressions do Korean youths and adults hold of science as a product of past engagement? Do those impressions reflect a product consistent with our PEP/IS model?

To answer those questions, we present, first, measures of the public's engagement in relation to science, and then, its impressions of science. These measures should show the state and potentiality of PEP/IS in South Korea, and, above all, suggest how to improve communicative effectiveness for PEP/IS.

To find the level of individual engagement for the aggregate public, we asked each youth or adult to check three "personally" most important problems (A in Table 1). To find the level of collective engagement, we asked each youth or adult to check those problems she or he thinks are "socially" serious (B in Table 1). And, we tried to find "potential" engagement by asking what problems need more attention (C in Table 1). Finally, we asked each youth or adult to check those problems she or he thinks are up to science to solve (D in Table 1). We might need to note especially the top three percentages (shaded) in each column of the table (and the following tables)—problems that bring about or could bring about engagement.

We found that a little more than ten percent of the Korean population, youths and adults, are likely to engage with major social problems, individually or collectively (Table 1: 1st row). However, youths and adults show quite different problems in their engagement. For individual engagement, the youths are most engaged with the problems of global warming, the college entrance exam system, and war, whereas the adults are most engaged with the problems of unemployment, elderly citizen support, and inflation (A in Table 1). For collective engagement, the youths are more into corruption, the rich-poor gap, labor-management conflict, and political unrest at the social level, whereas the adults are more into unemployment, corruption, and the recession (B in Table 1). This shows that the youths tend to quite individually engage with some global problems such as global warming and war and to collectively engage with economic and political problems, whereas the adults tend to individually and collectively engage mainly with economic problems.

For potential engagement with problems that need more attention, the youths and the adults seem ready to cofocus on such problems as the energy shortage, water pollution, and global warming (C in Table 1). This suggests that some problems are likely to establish a national collective public, young and old, as they develop into hot agenda items. Of course, the adults continue to need more attention on the problems of elderly citizen support and unemployment.

Table 1
Public Engagement with Problems Relative to Science (each cell a simple deviation from the corresponding total mean on the first row)

	A. Personal-Important[a]		B. Social-Serious[a]		C. Need More Attention[b]		D. Up to Science to Solve[b]	
Problem	Youth	Adult	Youth	Adult	Youth	Adult	Youth	Adult
Total mean (%)[c]	11.1	10.2	11.1	10.3	13.7	17.6	14.7	16.8
Private information leak (%)	3.6	6.5	–2.9	–1.8	–3.5	2.1	6.8	7.5
Recession	3.1	10.4	7.6	15.9	–.5	3.1	–11.7	–8.5
Transportation problem	–2.1	8.7	–.3	4.7	–3.9	7.1	11.5	8.0
Elderly citizen support	–8.4	12.1	–5.6	13.5	–1.5	14.9	–7.2	–9.5
Climate change	0.4	–4.9	–5.4	–8.4	5.8	5.0	12.1	21.5
Corruption	4.4	1.7	15.1	16.6	–.4	4.7	–13.4	–12.4
Inflation	–2.4	11.2	–1.8	4.0	–5.4	–.8	–10.2	–12.2
Water pollution	2.7	–.8	–.4	–1.6	11.1	7.1	31.1	25.5
AIDS	–3.3	–8.3	–4.6	–7.9	4.1	–4.0	30.1	13.1
Rich-poor gap	8.6	5.4	10.4	10.4	5.0	5.7	–11.2	–11.4
Educational expenses	–.4	5.3	–.9	–.9	–8.9	–6.4	–13.0	–13.1
Energy shortage	4.7	–3.9	–.9	–3.8	19.3	12.8	44.5	33.4
College entrance exam	9.4	–.2	1.4	–2.8	1.1	–4.5	–13.4	–12.7
Child and/or spouse abuse	–2.1	–5.3	–6.1	–7.1	–6.5	–6.5	–13.5	–13.7
Global warming	9.7	–2.9	2.2	–4.7	19.8	4.0	33.1	27.6
Regional prejudice	–7.8	–4.9	–4.8	–.9	–9.7	–5.9	–12.9	–12.5
Housing price jump	–3.8	–1.9	–1.8	–6.6	–9.5	–8.6	–12.4	–13.6
Terrorism	–6.4	–7.0	–5.3	1.6	–5.2	–4.5	–9.2	–7.4
Teen prostitution	NA	–2.4	NA	10.8	NA	5.2	NA	–13.4
Unemployment	NA	12.8	NA	22.0	NA	11.1	NA	–8.1
Cancer	NA	2.6	NA	–6.6	NA	–3.5	NA	23.2
Adult diseases	NA	4.4	NA	–7.1	NA	–6.5	NA	7.5
Overdiet	NA	–5.9	NA	–8.3	NA	–11.6	NA	–6.9
Species extinction	NA	–6.8	NA	–8.1	NA	1.6	NA	9.6
Japan's history distortion	NA	–3.2	NA	1.8	NA	–2.0	NA	–12.9
Red and/or green tide	NA	–9.9	NA	–9.4	NA	–8.6	NA	11.9
Health insurance crisis	NA	–1.7	NA	–5.0	NA	–6.0	NA	–12.2
Information gap	NA	–3.2	NA	–7.9	NA	–4.0	NA	4.8
Teen pregnancy	NA	–6.6	NA	–3.7	NA	–.4	NA	–12.0

