PUBLIC ENGAGEMENT RESEARCH AND MAJOR APPROACHES

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PREFACE

AAAS describes public engagement with science as intentional, meaningful interactions that provide opportunities for mutual learning between scientists and members of the public.

Through the Alan I. Leshner Leadership Institute for Public Engagement with Science, AAAS empowers scientists and engineers to practice high-impact public engagement by fostering leaders who advocate for critical dialogue between scientists and the public and lead change to enable their communities, institutions, and others to support public engagement.

The bibliography below, with additional work on understanding mechanisms for institutional change, as well as practical experience in public engagement with science, will guide the work of the Leshner Leadership Institute, as well as other programs of the AAAS Center for Public Engagement with Science (Center).

The Center, which manages the Leshner Leadership Institute, offers this bibliography as a resource for the broader community of public engagement practitioners, researchers, and scientists doing public engagement.

INTRODUCTION

Public engagement with science is not a singular field of academic study, concept, process, or set of professional activities; there are a diversity of public engagement models and strategies. Yet each tends to define communication as an iterative back-and-forth process between various publics, experts, and decision-makers. Such approaches assume that there is more than one "correct" way to talk about and understand science-related issues. The public is invited to be active participants influencing what is discussed, contributing to the production of expert knowledge and/or the formulation of policy options and decisions (Buhr & Wibeck, 2014). The advantages of such practices are considered to be *normative* in that they strengthen democratic processes, *substantive* in that they bring new knowledge and insight to decision-making; and *instrumental* in that they are effective at promoting public learning, trust in science and scientists, and support for decisions (Young et al., 2013).

Following a previously defined scope of work for the annotated bibliography, in Section I we focus on the history, conceptualization, philosophy, and theories that inform public engagement initiatives and activities. These articles also highlight major debates and critiques specific to the public engagement movement, research specific to emerging technologies such as nanotechnology and food biotechnology, and questions related to practitioners, evaluation, and impact.

In Section II, we focus on research and initiatives that are specific to other major issues, controversies, or debates that are priorities for AAAS, the Leshner Leadership Institute, and the broader U.S. scientific community. These topics include climate change, sustainability issues, and energy technologies.

In Section III, we focus on types of public engagement initiatives that differ from policy-focused deliberation. These other initiatives include citizen science and other forms of participatory research where knowledge is co-produced with lay members of the public. Other examples include science cafés, science festivals, and university-led cooperative engagement activities.

Across these areas, we chose articles for the bibliography that (by scholarly standards) were broadly accessible and relevant to a non-specialist audience, balancing articles that are theoretical, conceptual, or historical in focus with those that are empirical and evidence-based. Articles were selected based on the quality of the journal or outlet in which they were published, and their impact in terms of citations, reputation, and influence. Articles published within the past five years were given stronger priority over older articles.

In identifying articles, we drew on our more than 20 years of combined experience researching multiple dimensions of science and environmental communication, contributing to and closely following the interdisciplinary literature on public engagement as authors, reviewers, editors, consultants, and teachers. Informed by this experience, using Google Scholar we searched the literature using a variety of key word terms, focusing both on major specialized outlets like *Science Communication*, *Public Understanding of Science*, and *Science, Technology, and Human Values* as well as interdisciplinary journals in the social sciences and sciences. In some cases, we also included key articles or chapters from recent special issues of journals or edited volumes devoted to research and scholarship on public engagement.

Overall, drawing on our experience and expertise, in many cases we make connections between journal outlets and literatures that do not often intersect with each other. For example, we link together insights from work in the field of science communication with research in policy studies and in sustainability science, and go further by drawing on work evaluating agricultural extension. This type of synthesis is unique, but we believe there is a need for scholars, scientists, and practitioners to look across these fields for insight.

Our search necessitated drawing boundaries within a broad, expansive literature, including in the bibliography some lines of research while excluding others. For example, as the bibliography reflects, many models of public engagement and their related strategies are implemented and sponsored by science museums, science centers, and other organizations focused on informal learning about science. Examples include deliberative forums, science festivals, and citizen science. Yet beyond research specific to these types of activities, there is a broader literature on informal science learning that in prioritizing relevance and space was not included. This literature often uses the term "engagement" in relation to the education of students, young people, and adults both inside and outside of a formal classroom setting.[1]

Our initial search of the literature identified more than 50 relevant studies and articles. During the process of reviewing and summarizing these articles, we excluded those articles that were either redundant, or upon further examination less relevant. This resulted in a final bibliography of 29 summarized articles.

In the rest of this introduction, drawing on summarized articles, we briefly define major approaches to public engagement; relevant gaps between theory, evidence, and practice; and recommendations that have been made to bridge such gaps.

MAJOR APPROACHES TO PUBLIC ENGAGEMENT

Policy Deliberation Approaches

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[1] For overviews not included in the current bibliography see Appleton, J. J., Christenson, S. L., & Furlong, M. J. (2008). Student engagement with school: Critical conceptual and methodological issues of the construct. Psychology in the Schools, 45(5), 369-386 and McKinnon, Merryn, & Vos, Judith. (2015). Engagement as a Threshold Concept for Science Education and Science Communication. International Journal of Science Education, Part B, 5(4), 297-318. doi:10.1080/21548455.2014.986770

In 2000, drawing on conclusions and arguments of science communication scholars, a U.K. House of Lords report urged science institutions to move beyond just a one-way transmission model of science communication toward a new focus on deliberative contexts where a variety of stakeholders could participate in a dialogue and exchange of views about science policy. These recommendations, joined by other expert bodies in Europe, were a response to perceived public demand for greater accountability and transparency in government decision-making (Einsiedel, 2015).

There was also a sense following the Chernobyl nuclear disaster, the U.K. debate over mad cow disease, and other high profile environmental crises that the public had lost faith in the ability of experts and government officials to effectively manage large-scale risk issues. A leader in this movement was the Danish Technology Board, which operated on the premise that "citizens have the right to be involved in decisions that affect them, and through dialog informed by experts that is focused on uncovering the common good, can make substantive contributions to governance" (Blue and Medlock, 2014).

In the late 1990s and early 2000s, there was a wave of consensus conferences, deliberative forums, and town meetings focused primarily on different dimensions of biotechnology. In these initiatives, recruited lay participants receive background materials in advance, provide input on the types of questions they would like addressed at the meeting, and then provide direct input on recommendations about what should be done in terms of policy. Each format, however, varies by how participants are asked for feedback, how much their feedback matters, and exactly when in the development of a scientific debate consultation occurs. During this period, an estimated 18 countries conducted over 40 such exercises, with most held in Europe, but also the U.S., Canada, Japan, Taiwan, and South Korea (Einsiedel, 2014).

In the mid-2000s, with a legislative mandate from Congress and funding from the National Science Foundation, policy-focused engagement efforts in the U.S. expanded to focus on emerging issues related to nanotechnology and synthetic biology, with deliberation taking place "upstream." Such efforts conducted early on in the social development of a technology can involve publics in important exploratory conversations that identify and anticipate social, political, and ethical concerns. On more mature issues such as drug regulation or stem cell research, deliberation exercises can enrich discussion of possible policy options, eliciting public input on pros and cons of different courses of action, including whether and how to move forward with policy (Macnaghten and Chilvers, 2013). In recent years, newer "responsible innovation" and "anticipatory governance" approaches focus on longer-range perspectives, continuous public consultation, and institutional self-reflection and course correction in response to public input (Einsiedel, 2014).

Deliberative approaches have even been used in formal science education curricula, guided by the assumption that explaining and critically evaluating science is central to the scientific process. One example was the use of a consensus conference that divided secondary science students into an “expert group” and a “lay group." The expert group researched one aspect of the controversial topic and presented it to the lay group whose objective was to ask clarifying questions, discuss, and reach a consensus policy recommendation (Jones et al., 2014).

Public Dialogue Approaches

In public dialogue approaches the goal is to promote dialogue as an end in itself, recognizing that informal discussions with the public result in learning on behalf of both the public and experts. Dialogue-focused forums also serve as opportunities for experts to enhance their own communication knowledge, skills, and experience. Overall, such initiatives provide opportunities for sponsors and participants to explore scientific issues via multiple lenses and perspectives (Einsiedel 2014).