Table 1 (continued)

	A. Personal-Important[a]		B. Social-Serious[a]		C. Need More Attention[b]		D. Up to Science to Solve[b]	
Problem	Youth	Adult	Youth	Adult	Youth	Adult	Youth	Adult
Juvenile delinquency	4.7	NA	–1.9	NA	3.1	NA	–13.9	NA
Racial discrimination	–2.3	NA	–4.1	NA	0.0	NA	–12.2	NA
Severe acute respiratory syndrome	–6.4	NA	–6.4	NA	–3.0	NA	30.3	NA
Gender discrimination	–1.4	NA	–4.1	NA	–3.2	NA	–11.9	NA
Labor-management conflict	–5.3	NA	8.1	NA	–6.5	NA	–13.5	NA
North Korea's nuke	–2.4	NA	3.6	NA	–1.7	NA	–1.0	NA
War	9.4	NA	6.9	NA	9.1	NA	–5.7	NA
Internet misuse	–3.3	NA	–5.1	NA	–3.4	NA	–.5	NA
Political unrest	–2.6	NA	7.6	NA	–4.7	NA	–13.2	NA

a. Three responses.
b. Multiple responses.
c. Total mean (%) = (the total sum of responses per problem) / (the number of problems × the number of youth or adult respondents) × 100. NA = not applicable

For "cocognizing" engagement that relates problem solving to science, we found that youths and adults see major potential engagement in the problems of energy shortage, global warming, and water pollution (D in Table 1). On the other hand, we found some mismatches of engagement between respondents' individual- or social-engaged problems and what they see as problems needing solutions from "science." This seems to indicate limited relevance of science and/or lack of communicative effectiveness in making known scientific contributions to solving those problems.

Also, we measured collective engagement with controversial issues that might have brought about the public's coexposure and cofocused attention, thus engagement with them (Table 2). To find the level of the Korean public's cocognizing engagement with issues,[4] we asked each youth or adult to check those issues that she or he thought are up to science to resolve (A in Table 2). And, to find potential engagement, we asked each youth and adult to check those issues she or he thought need more attention (B in Table 2) and those which scientists should play a greater role in resolving (C in Table 2).

We found the Korean public (12.7 to 22.6 percent) to show larger cocognizing engagement and potential engagement with issues than with problems (10.2 to 17.6 percent). And, medical-related issues seem to bring

Table 2
Public Engagement with Issues Relative to Science (each cell a simple deviation from the total mean on the first row)

Issue	A. Up to Science to Resolve[a]		B. Need More Attention[a]		C. Need Scientists' More Role[a]	
	Youth	Adult	Youth	Adult	Youth	Adult
Total mean (%)[b]	18.5	20.0	22.6	22.0	13.7	12.7
New family headship system (%)	–14.3	–14.6	–4.8	–4.8	–11.5	–10.3
Cloning research limit	38.7	36.8	42.9	17.5	52.1	37.0
Animal experiments	24.8	31.5	–.1	–9.0	12.5	13.7
Euthanasia	2.5	12.0	4.1	7.0	–1.0	6.5
Homosexual's and/or transsexual's rights	–2.8	–8.1	4.4	–4.8	–3.4	–5.7
Sunshine policy to North Korea	–15.8	–14.0	–11.9	–3.2	–11.4	–9.3
Abortion	–3.7	–3.7	1.9	1.2	–4.2	.6
National security law	NA	–15.4	NA	–8.2	NA	–10.0
Cremation site	NA	–7.2	NA	–5.9	NA	–6.9
Five-day-per-week work system	NA	–6.1	NA	2.6	NA	–7.3
Public disclosure of sexual misconduct with teen	NA	–11.5	NA	7.0	NA	–8.6
Government workers union	–17.0	NA	–18.1	NA	–11.5	NA
New educational information system	–2.2	NA	–8.4	NA	–4.5	NA
U.S. forces evacuation	–12.3	NA	–2.8	NA	–10.9	NA
Continuation of land reclamation by drainage	2.2	NA	–6.9	NA	–5.2	NA

a. Multiple responses.
b. Total mean (%) = (the total sum of responses per issue) / (the number of issues × the number of youth or adult respondents) × 100.

about more public engagement. The issues of cloning research limit, animal experiments, and euthanasia are most likely to be seen as up to science to resolve by the youths and the adults (A in Table 2).

For potential engagement with issues that need more attention generally and those needing a greater role for scientists, youths and adults seem prepared to get into the issues of cloning research limit and euthanasia (B and C in Table 2). However, for the issue of animal experiments, the youths and the adults seem to yield resolving it to science. They, themselves, do not need to cofocus attention on it. Instead, the youths seem to need cofocused attention more on the issue of homosexual's and/or transsexual's rights, whereas the adults do more on the issue of public disclosure of sexual misconduct with teens. Neither sees scientists needing to play a greater role in resolving these two issues.

Overall, we see that the Korean youths and adults are likely to make cocognizing engagement relative to science primarily with only a few medical-related issues, and much less with other major social issues. If behavioral and social sciences are addressing these issues (they may not be) the news is not getting to the public or perhaps the public does not identify those disciplines as science.

Nonetheless, the public must have continued, at least sporadically, to relate science to many other problems or issues in their past life. So, we tried to obtain their impressions of science by asking each person what word first comes to mind as she or he hears the word *science*,[5] and how the word *associate* (element) relates to science, that is, which one of six cognitive relations is used: (a) it is a part of science, or (b) science is a part of it (inside-outside); (c) it is a consequence of science, or (d) science is a consequence of it (before-after); (e) it and science are the same thing, or (f) it is not science (similarity vs. difference).

We found the top three categories of impression elements evoked in relation to science to be scientific products (26.5 percent; e.g., computers, electric devices, transportation), research activities (17.3 percent; e.g., experiment, microscope, laboratory), and evaluative attributes (12.5 percent; e.g., good, useful, difficult, complex) (Table 3).

Of special interest, the adults' scientific products as elements are about three times more than the youths', whereas the youths' research activities and evaluative attributes are greater than those of the adults. Also, the adults are more impressed by scientific consequences (10.5 percent; e.g., development, civilization, life quality), whereas the youths are more impressed by research objects (12.3 percent; e.g., space, planet, life).

What is noteworthy here is that vocabulary (e.g., DNA, molecule, mutation), nature of science (e.g., objectivity, creativity, accuracy), and definition of *science* (e.g., discovery, inquiry, proof) are negligible—this despite the scientific establishment's concern to broaden the public's knowledge of them under the traditional PUS model.

Evaluative attributes (12.5 percent; e.g., good, useful, difficult, complex), germane to PUS's concern for public attitudes, are not considerable. Nor are they given as much emphasis by adults as by youths.

Science does do well in the public's impressions if we look at the relations used in making their impressions (Table 4). It stands outside (the first relation:

Table 3
Elements Used in Impressions of Science (%, frequency)

Category	Youth	Adult	Sum
Scientific products	13.6% (82)	39.6% (233)	26.5% (315)
Research activities	21.8 (131)	12.6 (74)	17.3 (205)
Research objects	12.3 (74)	7.8 (46)	10.1 (120)
Areas	10.6 (64)	7.0 (41)	8.8 (105)
Scientific consequences	8.0 (48)	10.5 (62)	9.3 (110)
Evaluative attributes	18.8 (112)	6.3 (37)	12.5 (149)
Education related	.7 (4)	3.1 (18)	1.9 (22)
Nature of science	3.0 (18)	2.4 (14)	2.7 (32)
Definition of science	1.8 (11)	2.2 (13)	2.0 (24)
Vocabulary	1.5 (9)	1.0 (6)	1.3 (15)
Media related	.5 (3)	1.0 (6)	.8 (9)
Life related	2.0 (12)	.9 (5)	1.4 (17)
International context	.3 (2)	.7 (4)	.5 (6)
Others	1.7 (10)	.3 (2)	1.0 (12)
None	.3 (2)	.2 (1)	.3 (3)
Don't know	.7 (4)	1.5 (9)	1.1 (13)
No response	2.3 (14)	2.9 (17)	2.6 (31)
Total	100% (600)	100% (588)	100% (1,188)

$\chi^2 = 161.8$, $df = 16$, $p < .001$.

33.9 percent; other things are a part of science), it stands before (the third relation: 23.1 percent; other things are in consequence of science).