Science cafés are casual forums that "host conversations between scientists and the public about current science topics." They are generally small in size, take place in cafés, restaurants, bookstores, or similar venues, and are open to everyone regardless of scientific knowledge or training. They provide an opportunity to engage citizens who otherwise might not participate in societal discussions surrounding emerging technologies or issues. A typical science café is approximately 90 minutes long and involves both expert speakers and a moderator. Usually speakers give short presentations without visual aids, aiding connection with the audience (Navid and Einsiedel, 2012). Science festivals are a relatively newer example of dialogue-based engagement but appear to be rapidly growing, at least in the U.K. and Europe. Festivals generally bring together temporary exhibits, museum type activities, scientists, art organizations, students, and members of the general public, and attract upwards of 5,000-50,000 visitors (Jensen & Buckley, 2014).

Knowledge Co-Production Approaches

These public engagement initiatives sponsor "intentional collaborations in which members of the public engage in the process of research to generate new science-based knowledge" (Shirk et al. 2012). Citizen science projects are a leading example. Initially begun as a way to use the public as a free source of labor and computational power, today citizen science projects are more inclusive, even involving citizens in the definition of research questions, the interpretation of data, and broader translation and policy efforts (Einsiedel 2014). Emerging information science technologies and software, including advanced handheld devices, easy-to-use graphical user interfaces and web-based data management systems, have allowed citizen science to grow both in scope and quality over the decade (Dickenson et al 2012).

Another example is scenario visioning, a method applied primarily to the issue of climate change that produces future projections, scenarios, and visualizations in collaboration with local stakeholders and scientists. On climate change in particular, participatory knowledge co-production processes are necessary for various reasons. The availability of scientific data is often too complex for decision-makers to use; most expert information is biophysical, with little focus on socio-economic scenarios; information is often not salient for local users; and there are often few structured processes for community outreach on the issue (Sheppard et al., 2011).

Specific tools include using interactive timelines to talk about past adaptation efforts (including telling stories from experience); future-oriented scenario visioning; and technology "exchange," which allows participants to learn about specific adaptation efforts that various people had undertaken (Kass et al., 2011). The most popular approach involves "backcasting—starting from a desired future outcome and working backwards to figure out pathways towards that outcome. This approach is flexible and allows for creativity while maintaining a firm grip on desired and plausible outcomes" (Salter, Robinson, & Wiek, 2011). A similar but unique future scenario method called "Participatory Integrated Assessment" seeks to actively involve stakeholders such as farmers in complex decisions related to land use and ecosystem management specific, for example, to the adoption of sustainable farming practices to benefit local watershed conservation.[2]

University-Led Cooperative Engagement Approaches

The emphasis in these initiatives is on trust building and social learning in collaboration with key stakeholder groups such as farmers, coastal landowners, minority groups, and industry members. These initiatives are typically led by universities and/or deploy university-based infrastructures such as cooperative extension and Sea Grant programs, and/or faculty and outreach staff affiliated with specific university departments, colleges, and schools (Diehl et al., 2015). This is especially relevant to problems like climate change, since the history in the U.S. of decentralized policymaking and antipathy towards federal government-led education initiatives prevents coordinated response and requires universities to step in to meet state and regional needs (Chambliss & Lewenstein, 2012).

The emphasis in these approaches is on using existing university-affiliated infrastructures, networks, resources, and expertise to facilitate an iterative, two-way exchange of information, knowledge, and views among experts, stakeholders and segments of the public. Expert advice and techniques on issues such as sustainable farming practices and climate resilience strategies are provided to farmers and related professionals; these groups provide feedback to university representatives and experts on what is needed and/or likely to work. This process involves not only consulting the public specific to their concerns, needs, and specialized knowledge, but also recruiting opinion-leaders and early adopters of best practices among these groups to influence their peers.

GAPS IN THEORY, EVIDENCE, AND PRACTICE

Broadly defined, the disadvantages of public engagement approaches include experts potentially giving up control over the "message" or key decisions; the logistical challenges, cost,

[2] For overviews on this method not included in the annotated bibliography see Murgue, C., Therond, O., & Leenhardt, D. (2015). Toward integrated water and agricultural land management: Participatory design of agricultural landscapes. *Land Use Policy*, 45, 52-63 and Fontaine, C. M. et al. (2014). Towards participatory integrated valuation and modelling of ecosystem services under land-use change. *Journal of Land Use Science*, 9(3), 278-303.

and time expended; and the potential to cause delays in technology development or policy decisions (Buhr and Wibeck, 2014). Other weaknesses stem from how the scholarly community has conceived of and studied public engagement. Many researchers ardently insist that "true" public engagement is policy-focused and requires shared power in decision-making between the public, experts, and policy-makers (Einsiedel 2014). Yet although such ideals among scholars are commendable, they also have contributed to several weaknesses and tensions in respect to theory, evidence, and practice.

Despite the focus of many scholars on policy impact, there is a lack of systematic evidence demonstrating how and under what conditions public engagement activities influence policy outcomes (Emery, Mulder, & Frewer, 2015). Many public engagement exercises may also be an example of "stealth issue advocacy," in which deliberation is used as a strategy to steer the public towards a predefined goal such as support for a specific policy action, thereby adding political legitimacy to that goal (Macnaghten & Chilvers, 2013). In public forums, how information is presented and framed influences how people make decisions about the issue (Corner, Pidgeon, & Parkhill, 2012). In such cases, public participants are "situated as consumers of dominant scientific knowledge, tasked with responding to a limited slate of policy options that they had no role in creating, vetting, or altering" (Blue & Medlock, 2014).

These weaknesses are reflective of a tendency for scholars to focus too much on the process and "how" of public engagement and not enough on why such activities matter, the potential limits or biases involved, and when or what type of public engagement activities should be conducted. At risk is a scholarly literature that becomes "a litany of engagement case studies and evaluations" that do not consider broader questions or practical implications (Stilgoe, Lock & Wilsdon, 2014).

For example, few studies have examined the public's motivation to participate in public engagement activities and to provide feedback (Brossard and Lewenstein, 2009). The public may be romanticized as motivated and capable of active involvement in science and technology decisions, when they may in fact be ill prepared, fatalistic, and/or cynical about such processes (Stilgoe et al., 2014). Other evidence suggests that the members of the public most likely to turn out to a deliberative forum or meeting are those of higher socio-economic background, who already possess stronger levels of interest and knowledge about an issue, and who may be the most polarized in their worldviews and opinions (Trousset et al. 2015).

In contrast to public engagement scholars, scientists and practitioners tend to define public engagement more pragmatically in terms of "interest" and "involvement" rather than focusing narrowly on political ideals and policy outcomes. In real world situations, efforts at public engagement and outreach also tend to draw on and reflect multiple models of science communication. Most projects "share as a backbone" some element of the deficit model, aiming to increase public knowledge, even while deploying the strategies of two-way public interaction and participation to do so (Brossard and Lewenstein, 2009).

Some critics argue that the scholarly research on public engagement is often needlessly jargon heavy, littered with dense and obfuscating terms such as "scientism," "imaginaries," and "governance" (Salmon et al., 2015). Yet to be fair, scientific research is also often needlessly jargon heavy. The problem is not the terms used in the peer-reviewed literature, but rather those instances when public engagement scholars are directly communicating with scientists and practitioners about their work and do not replace such jargon with more understandable terms.

Critics also argue that scholars tend to critique communication assumptions and practices without offering advice on how things might be done differently, alienating scientists among their readers. At science journals, as a consequence, there is a dearth of analytically rigorous discussion about public engagement or outreach aimed at scientists, from which they can learn and to which they can contribute. Articles on outreach are instead "dominated by short opinion pieces—typically urging scientists to do more outreach, or describing outreach activities," write Salmon et al (2015). This gulf between scholars, scientists, and practitioners leads to theory that is not informed by the challenges of real world activities, and practice that does not incorporate critical reflection, they observe.

Finally, our review identifies a major gap in the literature relative to theorizing, research, activities, and evaluation focused directly on engaging minority and economically disadvantaged segments of the public in the United States. Nor does there appear to be adequate consideration of the different factors, considerations, and strategies involved when communicating across cultures and country settings, especially those initiatives taking place in the developing world and within emerging economies.

BRIDGING THEORY AND PRACTICE

Specific to the tensions between the democratic ideals of scholars and the more pragmatic considerations of scientists, Brossard and Lewenstein (2009) argue for defining public engagement in terms of a continuum where audiences can be engaged by way of interest in discussing issues with an expert; can be empowered by way of specific processes and mechanisms to have a say in decisions; and/or can be given the direct authority to make decisions. Einsiedel (2014) similarly emphasizes the need to think in terms of a ladder of participation where "degrees of participation are recognized in different contexts, for different goals or purposes."

Rather than investing in a single public engagement approach or model, research evaluating a national U.K. public engagement process on energy policy suggests the need for mixed-methods approaches. This would combine insights from expert interviews with feedback gained via in-depth workshops, deliberative forums, focus groups, and more representative public opinion surveys. In the energy policy initiative, the organizers used all of these approaches, as well as interactive scenario planning tools such as visualizations and models to elicit a robust picture of expert and public perceptions of national-level energy system change in the U.K. In-person workshops used both model-based scenario tools and scenario narratives, and the same scenario planning tool was also used in the nationally representative surveys, making the surveys somewhat more interactive than traditional public opinion polling (Pidgeon et al., 2014).

Given the difficulties in demonstrating direct policy impact for deliberative forms of public engagement, some scholars have argued for framing the political significance of such activities in terms of "policy relevance," emphasizing the propensity to influence decisions, as opposed to the achievement of a measurable outcome. For example, deliberative forums held in the U.S. on nanotechnology, according to the organizers, sponsored more "elusive" policy outcomes related to "changes in framing and vocabulary as well as substantive, procedural, and reflexive learning by elites and mass publics (Guston, 2014).

To bridge the tensions among scholars, scientists, and practitioners, Salmon and colleagues (2015) argue that scholars would be wise to write with an interdisciplinary and professional audience in mind, publishing their research and analysis in journals that are likely to be read by scientists and practitioners. In these cases, criticism of current science communication practice should be paired with specific recommendations for improvement. Scientists through their university and funding agencies should look to engage in equal partnerships with social scientists, integrating theory and rigorous evaluation into their outreach efforts. Formal education for scientists should be integrated with coursework and training on the social and political dimensions of science; communication research and theory; and skills-based training. Similarly, workshops focused on skills-based training should also integrate communication research and theory, and be taught by a combination of scientists, social scientists, and communication practitioners.

STUDYING EVERYDAY INFORMAL ENGAGEMENT

Finally, as this bibliography reflects, the published research and scholarship on public engagement has a strong normative focus on achieving specific democratic principles related to empowering public dialogue and/or formalized input on policy. From this normative starting point, the conceptual, theoretical, and research focus has been on different process-related strategies, such as deliberative forums, citizen science projects, and science cafés that are intended to live up to these ideals and achieve these outcomes.

As a consequence, what is missing from the literature is an evaluation of the everyday, informal interactions that scientists can and do have with members of their communities. These interactions include conversations with neighbors or friends, people they meet out in the field or while conducting research, community and business leaders, meetings they might have with elected officials and policy-makers, or interactions via social media. As will be covered in a separate review of science communication research, studies have begun to survey and interview scientists about their views on public communication and engagement and to examine the predictors of different communication-related activities and behaviors, but few if any studies exist examining in more fine-grained detail the nature of this wide array of interactions or the range of their impacts.

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I. PUBLIC ENGAGEMENT:
HISTORY, MODELS & KEY ISSUES

Emery, S. B., Mulder, H. A., & Frewer, L. J. (2015). Maximizing the Policy Impacts of Public Engagement: A European Study. Science, Technology & Human Values, 40(3), 421-444.

Most public engagement (PE) activities are typically defined and evaluated in terms of how the activity has shaped the knowledge, attitudes, and behaviors of the direct participants in the event. This article focuses instead on the goal of using PE activities to inform and influence the decisions of policy-makers. The reasoning is that PE activities help communicate public preferences and knowledge that should inform more effective policy decisions. Therefore, the outcomes of PE activities should be part of the criteria that policy-makers use to reach decisions and formulate policy.

Yet within the European Union/U.K. context there is a lack of systematic evidence demonstrating how and under what conditions PE activities influence public policy outcomes. Such evidence, argue the authors, is needed in order to evaluate the overall effectiveness of PE activities, to improve and tailor practices, to bolster the reputation and adoption of PE activities, and to boost its credibility among funders, experts, and policy-makers. Given this gap in the literature, the authors reviewed previous studies and analyzed interviews with seven E.U. public engagement specialists and seven E.U. policy-makers/civil servants. Their goal was to identify and conceptualize the factors relevant to the impact of PE activities on policy decisions.

Key Takeaways:

1) Activities specific to higher profile issues undertaken at policy-maker request and/or involve policy-makers as participants are more likely to be impactful.
2) Activities must be timely enough to fit within the policy decision window.
3) The framing of topics, activities, and communication of results is critical. Yet many PE activities are not carefully enough conceived and strategically communicated.
4) The scale of the PE activity should match the intended policy influence; e.g., local engagement activities should target local decision-makers, national engagement exercises are needed to target national leaders.
5) One-off activities are not likely to be impactful; PE activities need to be sustained, held over time, and seen as part of a continuous, institutionalized process.
6) The legitimacy and credibility of PE activities are enhanced in the eyes of policy-makers when activities are formally evaluated, showing evidence that public input is representative, credible, and a valid expression of public preferences.
7) With the diversity of evidence that they must consider, in many cases policymakers simply pick and choose what they want to take from the available evidence, thereby limiting PE impact.

8) Other institutional barriers and political pressures such as lobbying, competing priorities and issues, turnover in office holders and staff, and elections are likely to limit PE impact.
9) Given such barriers, some scholars have argued for framing the political significance of PE activities in terms of "policy relevance," emphasizing the propensity to influence policy, as opposed to the achievement of a measurable policy outcome.
10) More research is needed to adapt and build on these insights in terms of their relevance to U.S. local, state, and national contexts.

Trousset, S., Gupta, K., Jenkins‐Smith, H., Silva, C. L., & Herron, K. (2015). Degrees of Engagement: Using Cultural Worldviews to Explain Variations in Public Preferences for Engagement in the Policy Process. Policy Studies Journal, 43(1), 44-69.

Research on public engagement (PE) assumes that the public has the motivation and ability to participate in various PE-related activities. Yet as the authors argue "without a more comprehensive understanding of the basis for individual decisions to engage in the policy process, efforts to design mechanisms of engagement and evaluate their effectiveness will remain incomplete." Analyzing U.S. national survey data collected in 2013, this study examined the factors that predict whether or not an individual said they were willing to participate in a variety of policy-related activities specific to debates over nuclear energy.

Half the sample were asked about specific activities related to nuclear waste and half the sample about transportation. The authors then combined these individual forms of participation into a single dependent variable. Using regression analysis, they examined the social background and belief system factors that predicted overall willingness to participate.

Likely to Engage in… **(% with score above scale mid-point)**	**Interim Storage**	**Transportation Route**
Attend informational meetings held by authorities	51%	49%
Write or phone your elected representatives	47%	47%
Express your opinion using social media	43%	46%
Serve on a citizens’ advisory committee	37%	40%
Speak at a public hearing in your area	21%	24%
Help organize public ***support***	22%	21%
Help organize public ***opposition***	21%	21%

Consistent with past research on political participation generally, after all controls, those individuals of higher socio-economic status who have more time, flexibility, and resources to draw upon were more likely to say they would be likely to participate in debate. Similarly, those who were male and those who were already politically active were also more likely to participate. Somewhat surprisingly, however, respondents of non-white or minority background were also more likely to say they would be likely to participate.