The first relation implies some authority of science, in that science embraces an evoked element inside, perhaps being capable of controlling it; the third relation implies some strength of science because science contributes to an evoked element. (The second and the fourth relations imply the opposites.) Thus, we can obtain a "power ratio" for science, indicating relative consequentiality of science, dividing the first and third relations by the second and fourth relations (Carter and Stamm 1993; Clark 1998). The youths (power ratio of 3.22) and the adults (power ratio of 3.47) seem to consider science very consequential, the adults a little more than the youths.

We also found similarity, the fifth relation, to be highly used (19.8 percent). Is science all that well understood if so much is merely synonymous with it?

Table 4
Relations Used in Making Impressions of Science (%, frequency)

Relation	Youth	Adult	Sum
It is a part of science	36.7% (220)	31.1% (183)	33.9% (403)
Science is a part of it	8.8 (53)	8.3 (49)	8.6 (102)
It is a consequence of science	21.3 (128)	25.0 (147)	23.1 (275)
Science is a consequence of it	9.2 (55)	7.8 (46)	8.5 (101)
It and science are the same thing	18.3 (110)	21.3 (125)	19.8 (235)
It is not science	3.7 (22)	3.7 (22)	3.7 (44)
No response	2.0 (12)	2.7 (16)	2.4 (28)
Total	100% (600)	100% (588)	100% (1188)

$\chi^2 = 7.1$, $df = 6$, *ns*.

Summary and Conclusion

We have explored Korean youth and adult individual and collective engagement with problems or issues relative to science, and their impressions of science.

For engagement relative to science, we found that the youths and the adults are quite different in their respective individual engagement but are likely to progress into a collective public by cofocusing attention on economic problems. Also, both seem ready to progress into a national collective public if such problems as the energy shortage, water pollution, and global warming develop into pressing agenda items. This attention seems to enable such a public to step forward to a more thoughtful engagement with "science."

Nevertheless, we found that Korean youths and adults do not complete the full behavioral process of individual or collective engagement with science in regard to almost every major problem. This is also found to be the case for most social issues, with the exception of medical instances, such as limiting cloning research, which have already achieved high cofocused attention. Despite incomplete (or lack of any) engagement with major problems and issues relative to science, the Korean public hold impressions of science that imply its consequentiality.

This new conceptualization of PEP/IS highlights the difference between a quantitative public and a qualitative public. The former, the aggregate public, stresses how many persons are somehow involved with a problem or an issue, whereas the latter, the collective public, stresses what problem or issue brings, or might bring, together persons into a collectivity. The latter enables collective problem solving or collective issue resolution whose process consists of coexposing, cofocusing attention, cocognizing and/or comoving. Minimally, it can result in the sharing of an agenda, preventing the too frequent loss of collective cognitive capability for problem solving or issue resolution. At best it might even produce a unity, that is, a collectively constructed solution plus a collective resolution to move together toward it, a great asset for challenging current and future problems or issues (Kim 2003). If we disregard the "quality" of engagement we are as likely to produce further problems as to solve the ones we already have.

However, this PEP/IS is not easy to achieve. We often see a public end up only cofocusing attention on a problem or issue, as in mass media's agenda setting. Then, without adequate cocognizing, the public may be forced to premature comoving, threatened by partisanship (as in voting). We can be greatly frustrated and sharply divided by such incomplete collective processes. Thus, we need to heed communicative effectiveness, to see if communication is helpful to achieve cofocused attention on a problem or issue, to realize cocognition relative to science, and to direct comoving to the cognized end. For example, communication that essentially functions as information exchange rather than persuasion (see Kim 1986) might be more effective.

At this point, we can suggest some practical steps to take in accomplishing PEP/IS. First, we need to effectively communicate our (shared or to be shared) problems, for instance, energy shortage as a potentially salient collective problem shown in our data, so as to develop that cofocusing (a.k.a. *agenda*) by which a collective public begins to arise. Second, we need to effectively communicate all of the problem's relevance—and relevance of issues that have arisen in regard to that problem—to science's solving or resolving capability. These look quite feasible and have the potential to develop the Korean public into a constructive problem-solving collectivity (on energy shortage) relative to science. Such effective communicating tells the importance of relevant communication in "content" and "timing" to enable the sequential respective acts of coexposing, cofocusing attention, cocognizing, and comoving.

Third, to achieve the above communicative effectiveness better, we need to establish a more genuine sense of scientific communities, one in which science tries to help produce collective publics, to lead in the process of full collective engagement. To do so, scientists need to consider questions about what science can contribute to problem solving, not just questions of scientific (factual) puzzles. Scientists, natural and social, need to get into problem solving together, and with the public, because there emerge many collective problems (e.g., population overgrowth, global warming, atomic war) that technology simply cannot solve (see Crowe 1969). The danger of the cultural divide between the public and scientists seems to exist in their not having a "joint" problem-solving and issue-resolving capability, not in the wide, but artifactual, gap of scientific literacy between them.