Also consistent with past research, those who saw more at stake in the decisions specific to nuclear energy were also more likely to engage. In this case, those who held stronger risk perceptions specific to nuclear energy and those who held a stronger belief in the benefits of nuclear energy were each more likely to participate, though risk perceptions were the stronger overall motivator.

Key Takeaways:

- Skeptics of PE activities have long warned that those who turn out to participate are likely to be the already knowledgeable and better-off in society and to feel the most intensely about the issues involved.
- This study provides support for this critique, adding an additional dimension related to worldviews. In debates over nuclear energy or similar issues like climate change, it is hierarchicalists and egalitarians, who studies show are already the most polarized in their views, who are more likely to turn out.
- The findings on non-whites and minorities indicating that they are more likely to engage are surprising, and more research is needed in this area. One possible factor may be the perceived link of the issues involved to environmental health and justice.
- This suggests considering and examining how participation may vary based on the issue and social/political context, including the proximity of a debate to where an individual lives.

Salmon, R. A., Priestley, R. K., & Goven, J. (2015). The reflexive scientist: an approach to transforming public engagement. Journal of Environmental Studies and Sciences, 1-16.

The authors discuss the contrast between the view of most scientists that the goal of communication is "to raise awareness, transmit the importance of science or correct misconceptions" and the assumptions of most public engagement (PE) scholars that the goal "should be to enable democratic publics to influence decisions about the development and use of science and technology." To bridge these differences, the authors argue that there needs to be a genuine dialogue between social scientists, scientists, and communication practitioners. Such a dialogue "must involve more than social scientists simply correcting scientists' communication efforts—i.e. enacting their own deficit model."

To engage in such a dialogue, drawing on a diversity of backgrounds, each of the three authors reacted to 6 articles from a 2014 special issue of *Public Understanding of Science*. The authors included a climate scientist, a social scientist who studies public engagement, and a science writer/historian with scientific training. Among the authors' major observations or recommendations for PE scholars:

- **Focus on specific scientific disciplines, contexts, or topics**: In the PE literature, there is a tendency to treat science in an undifferentiated way, not distinguishing among the varied institutional and political contexts in which scientists work and communicate with the public. This can lead to alienation of individual scientists attempting to engage with the literature.

- **More precision, clarity, and parsimony in language needed***:* The scientist and science writer found the language of the articles to be "dense and obfuscating." Examples included terms such as scientism and scientistic, governance (as in governance of science), deficit model, knowledge co-production, political imaginaries, deliberative democracy, and normative. As they remarked: "In science, there is a right meaning and a wrong meaning. It's hard work not having those boundaries to work within."
- **Be sensitive to different views of science**: Scientists view science as a "systematic process of observation and experiment that leads to deeper understanding about the structure and nature of the physical and natural world." Social scientists see science as "a social activity, not exempt from the kinds of social influences, processes, and tendencies found in other spheres of activity." They also view "science as a discursive resource used to legitimate the agendas of those with particular political or economic interests."
- **Pair criticism with recommendation**: For the scientist and science writer, they were frustrated by what they saw as criticism of science communication practitioners that was not accompanied by helpful advice on how they might do things differently and therefore avoid the pitfalls that are the focus of much of the critical literature.
- **Be sensitive to perceived attacks**: The scientist and science writer felt attacked by some of the literature and experienced anger and resentment in response to an "us versus them" tone to the articles. The social scientist did not read these criticisms as attacks on scientists in general, but rather as criticisms of public actors such as political leaders, government bodies, etc., who inappropriately use the authority of science to achieve specific political goals.
- **Should the public inform science?** Both the scientist and science writer thought that public input informing science could just be another "route through which the politically and economically powerful could influence science and to entail a complete disregard of the value of scientists' training and scientific process and data."

The authors argue that PE scholars and scientists would benefit from more direct and extensive engagement with each other and with communication practitioners. This collaboration would lead to "theory that is informed by the challenges of real world activities, and practice that is informed by critical reflection," thereby enhancing the effectiveness of public engagement activities. Yet there are several barriers to this type of direct engagement:

- **Training reinforces deficit model**: The training scientists typically receive reinforces view that communication is about one-way knowledge transfer.
- **Few incentives**: There are few incentives for scientists to invest additional time/energy into thinking critically about outreach.
- **Limited scientist-targeted literature**: There is very little analytical literature about outreach or engagement aimed at scientists, from which they can learn and to which they can contribute. The literature on outreach is instead "dominated by short opinion pieces—typically urging scientists to do more outreach, or describing outreach activities."

The authors argue that these barriers result in the following: "(a) the scientific community at large is not aware of opportunities to engage in scholarly dialogue about science communication and public engagement with science; and (b) there is little systematic study of, or data collection related to, outreach by scientists; with the result that (c) science outreach activities remain under-researched and uninformed by theory."

Key Takeaways:

The authors provide several recommendations for overcoming or reducing the barriers to greater dialogue and collaboration among scientists, social scientists, and science communication practitioners:

1) Formal education for scientists should be integrated with coursework and training on the social and political dimensions of science, science communication and PE research and theory, and skills-based training.
2) Workshops that focus on skills-based training should also integrate science communication and PE research and theory, taught by a combination of scientists, social scientists, and communication practitioners.
3) Perceived threat can be overcome by introducing scientists to key concepts and issues from PE using humor, images, and conceptual figures rather than relying on vague or confusing terms and jargon.
4) The field would benefit from developing a broader portfolio of outcomes and indicators of science outreach that emphasize quality of engagement over quantity. Instead of measuring the success of a dialogue event by attendance numbers, the authors instead recommend also "collecting references provided by external [PE] scholars, reports in the media, and anonymous participant feedback, as well as an evaluation or assessment exercise."

Jones, A. R., Anderson, A. A., Yeo, S. K., Greenberg, A. E., Brossard, D., & Moore, J. W. (2014). Using a deliberative exercise to foster public engagement in nanotechnology. Journal of Chemical Education, 91(2), 179-187.

In 2003, federal legislation on nanotechnology included a statute that called for “the convening of regular and ongoing public discussions, through mechanisms such as citizens’ panels, consensus conferences, and educational events, as appropriate.” The result was funding and efforts to organize dozens of public engagement activities and nationwide surveys on the issue. Findings suggest that broader publics are still unfamiliar and unaware of nanotechnology, with formative, nascent opinions more positive than negative.

Designing a consensus conference on nanotechnology. The authors detail the design of consensus conference exercises organized on separate occasions by a team of scientists and social scientists at the University of Wisconsin. The four different social groups involved included senior citizens who meet weekly to discuss topics in the life sciences; members of a "science at the pub" informal discussion group; volunteers who met at a library and were recruited by way of posters and email; and a class of undergraduate students enrolled in an introductory chemistry class.

During their respective two-hour deliberations, the four groups of citizens were divided into pairs and each pair was assigned one of 10 different research areas to present to the whole group. Each pair in this format became the "citizen expert" on the research area. Each pair was randomly handed a background packet on one of the 10 research areas and given three red index cards on which to write down benefits and three green index cards on which to write down *perceived* risks. Since consensus conferences are intended to uncover concerns that experts might not have considered, the background packets did not specifically highlight risks, leaving such risks open to participant identification and interpretation.

After the participants agreed on their risks and benefits, they were read a script defining what reaching a consensus meant and explaining the option to block the consensus about risks and benefits or "stand aside" (meaning that a participant disagrees with the consensus position but does not block the consensus). Participants then voted for the two research areas that should be allotted the greatest amount of money, and were encouraged to vote and argue based on their own opinion regardless of assigned research area. After the votes were tallied and research areas ranked, facilitators then led the group in a 20−30 minute discussion of how well the preliminary order reflected the priorities of the whole group. After the group reached an agreement regarding the order of the top two priorities, the group spent 20−30 minutes deliberating over what percentage of the $1.5 billion should be allotted to each group. After a consensus was reached, participants completed the post-survey.

Impacts on Knowledge, Interest, and Support. To measure knowledge, participants were asked to indicate how correct or incorrect they thought six statements about nanotechnology were, with participants asked to distinguish between "think" and "know" to indicate how sure they were of their answer. This allowed for a "knowledge score" that reflected on a six point scale a correct answer regardless of confidence in the answer and a "confidence knowledge score" on a 12 point scale that combined accuracy in knowledge with how sure respondents were of their answers.

Across the combined four groups, deliberation was observed to promote small improvements in factual knowledge and a stronger increase in knowledge confidence. From these items a sophisticated "knowledge change score" was also calculated. Overall, following the deliberative exercise, across all four groups, 16% of the knowledge answers were worse, 47% of the answers were improved, while 37% answered the same. Of those who answered the same, 74% answered with a right answer before the intervention.

Specific to interest in nanotechnology, there was a statistically small improvement in interest among the student group and non-significant improvements among the other groups. The lack of improvement in interest is likely in part due to the already high level of interest among the science pub and retiree samples. The library group also had higher interest levels, given that they had volunteered to turn out on a Saturday to learn about nanotechnology. In terms of support for nanotechnology, the student group similarly showed the most increase in support over the other groups. The study also included a measure indicating how likely a participant was to turn out for a future event on nanotechnology. In this there were only significant improvements for the student group.

Overall, the authors interpret these findings as important: the student group which had lower levels of overall engagement with nanotechnology at the start of the exercise compared to the already-engaged other groups saw significant improvement in their interest levels, support, and willingness to participate in the future.

All of the participants in open-ended questions were also asked what they valued about the experience. In this case, of the 80 participants who responded, the result was about equal: they valued learning, gaining knowledge, gaining information, and the deliberation. More specifically on this last topic, some valued the opportunity to discuss/deliberate (68%), others the opportunity to hear what peers had to say (34%), and others to have a voice (9%).

Key Takeaways:

1) Published at an interdisciplinary journal that reaches scientists, educators, and decision-makers, this study is among the most sophisticated and detailed examples in the literature on the design of a university-led deliberation exercise with theoretically informed, rigorous evaluation of outcomes. The study also involved collaboration between scientists and social scientists. In this regard, it is in line with several of the major recommendations of Salmon and colleagues (2015).
2) Overall, the findings show that in deliberation exercises, given the already interested and motivated background of likely participants, significant gains in knowledge and outcomes may be difficult to observe. In this case, there is a risk that despite resources and time spent, deliberation exercises engage the already enthusiastic and knowledgeable about emerging technologies, leaving other segments of the public out of the process.

Stilgoe, J., Lock, S. J., & Wilsdon, J. (2014). Why should we promote public engagement with science? Public Understanding of Science, 23(1), 4-15.

In this paper the authors review two decades of research and analysis specific to public engagement (PE) activities, drawing on additional insights from invited papers published as part of a special issue of *Public Understanding of Science*. The authors believe that the PE movement has focused too much on the process and "how" of public engagement and not enough on why such activities matter, the potential limits or biases involved, and when PE activities should be conducted. As a consequence, "the literature risks becoming a litany of engagement case studies and evaluations" that do not consider a broader set of issues. The authors identify a series of challenging questions that should be carefully considered by scientific organizations, agencies, universities, and funders sponsoring PE activities and by academic researchers studying and evaluating them.

Key Takeaways:

1) *Are PE activities just a form of strategic persuasion?* Many scholars argue that PE activities do not do enough to challenge the status quo, forcing institutions to rethink their practices or decisions. PE activities instead become strategies for gaining public trust and acceptance of a predetermined outcome. The focus on consensus as a chief goal also risks overlooking what can be gained by learning from disagreement and a plurality of perspectives.
2) *Do sponsors bias PE efforts?* The sponsorship of PE activities by governments and universities has led to extensive research on issues of top priority for these institutions such as biomedical advances and emerging technologies. In contrast there has been limited research specific to other fields such as information technology or relative to innovations coming out of the private (rather than public) sector. PE researchers can also lose their independence if they become too cozy with scientists and their organizations, "defining themselves in scientific terms and allowing their studies and engagement to be skewed accordingly."
3) *Are PE activities too financially costly and politically risky?* In an area of austerity, sponsors will increasingly ask whether or not PE activities are worth it and emphasize instrumental outcomes that serve their goals. Yet in some cases, PE activities can unintentionally reveal or promote elements of disagreement in ways that are politically challenging to the sponsoring institutions. Participants in a dialogue about nanotechnology, for example, may be so alarmed by what they learn that they may join or form advocacy groups to oppose the technology.
4) *Which publics matter and are motivated to participate?* Few studies have examined the public's interest and motivation to participate in PE activities and provide feedback. The public may be idealized by PE practitioners as motivated and capable of active involvement in science and technology decisions, when they may in fact be fatalistic and cynical about such processes. Other scholars argue that the publics that matter are those segments who have followed an issue and are passionate about related outcomes. In this case, it is the meanings that these publics attach to science and technology that should be given greater consideration and attention rather than being discounted in deference to scientifically defined benefits and risks. There is also limited research on how social media, science cafés, science festivals, and open-access scientific publishing platforms are serving as new spaces for engagement by highly motivated, already knowledgeable science enthusiasts and "geeks."

Guston, D. H. (2014). Building the capacity for public engagement with science in the United States. Public Understanding of Science, 23(1), 53-59.

Guston argues that public engagement activities designed to promote active citizen deliberation about emerging scientific and technological questions address two main weaknesses in U.S. political culture. First, many high profile science issues have become defined in starkly partisan and ideological terms. Second, many decisions about science and technology lack public accountability or input. This is especially the case as technological innovations are transferred from government and university labs to industry and then introduced into the consumer market with little or no public attention, awareness, or consultation.

In presenting a possible model for addressing these weaknesses, Guston describes key features and insights from the work of the Center for Nanotechnology and Society at Arizona State

University (CNS-ASU), and its sponsorship of the National Citizens Technology Forum (NCTF). By focusing on nanotechnology and by recruiting participants from six geographically dispersed communities, the initiative promoted democratic deliberation at a national scale and engaged participants on an emerging issue prior to them having significant factual knowledge or established opinions about it.

Participants were recruited via local newspapers, leaflets, and online ads, and received $500 after completing the full deliberation process. Prior to the process, each individual received a 61-page background document. Participants then deliberated over the course of a month, including an initial face-to-face weekend, a series of online interactions with other panelists and experts across the country, and a final face-to-face weekend to draft their reports and recommendations. They were surveyed before and after the process to assess specific outcomes.

Key Takeaways:

According to Guston, evaluation of the NCTF strongly supports the contention that members of the public can deliberate in a thoughtful way at a national level about emerging technologies. Specific findings include:

1) Participants mastered technical aspects of nanotechnology presented to them, and engaged content experts in active, informed, and critical questioning.
2) Common biases in small group decision-making such as deference to perceived majority opinion or forceful individuals did not appear to determine outcomes.
3) Participants expressed a complex ambivalence about nanotechnology, expressing unease about enhancement technologies, hope specific to nano-enabled therapies, and concern for issues of equity underlying policy formulation.
4) Participants expressed a strong understanding of their own role and capacities relative to deliberation.
5) Roughly two years after the NCTF, participants remained more knowledgeable than a control group about nanotechnology.
6) But somewhat surprisingly, two years later, participants were overall less civically involved than members of the control group. In other words, participation in the NCTF did not seem to promote other civic-related outcomes.

Although findings from NCTF were presented to Congressional decision-makers, it is not clear if or how the findings may have shaped policy decisions. Instead, Guston argues that the event did help promote more "elusive" policy outcomes related to "changes in framing and vocabulary as well as substantive, procedural and reflexive learning by elites and mass publics." In continuing to study and develop innovative deliberative processes, the CNS-ASU has experimented with a variety of new platforms including immersive simulations, gaming, and experiential art to motivate participation, deliberation, and opinion expression.

Einsiedel, E. F. (2014). Publics and their participation in science and technology. Routledge Handbook of Public Communication of Science and Technology, 125.