These possible steps could bring about more salient and constructive impressions regarding the "consequentiality" of science. Although we have already seen some of this as a product of the public's past, occasional, and informal relationships with science (its impressions), much of significance remains to be done. For example, improved impressions might induce more talented youths into science careers, where shortages grow imminent and desperate (e.g., Broad 2004, for the United States; Kim, Hong, and Park 2003, for Korea). Prevailing modes of science communication such as science journalism, science exhibits, science festivals, and even science education need to be no less concerned with communicative effectiveness for PEP/IS than with whatever responsibility that science feels to report to the public.

Finally, we need to improve survey research by using relatively consistent problems and issues across youths and adults, years, and nations, to enable comparative analysis. We need to develop indexes and more refined statistical analysis for precise interpretation of current PEP/IS, to suggest where we should try to improve communication. What new communicative strategies could help? What science could best be used to help communication in accomplishing PEP/IS? Would an interdisciplinary approach be needed to make all of this work? Above all, we need to conduct research utilizing this new PEP/IS model and the traditional PUS one so their respective contributions to communicative effectiveness of science can be discerned.

This PEP/IS conceptualization and its exploratory data analysis turn our focus toward theoretical and methodological considerations in the public's perspective, as a complement to PUS measurements in the scientist's perspective.

Notes

1. The partial order condition under which we as humans operate (Carter 1990b; Dewey 1938) requires more of minding than learning. Collisions exemplify our minding needs: exposing to any and all possible collisions, focusing attention for collisions to be avoided or arranged, cognizing to relate something to something else. In this latter regard, cognizing (or thinking) is more than having acquaintance or knowledge (its historic meanings); it is called on to observe and make use of discrepancies, to provide ideational implication for behavioral guidance (by

using a variety of relations and element types), to assess behavioral outcomes (e.g., feelings), and to dynamically distinguish and balance sometimes-competing behavioral conditions (e.g., wants vs. needs, agreement vs. understanding, economy vs. polity). Communicating helps cognizing provide implication—and instruction—where there is none given, by providing signification to which cognizing's relatings can add implicatory content (Carter in press). Traditional conceptions of cognition (as acquaintance, recognition, knowledge, and/or thought; e.g., Sternberg 1999) do not afford a complete and accurate assessment of our need for, and capabilities developed for, cognizing's contributions to minding.

2. We nationally sampled 600 adults at age 20 years or older (based on the 2000 census data) and 600 youths (based on the 2003 Education Ministry Statistics) from the second year of middle school to the sophomore year of college, by the multistage stratified sampling design. Then, we conducted a face-to-face survey for obtaining 588 adult respondents and 600 youth respondents (202 for middle school, 197 for high school, and 201 for college).

3. We sampled highly publicized social problems and issues, steady or current, from South Korea's major print media to establish "minimal engagement." After pretests, we assumed that people were very likely to have been "exposed" to those selected "problems" and even to have advanced to "focusing attention" on those selected (highly controversial) "issues." The difference between the 2001 survey for adults and the 2003 survey for youths produces those NA (not applicable) cells in the subsequent data tables.

4. A few issues seem to need some description: The new family headship system pertains to opening the headship to a female or a single family, whereas the previous system based on the Confucian tradition requires a family to be headed by a male elder for keeping the family tree; the five-day-per-week work system pertains to applying it immediately in all public and private levels; and, the new educational information system pertains to putting together all students' information in one single system, which might contribute to efficient management of students' education or endangerment of students' privacy.

5. This was asked as an open-ended question. To explore the full range for impressions of science, the author and a research assistant screened all responses, carefully formed many subcategories, and then those final categories shown in Table 3. These categories would be useable for future research's intercoder reliability. Here, agreement was reached on everything.

References

Bauer, M., J. Durant, and G. Evans. 1994. European public perceptions of science. *International Journal of Public Opinion Research* 6 (2): 163–86.

Bauer, M., K. Petkova, and P. Boyadjieva. 2000. Public knowledge of and attitudes to science: Alternative measures that may end the "science war." *Science, Technology, and Human Values* 25 (1): 30–51.

Bennet, W. L. 1998. The uncivic culture: Communication, identity, and the rise of lifestyle politics. *PS: Political Science and Politics* 31 (4): 741–61.

Blumer, H. 1966. The mass, the public, and public opinion. In *Reader in public opinion and communication*, edited by B. Berelson and M. Janowit, 43–50. New York: Free Press.

Bodmer, W. 1985. *The public understanding of science.* London: Royal Society.

Broad, W. 2004. U.S. is losing its dominance in the sciences. *The New York Times*, May 3, 2004, A1, A19.