In this chapter, the author reviews the philosophical foundations, history, major approaches, and key issues specific to public engagement initiatives and strategies, drawing on the published literature but also her own experience as a leader in the field. Public engagement approaches are philosophically grounded in John Dewey's belief in the practical wisdom and capacity of the public to participate in complex societal decisions rather than remain spectators to elite debates. Contemporary political theorists argue the potential for organized deliberation to "broaden perspectives, promote toleration and understanding among groups, and encourage public-spirited attitudes." Other scholarship suggests that so-called "issue publics" who follow and participate more heavily on an issue, offer their own forms of valuable expertise that should be taken into account by experts and decision-makers. Influenced by these key assumptions, Einsiedel organizes and reviews forms of public engagement initiatives by specific purpose or goal; by their primary actors and sponsors; and by their specific forms.

To Influence Policymaking. In this focus, the purpose of public engagement is to inform or influence policy decisions. The primary sponsors are often governments, research institutions, international organizations, and stakeholder organizations. Engagement takes the form of consensus conferences, citizen juries, deliberative polls, and negotiated rulemaking. Einsiedel discusses the historical evolution of these approaches across two key stages.

- *Stage 1 Social Experimentation and Institutionalization*. In 1980s and 1990s, efforts in the U.S. to engage the public in the policy process focused on environmental issues and took the form of public hearings and negotiated rulemaking. In the late 1990s and 2000s, biotechnology became the focus of consensus conferences, citizen juries, and study circles. An estimated 18 countries conducted over 40 such exercises with most held in Europe, but also in the U.S., Canada, Japan, Taiwan, and South Korea.
- *Stage 2 Upstream Public Engagement*. In the 2000s, public engagement efforts expanded to focus on emerging issues related to nanotechnology and synthetic biology, taking place "upstream." These efforts were designed to be anticipatory of public concerns and to provide input on the development of policy and applications. Newer "responsible innovation" and "anticipatory governance" approaches focused on longer range perspectives, continuous public consultation, and institutional self-reflection.

To Promote Public Dialogue. In these approaches the goal is to promote dialogue as an end to itself, recognizing that informal discussions with the public promote cross-learning on behalf of both the public and experts. They also serve as opportunities where experts can enhance their own communication knowledge, skills, and experience. Examples include science cafés, science festivals, and science-art exhibits and performances. Each of these forums provide opportunities for sponsors and participants to explore scientific issues via multiple lenses and perspectives. Common sponsors include government, universities, research institutes, museums, arts institutions, and stakeholder groups.

To Promote Knowledge Production. Initiatives in this area are often informed by what scholars call a "Mode 2" conceptualization of science in which knowledge production is less bounded by a specific discipline, more socially accountable, and more reflexive. This has led to multiple sites of knowledge production, a greater range of tools used, and multiple actors and skills sets needed. Key questions include what counts as knowledge and whose knowledge counts.

- *Citizen science* is a lead example of this approach. Initially begun as a way to use the public as a free source of labor and computational power, today citizen science projects are more inclusive, even involving citizens in the definition of research questions, the interpretation of data, and the broader translation and policy efforts. Other examples include using social media to "crowd source" knowledge about a topic; video games like "Fold It" that harness large numbers of players to devise novel research solutions; and open source publishing and peer-review of scientific studies.
- *Community-Based Participatory Research* involves experts working with affected groups or communities on research related to specific problems, actively involving community members in research and solutions. Examples include working with community groups on issues related to environmental risks or climate change adaptation, or scientists working with patient groups on the development and evaluation of new drug therapies.

Key Takeaway:

1) Many scholars insist that *true participation* requires shared power in decision-making, focusing on the impact of participation on policy outcomes. But Einsiedel argues instead for a *ladder of participation* where "degrees of participation are recognized in different contexts, for different goals or purposes," as her typology of purposes describes.

Macnaghten, P., & Chilvers, J. (2013). The future of science governance: publics, policies, practices. Environment and Planning C: Government and Policy, 31, 000-000.

The authors argue that analysis of dialogue-focused public engagement (PE) initiatives have been limited to specific technologies or issues, without considering the common concerns or themes that are expressed across issues and PE events. Nor has there been enough focus on how different PE activities might differ in their timing, design, and goals. To address these gaps, the authors conducted a qualitative meta-analysis of 17 dialogue-focused events organized by "Sciencewise," the U.K.'s national center for public dialogue in science policymaking. These PE events focused on topics including nanotechnology, stem cell research, animal chimeras, pharmaceutical development, the future of industrial biotechnology, forensic use of DNA, climate change, geoengineering, and the transition away from fossil fuel energy sources. To classify these 17 dialogue events, the authors adapted a typology applied by Pielke (2007), defining three main types of PE dialogue events. Across these events, they then identified common questions raised by participants.

Upstream model of engagement. The goal of these events was to engage publics in exploratory conversations at an early stage in the innovation process. Examples of issues include nanotechnology and geoengineering. Events were only loosely tied to specific policy goals, with subjects serving as "exploratory subjects" to identify social and ethical concerns and issues. In these events, common concerns raised by the public included:

- Purposes: Were the motivations of scientists good and transparent?
- Trust: Were funding bodies directing research to the public interest?
- Inclusion: Would public input have the power to shape science's political economy?
- Speed and direction: Would science respond to society? Respect the "natural order"?
- Ethics, trade-offs, inequity: Would individual/market values override collective values?

Honest broker model of engagement. This model was used on issues such as drug regulation or stem cell research where science was already mature, the social/ethical issues mostly identified, and where different policy options needed to be defined. Examples include stem cell research, drug regulation, and forensic use of DNA. The goal was to foster public discussion specific to pros and cons of different courses of action and which options were socially acceptable. The public is positioned as "reflective subjects" who contemplate whether and how to move forward with policy.

- Purposes: Did research respect basic human values?
- Trust: Were funding bodies independent of interests?
- Inclusion: Would social/ethical values inform policy?
- Speed and direction: Would corporate pressures override social/ethical questions?
- Ethics, trade-offs, inequity: Would science unfairly impact most vulnerable?

Issue advocate model of engagement. This model was used where there was an already agreed upon policy goal such as climate change mitigation and the switch to renewable energy. The focus was on how this goal could be achieved by better understanding and mobilizing public views, beliefs, and participation. In this case, the public was assumed to be "malleable" subjects that could be persuaded to support a specific goal.

- Purposes: Were the predetermined goals legitimate/plausible?
- Trust: Could institutions involved be trusted?
- Inclusion: Could existing goals be challenged by public?
- Speed and direction: Would corporate values dominate?
- Ethics, trade-offs, inequity: Would social benefits override other ethical concerns?

To compare public views with that of science leaders and policy-makers, the authors followed by conducting forty in-depth interviews with senior staff from 23 U.K.-based science organizations that included government agencies, regulators, funders, industry, scientific societies, and non-governmental organizations. Their findings included:

- *Purposes:* Majority of interviewees did not recognize public concerns associated with the purposes of science; the good purposes were automatically assumed. For example, food biotechnology was unquestionably seen as serving the public good, particularly in relation to future food security.

- *Trust:* Respondents more likely to recognize concerns about trust in government and influence of industry on government.
- *Inclusion:* All respondents recognized "public feelings of powerlessness and the need for an inclusive governance processes," noting public dialogue as means to do this. Yet most also saw limited role for active public involvement in organizational decision-making. Instead dialogue was viewed as promoting public acceptance of decisions.
- *Ethics, trade-offs, inequity*: Few respondents considered issues related to ethics or inequities to be of concern, believing that most scientists were already considering ethics in their work, and that transparency would ensure ethics and equity.

Key Takeaway:

1) The authors find that those organizations where engagement had produced more impact on decision-making generally "had a supportive CEO, a decentralised decision-making culture, a culture of risk taking, and an appetite to embed focused engagement activity in policy departments rather than communications or science in society directorates."

Brossard, D., & Lewenstein, B. V. (2009). A Critical Appraisal of Models of Public Understanding of Science: Using Practice to Inform Theory. In L. Kahlor & P. Stout (Eds.), *Communicating Science: New Agendas in Communication*(pp. 11-39). New York: Routledge.

The authors in this study examined the ethical, legal, and social implications (ELSI) related to outreach efforts of the U.S. Human Genome Project to conceptualize and demonstrate with real-life examples how such activities reflect different models of science communication and public engagement. To begin their research process, they review four broad conceptualizations of science communication and public engagement as they have been defined in the literature.

- *The Deficit Model*: Emphasizes linear transmission of information from experts to public, believing that good transmission of information leads to reduced "deficit" in knowledge, and that reducing such deficits will lead to better decisions and more support for science.
- *The Contextual Model*: Focus on specific audiences or "publics," tailoring communication to the needs and situations of these audiences based on time, location, social background, language, specific concerns or beliefs etc., emphasizing the ability of audiences to become knowledgeable about science if communication is adapted to their needs.
- *The Lay Expertise Model*: Emphasizes that scientific knowledge has limits and that specific publics offer their own valuable expertise and insights that should be incorporated into decisions. Highlights the interactive co-production of knowledge.
- *The Public Engagement Model*: Focuses on policy issues involving scientific and technical knowledge, emphasizing the democratic ideal of public participation in the policy process and the need for mechanisms that enable public authority over policy and resources.

Approximately 5% of the Human Genome Project was devoted to "public understanding of science" studies under the umbrella of ELSI. From these funded projects that took place between 1996 and 2001, the authors selected four to analyze in depth, selecting a case study that matched each of the four conceptualized models. To better understand the selected outreach activities, the authors conducted a combined 19 in-depth interviews with affiliated staff and leaders of these four projects, examined related materials, and conducted surveys of participants where relevant.

Project 1 - Deficit Model: The Gene Letter. This project that ran between 1996 and 2001 attempted via a web-based newsletter to reach a broad audience interested in the ELSI dimensions of genetics research. The newsletter featured news articles on ELSI issues, book reviews, and information about conferences, events, and other resources. Impact was assessed by way of daily and average web traffic, the amount of time spent on the site by a visitor, and by way of feedback through a "Chatbox" function and emails that were answered by staff.
At first glance, the project does follow the assumptions of the deficit model, attempting to reach a broad audience by way of information dissemination. In this case, the site averaged 5,000 visits per week and had readers ranging from grade school through college education. But other characteristics also reflect contextual and interactive approaches. Articles on ELSI themes were tailored to anticipated audience interests and concerns, and readers were able to interact with editors by way of email and other chat functions.

Project 2 - Contextual Model: Conferences for Minorities on ELSI Issues. This project sponsored conferences and meetings of more than 200 attendees that would recruit participants by way of organizations and leaders who served the minority community. The meetings would provide background to participants on scientific topics, before focusing on ELSI issues relevant to minorities, generating lists of concerns and questions. Attendees could also sign up to become community liaison coordinators. The project followed the contextual model assumptions by designing and tailoring the provision of information to the background and concerns of a specific audience. Otherwise, the goals were to allow participants to raise concerns and get information from a group of experts.

Project 3 - Lay Expertise Model: Question of Genes Documentary. This documentary, which aired on PBS, featured seven profiles of people "like you and me" who had to deal with issues related to genetics testing. In first person testimonials, each individual directly shared their experience, with no narrator. The goal was to get audiences to think about ELSI while only presenting just enough science to understand the case study. The case studies were also presented at the affiliated website with an educator guide and a discussion forum. The goal of the producer was to have "real people" who have dealt with genetic counseling to explain "what it means, not what it does." By adopting the lay expertise model, the project demonstrates a strategy for "approaching issues that have high relevance in people's lives and that might provoke strong feelings." Other elements of the project featured an engagement process by fielding feedback via the website and a contextual approach by using interviews to tailor information to an audience.

Project 4 - Contextual/Public Engagement Model: Hispanic Radio Program. Between 1998 and 2000, project produced 75 1-2 minute radio segments and 3 hour-long programs that ran on the Hispanic Radio Network. The goal was to get listeners interested in ELSI genetics topics and to motivate them to seek out more information by way of a 1-800 telephone number or by way of participation in local community events at museums, festivals, zoos, and other family friendly venues. Topics covered in the segments and programs included Hispanic professionals involved in research, the economic implications of research, biotech industry involvement, and encouragement of Hispanic students to pursue science-related fields. The project clearly reflected aspects of both the contextual and public engagement model.

Key Takeaways:

1) Analysis of these cases shows that although scholars tend to portray the major models of science communication as in conflict and incommensurate, in practice projects are more likely to draw on and blend, with successful outcomes, different features of several models.
2) Theoretical conceptualizations of science communication do not accurately capture the complexity of science communication in practice.
3) All of the projects "shared as a backbone" some element of the deficit model, aiming to increasing public knowledge, though the strategies employed to boost knowledge varied from tailoring information to the background of audiences to fostering direct two-way interaction.
4) "What is engagement?" and "What kinds of engagement are the public interested in?" are questions that should be asked of science communication generally.
5) Practitioners tend to define engagement pragmatically in terms of "interest" and "involvement" whereas as scholars tend to define engagement in political and policy terms.
6) The authors identify a continuum of engagement where audiences can be engaged by way of interest in discussing issues with an expert; can be empowered by way of specific processes and mechanisms to have a say in decisions; or can be given the authority to make decisions (thereby disempowering experts.)

II. PUBLIC ENGAGEMENT ON CLIMATE CHANGE, SUSTAINABITY, AND ENERGY

CLIMATE CHANGE, BIODIVERSITY, AND SUSTAINABILITY

Blue, G., & Medlock, J. (2014). Public Engagement with Climate Change as Scientific Citizenship: A Case Study of World Wide Views on Global Warming. Science as Culture, 23(4), 560-579.

The authors discuss the September 2009 World Wide Views (WWViews) on Global Warming initiative that enrolled 4,400 members of the public across 38 countries in a day-long deliberation of key themes and questions addressed in the United Nations climate negotiations at Copenhagen. The event was designed to provide a forum for citizens to discuss and debate climate change outside of the highly politicized context of mass media and political campaigning. Held in collaboration with the Danish Technology Board (DTB), the event was an effort to "scale up" the consensus conference model to focus on policy issues such as climate change or biodiversity that transcend national boundaries.

The DBT philosophy is that "citizens have the right to be involved in decisions that affect them, and through dialog informed by experts that is focused on uncovering the common good, can make substantive contributions to governance." Held in the months preceding the Copenhagen meetings, the events were designed to be inexpensive; have a clear and timely policy link to national and international decision-making; and yield outcomes that could be clearly communicated to policy-makers. At each event, four structured thematic sessions were held in which, aided by a moderator, groups of 8– 10 participants discussed key issues. At the start of each session a brief video was shown that reinforced information available in booklet form. Following discussion, participants cast votes on multiple-choice style questions, reflecting the four themes:

- Climate change and its consequences
- Long-term goals and commitments
- Dealing with GHG emissions
- The economy of technology and adaptation

At the end of each session, responses to multiple-choice style questions were uploaded in real time to a web interface, which enabled comparison of results across countries and regions. These responses were then featured in the final report that was distributed to national delegations at the U.N. Copenhagen meetings. Across countries, outcomes were remarkably consistent, with majorities favoring:

- Keeping temperature increase below two degrees via firm reduction targets
- Prioritizing financial mechanisms and technology transfers
- Strengthening international institutions
- Introducing rewards and punishments for countries

Yet the authors argue, based on their analysis of the Canadian convening, that these remarkably similar results across countries were a direct consequences of the narrow framing of the terms of discussion and debate. As the authors write, this "framing is one in which narratives about global warming are strongly tied to the natural sciences and to a lesser degree economics, and to a problem-solving framework of targets and timetables which claims universal reach and authority."

Participants were not given the opportunity to pose different questions, to select alternative sources of expertise, or to provide alternative problem-framings that accord with their own unique social locations. Overall, "participants were situated as consumers of dominant scientific knowledge tasked with responding to a limited slate of policy options that they had no role in creating, vetting, or altering."