Burnham, J. C. 1987. *How superstition won and science lost: Popularizing science and health in the United States*. New Brunswick, NJ: Rutgers University Press.

Cappella, J. N., and K. H. Jamieson. 1997. *Spiral of cynicism: The press and the public good*. New York: Oxford University Press.

Carey, J. W. 1995. The press, public opinion, and public discourse. In *Public opinion and the communication of consent*, edited by T. L. Glasser and C. T. Salmon, 373–402. New York: Guilford.

Carter, R. F. 1978. A peculiar horse race. In *The Presidential debate: Media, electoral, and policy perspectives*, edited by G. F. Bishop, R. G. Meadow, and M. Jackson-Beeck, 3–17. New York: Praeger.

———. 1990a. *Mass communication effects: A weakness theorem.* Paper presented at the annual meeting of the Communication Theory and Methodology Division of the Association for Education in Journalism and Mass Communication, August, Minneapolis, MN.

———. 1990b. *Mass communication, mass cognition, and the behavioral molecule.* Paper presented at the American Psychological Association mini-conference on mass media and society, Boston, MA.

———. 1992. *Cognigraphics: Taking the measure of ideas.* Paper presented at the meeting of the American Association for Public Opinion Research, May, St. Petersburg, FL.

———. 2003. Communication: A harder science. In *Communication, a different kind of horserace: Essays honoring Richard F. Carter*, edited by B. Dervin and S. H. Chaffee, 369–76. Cresskill, NJ: Hampton Press.

———. In press. Art, art, and communication. In *Audiences and the arts: Communication perspectives,* edited by B. Dervin and L. Foreman-Wernet. Cresskill, NJ: Hampton Press.

Carter, R. F., W. L. Ruggels, K. M. Jackson, and M. B. Heffner. 1973. Application of signaled stopping technique to communication research. In *New models for communication research*, edited by P. Clarke, 15–43. Beverly Hills, CA: Sage.

Carter, R. F., and K. R. Stamm. 1993. How we thought about the Gulf War. In *Desert storm and the mass media*, edited by B. L. Greenberg and W. Gantz, 152–65. Cresskill, NJ: Hampton Press.

———. 1994. The 1992 presidential campaign and debates: A cognitive view. *Communication Research* 21: 380–95.

Carter, R. F., K. R. Stamm, and C. Heintz-Knowles. 1992. Agenda-setting and consequentiality. *Journalism Quarterly* 69 (4): 868–77.

Chaffee, S. H., and J. Schleuder. 1986. Measurement and effects of attention to media news. *Human Communication Research* 13 (1): 76–107.

Clark, F., and D. L. Illman. 2001. Dimensions of civic science. *Science Communication* 23 (1): 5–27.

Clark, F. J. 1998. *Thinking about global warming.* Master's thesis, University of Washington, Seattle.

Cohen, B. 1952. The education of the public in science. *Impact of Science on Society* 3 (3): 67–100.

Crowe, B. L. 1969. The tragedy of the commons revisited. *Science* 166 (3909), November 28: 1103–07.

Dewey, J. 1938. *Logic: The theory of inquiry*. New York: Henry Holt.

Dunwoody, S. 1986. The science writing inner club: A communication link between science and the lay public. In *Scientists and journalists: Reporting science as news*, edited by S. M. Friedman, S. Dunwoody, and C. L. Rogers, 155–69. New York: Free Press.

Durant, J., M. Bauer, G. Gaskell, C. Midden, M. Liakopoulos, and L. Scholton. 2000. Two cultures of public understanding of science and technology in Europe. In *Between understanding and trust: The public, science and technology*, edited by M. Dierkes and C. v. Grote, 131–56. Amsterdam: Harwood Academic.
Durant, J. R., G. A. Evans, and G. P. Thomas. 1989. The public understanding of science. *Nature* 340, July 6: 11–14.
Edwards, C. 2004. Evaluating European public awareness of science initiatives. *Science Communication* 25 (3): 260–71.
Evans, W. A., M. Krippendorf, J. H. Yoon, P. Posluszny, and S. Thomas. 1990. Science in the prestige and national tabloid presses. *Social Science Quarterly* 71: 105–17.
Fahnestock, J. 1993. Accommodating science: The rhetorical life of scientific facts. In *The literature of science: Perspectives on popular scientific writing*, edited by M. W. McRae, 17–36. Athens: University of Georgia Press.
Grote, C. v., and M. Dierkes. 2000. Public understanding of science and technology: State of the art and consequences for future research. In *Between understanding and trust: The public, science and technology*, edited by M. Dierkes and C. v. Grote, 341–62. Amsterdam: Harwood Academic.
Habermas, J. 1992. Further reflections on the public sphere. In *Habermas and the public sphere*, edited by C. Calhoun, 421–61. Cambridge, MA: MIT Press.
Irwin, A. 1995. *Citizen science: A study of people, expertise and sustainable development*. London: Routledge.
Irwin, A., and B. Wynne, eds. 1996. *Misunderstanding of science? The public reconstruction of science and technology*. Cambridge, UK: Cambridge University Press.
Kallerud, E., and I. Ramberg. 2002. The order of discourse in surveys of public understanding of science. *Public Understanding of Science* 11: 213–24.
Karl, H. A., and C. Turner. 2002. A model project for exploring the role of sustainability science in a citizen-centered, collaborative decision-making process. *Human Ecology Review* 9 (1): 67–71.
Kim, H.-S. 1986. Coorientation and communication. In *Progress in communication sciences VII*, edited by B. Dervin and M. J. Voigt, 31–54. Norwood, NJ: Ablex.
———. 1999. The processes of public science and science communication: A new conceptual explication. *Korean Journal of Journalism and Communication Studies* 43 (3): 79–110.
———. 2003. A theoretical explication of collective life: Coorienting and communicating. In *Communication, a different kind of horserace: Essays honoring Richard F. Carter*, edited by B. Dervin and S. H. Chaffee, 117–34. Cresskill, NJ: Hampton Press.
Kim, H.-S., R. F. Carter, and K. R. Stamm. 1996. Developing a standard model of measuring the public understanding of science and technology. *Journal of Science and Technology Policy* 7 (2): 51–78.
Kim, H.-S., J.-M. Choi, and T.-J. Jung. 2000. Impressions of the SET (Scientist-Engineer-Technician): A national survey analysis. *Journal of Technology Innovation* 8 (1): 95–123.
Kim, H.-S., H.-H. Hong, and S.-C. Park. 2003. Youths' impressions of the scientist: A national survey analysis. *Journal of Technology Innovation* 11 (2): 41–69.
Kim, H.-S., J.-H. Lee, and H.-H. Hong. 2002. Korean public understanding of science and technology: A national survey through a new conceptualization. *Journal of Technology Innovation* 10 (1): 124–47.
Kim, H.-S., J.-S. Park, S.-C. Park, and H.-H. Hong. 2003. *Developing a new measurement model for the youths' understanding of science and technology: A national survey*. Report

on a policy research project to the Ministry of Science and Technology, the Korean government, Seoul, Korea.

Lane, N. 1999. The civic scientist and science policy. In *Science and technology policy yearbook*, edited by the American Association for the Advancement of Science, ch. 22. Washington, DC. Retrieved from http://www.aaas.org/spp/yearbook/chap22.htm

Lee, S., and W.-M. Roth. 2003. Science and the "good citizenship": Community-based scientific literacy. *Science, Technology, and Human Values* 28 (3): 403–24.

Lubchenco, J. 1998. Entering the century of the environment: A new social contract for science. *Science* 279, January 23: 491–97.

Matthews, M. R. 2000. Appraising constructivism in science and mathematics education. In *Constructivism in education*, edited by D. C. Phillips, 161–92. Chicago, IL: University of Chicago Press.

McGuire, W. J. 1985. Attitudes and attitude change. In *Handbook of social psychology,* edited by G. Lindzey and E. Aronson, 233–346. New York: Random House.

McLeod, J., C. J. Glynn, and R. J. Griffin. 1987. Communication and energy conservation. *Journal of Environmental Education* 18: 28–37.

Meissner, H. I., A. L. Potosky, and R. Convissor. 1992. How sources of health information relate to knowledge and use of cancer screening exams. *Journal of Community Health* 17: 153–65.

Michael, M. 1992. Lay discourses of science: Science-in-general, science-in-particular, and self. *Science, Technology, and Human Values* 17 (3): 313–33.

Miller, J. D. 1983. Scientific literacy: A conceptual and empirical review. *Daedalus* 112 (2): 29–48.

———. 1986. Reaching the attentive and interested publics for science. In *Scientists and journalists: Reporting science as news*, edited by S. M. Friedman, S. Dunwoody, and C. L. Rogers, 55–69. New York: Free Press.

———. 1998. The measurement of civic scientific literacy. *Public Understanding of Science* 7: 203–23.

———. 2004. Public understanding of, and attitudes toward, scientific research: What we know and what we need to know. *Public Understanding of Science* 13 (3): 273–94.

Miller, J. D., and R. Pardo. 2000. Civic scientific literacy and attitude to science and technology: A comparative analysis of the European Union, the United States, Japan, and Canada. In *Between understanding and trust: The public, science and technology*, edited by M. Dierkes and C. v. Grote, 81–129. Amsterdam, The Netherlands: Harwood Academic.

Miller, S. 2001. Public understanding of science at the crossroads. *Public Understanding of Science* 10: 115–20.

National Science Board. 2004. *Science and engineering indicators 2004*. Washington, DC: National Science Foundation.

Nelkin, D. 1995. *Selling science: How the press covers science and technology* (rev. ed.). New York: Freeman.

Nisbet, M. C., D. A. Scheufele, J. Shanahan, P. Moy, D. Brossard, and B. V. Lewenstein. 2002. Knowledge, reservations, or promises? A media effects model for public perceptions of science and technology. *Communication Research* 29 (5): 584–608.

Paisley, W. J. 1998. Scientific literacy and the competition for public attention and understanding. *Science Communication* 20 (1): 70–80.

Pardo, R., and F. Calvo. 2002. Attitudes toward science among the European public: A methodological analysis. *Public Understanding of Science* 11: 155–95.

Pellechia, M. G. 1997. Trends in science coverage: A content analysis of three US newspapers. *Public Understanding of Science* 6: 49–68.
Petty, R. E., T. M. Ostrom, and T. C. Brock. 1981. Historical foundations of the cognitive response approach to attitudes and persuasion. In *Cognitive responses in persuasion*, edited by R. E. Petty, T. M. Ostrom, and T. C. Brock, 5–29. Hillsdale, NJ: Lawrence Erlbaum.
Phillips, D. C. 2000. An opinionated account of the constructivist landscape. In *Constructivism in education*, edited by D. C. Phillips, 1–16. Chicago: University of Chicago Press.
Pielke Jr., R. A., and R. Byerly, Jr. 1998. Beyond basic and applied. *Physics Today* 51 (2): 42–46.
Prewitt, K. 1983. Scientific illiteracy and democratic theory. *Daedalus* 112 (2): 49–64.
Pulford, D. L. 1976. Follow-up of study of science news accuracy. *Journalism Quarterly* 53: 119–21.
Roth, W.-M., and S. Lee. 2002. Scientific literacy as collective praxis. *Public Understanding of Science* 11: 33–56.
Schiele, B., ed. 1994. *When science becomes culture*. Ottawa, Canada: University of Ottawa Press.
Stamm, K. R., F. Clark, and P. R. Eblacas. 2000. Mass communication and public understanding of environmental problems: The case of global warming. *Public Understanding of Science* 9: 219–37.
Sternberg, R. J. 1999. A dialectical basis for understanding the study of cognition. In *The nature of cognition*, edited by R. J. Sternberg, 51–78. Cambridge, MA: MIT Press.
Sturgis, P. S., and N. Allum. 2004. Science in society: Re-evaluating the deficit model of public attitudes. *Public Understanding of Science* 13: 55–74.
Tankard, J. W., and M. Ryan. 1974. News source perceptions of accuracy of science coverage. *Journalism Quarterly* 51: 219–25, 334.
Taylor, S. E. 1998. The social being in social psychology. In *The handbook of social psychology*, edited by D. T. Gilbert, S. T. Fiske, and G. Lindzey, 58–95. New York: McGraw-Hill.
U.K. House of Lords. 2000. *Science and technology—Third report* (Select Committee on Science and Technology Third Report). Retrieved from http://www.parliament.the-stationery-office.co.uk/pa/ld199900/ldselect/ldsctech/38/3801.htm
Wellcome Trust. 2001. *The role of scientists in public debate*. Retrieved from http://www.wellcome.ac.uk/assets/wtd003425.pdf
Wheatley, G. H. 1991. Constructivist perspectives on science and mathematics learning. *Science Education* 75 (1): 9–21.
Wolfendale, S. A. 1995. *Report of the committee to review the contribution of scientists and engineers to public understanding of science, engineering and technology*. London: Her Majesty's Stationery Office.
Wynne, B. 1989. Sheepfarming after Chernobyl: A case study in communicating scientific information. *Environment* 31 (2): 11–39.
———. 1991. Knowledge in context. *Science, Technology, and Human Values* 16 (1): 111–21.
———. 1993. Public uptake of science: A case for institutional reflexivity. *Public Understanding of Science* 2: 321–37.
———. 1995. Public understanding of science. In *Handbook of science and technology studies*, edited by S. Jasanoff, G. E. Markle, J. C. Peterson, and T. Pinch, 361–88. Thousand Oaks, CA: Sage.

Zaal, R., and L. Leydesdorff. 1987. Amsterdam Science Shop and its influence on university research: The effects of ten years of dealing with non-academic questions. *Science and Public Policy* 14 (6): 310–16.
Ziman, J. 1991. Public understanding of science. *Science, Technology, and Human Values* 16 (1): 99–105.

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