Key Takeaway:

1) By the authors' account, the WWViews initiative is an example of what Macnaghten & Chilvers (2013) describe as an issue advocate model of public engagement in which deliberation is used as a strategy to steer the public towards a predefined goal, adding political legitimacy to that goal.

Young, J. C., Jordan, A., Searle, K. R., Butler, A., Chapman, D. S., Simmons, P., & Watt, A. D. (2013). Does stakeholder involvement really benefit biodiversity conservation? Biological Conservation, 158, 359-370.

This study employed a mixed methods approach to examine the relationship between stakeholder engagement processes and social and ecological outcomes. Using a case study approach in Scotland, the researchers explored how aspects of the process by which various stakeholders are involved in habitat protection plans influence trust, learning, and perceptions of long-term ecosystem outcomes. In the context of setting up and managing protected areas, integrating local stakeholders and resource users into the decision-making process is critical. In contrast, relying solely on university scientists and management agency members to make decisions is a recipe for disaster, argue the authors. Young et al. also identify three overarching reasons to involve stakeholders in decision-making processes. These include normative (e.g., strengthen democratic processes); substantive (e.g., bring additional knowledge, values into decision-making process); and instrumental (e.g., building trust and legitimacy in the process).

Key Takeaways:

1) Good process is important but not sufficient to ensure positive outcomes (or perceptions of outcomes). It is not safe to assume a good process will always result in better outcomes or greater long-term buy in, but it is an important prerequisite.
2) Stakeholder involvement in program development and implementation increases trust and social learning. Success thus requires long-term investment in bottom-up processes that keep stakeholders involved.
3) Independent processes fare better than top-down approaches, particularly for building trust. Engagement approaches should not be used to make the public more pliant, but rather to involve them in more effective outcomes. Local stakeholders need to perceive their role as critical to the effort, not simply an add-on or checkbox to be marked off.
4) It is important to emphasize that stakeholder engagement does not happen in a vacuum but is embedded in complex social processes, including governance structures. It is therefore critical to clarify shared objectives early on (and to make sure that the same words aren't being used to mean different things).

Bartels, W. L., Furman, C. A., Diehl, D. C., Royce, F. S., Dourte, D. R., Ortiz, B. V., ... & Jones, J. W. (2013). Warming up to climate change: a participatory approach to engaging with agricultural stakeholders in the Southeast US. Regional Environmental Change, 13(1), 45-55.

The paper presents a case study of a multiyear effort to bring together row crop farmers, agricultural extension specialists, researchers, and climate scientists in the Southeast U.S. The engagement activities included biannual workshops that formed part of a "climate learning network" with the broad aim of providing a physical space and social network for different stakeholders to exchange analytical and experiential knowledge that can be used to prepare for an uncertain future under climate change. The workshop organizers used Kolb's experiential learning cycle theory as a basis for determining activities at workshops which includes experiential learning, reflection, abstract conceptualization, and experimentation.

Specific tools used to encourage engagement included: using interactive timelines to talk about past adaptation efforts (including telling stories from experience); future-oriented scenario visioning; and technology "exchange," which included allowing participants to learn about specific adaptation efforts that various people had undertaken. Participatory tools in workshops create space for the co-production of knowledge. In this case, identifying historical timelines, possible climate scenarios, and technology exchange gets people talking and thinking about climate-related risk management.

Key Takeaways:

1) It is not enough to simply have scientific knowledge, even regional or localized information, if the aim is for the information actually to be used. Knowledge must be contextualized and personal relevance has to be developed in concert with local decision-makers and there needs to be a deep understanding of what motivates stakeholders in order to develop useful decision tools.
2) There are many techniques for figuring out what people need, including interviews, surveys, focus groups, workshops, and advisory board meetings. Yet one-time efforts aren't enough. There needs to be sustained engagement over time to build trust.
3) Hybrid approaches can balance the needs of stakeholders with scientists' agendas. But this requires time commitment and iteration of strategies over time. Non-scientists can't be treated as passive receivers of "wisdom" but also can't derail scientific inquiry. There need to be processes that encourage analytical and experiential learning.
4) Local resource users such as farmers have significant stores of context-specific, experiential knowledge that must be surfaced and incorporated into any meaningful co-production process. Such efforts must also recognize the often short-term planning horizons of decision-makers driven by market and other non-climate related factors.
5) The combination of the right social infrastructure (network), stakeholders, and participatory processes and tools can lead to greater levels of engagement and buy-in among players at the table.
6) Engagement activities have to work within a specific socio-cultural context if they are to succeed. This includes recognizing values, beliefs, identities, goals, and social networks.

Kass, G. S., Shaw, R. F., Tew, T., & Macdonald, D. W. (2011). Securing the future of the natural environment: using scenarios to anticipate challenges to biodiversity, landscapes and public engagement with nature. Journal of Applied Ecology, 48(6), 1518-1526.

This study reviews the importance and utility of using scenario planning at local scales to improve conservation efforts. In most scenario planning, values and attitudes of relevant stakeholders are rarely included in scenario planning exercises. To address this deficit, the authors use the "ethnographic futures framework" and "three horizons approach" to identify how future changes will be influenced by and experienced by humans and to highlight how ideas become more or less dominant in society over time.

- *An ethnographic futures framework* focuses on the "point of impact" of future changes, rather than on the causes or origins of change. It incorporates five dimensions of change: asking how people will define themselves; how people will relate to each other and the world; how media and technology will be used to connect people; how goods and services will be created; and how people will use and dispose of resources.
- *The three horizons approach* helps people identify the current prevailing system (1st horizon), currently unrealistic system structures that society is moving towards (3rd horizon), and the space through which the change from 1st to 3rd horizons may occur (2nd horizon).

Research suggests that these approaches can help people identify how possible future states of the world are determined by societal decisions, not solely by external changes in the environment such as those imposed by climate change.

Key Takeaways:

1) One challenge in future visioning and/or scenarios engagement processes is balancing the need for local relevance (particularly to engage local decision-makers) with providing a more large-scale, global context for thinking about the future, particularly with respect to climate change.
2) The ethnographic futures framework can help focus attention on the role of human decision-making and agency in unique ways, leading to deeper engagement and thinking around how changes in the social and physical worlds will actually come about.
3) The use of the three horizons approach similarly pushes stakeholders to envision and create scenarios that truly reflect paradigm shifts in societal values and functions; this can lead to more robust, diverse scenarios rather than incremental visions of a future world that looks essentially the same as today.

Salter, J., Robinson, J., & Wiek, A. (2010). Participatory methods of integrated assessment—a review. Wiley Interdisciplinary Reviews: Climate Change, 1(5), 697-717.

The authors review the small but growing field of Participatory Integrated Assessment (PIA), which suggests that decision-making is improved by direct involvement of stakeholders in assessment processes. One major advantage over traditional IA approaches to informing complex decisions is that PIA can encompass societal values and norms, culture and institutions.

The three key dimensions of PIA efforts include methods, the participation model, and outcomes. Methods refer to techniques (qualitative or quantitative) for generating results to be considered such as scenarios and models. Participation refers to mechanisms or processes for engaging stakeholders such as focus groups and workshops. Outcomes refer to ways in which PIA efforts inform decision-making and policy, including the impact of process itself on stakeholders.

Key Takeaways:

1) There are many models for doing PIA, each of which has its own strengthens and weaknesses. More quantitatively informed future scenario use, for example, can restrict creativity and input from stakeholders if initial considerations are overly influenced by experts providing quantitative information. More qualitative methods such as narrative storylines can lead to unrealistic scenarios if not constrained by PIA facilitators. Backcasting—starting from a desired future outcome and working backwards to figure out pathways towards that outcome—has become popular because it allows for creativity while maintaining a firm grip on desired and plausible outcomes.
2) Use of formal computer models also poses challenges and opportunities. There is often a need to mediate between expert-based models and other stakeholders through participatory model building which can include a) system dynamics models built collaboratively by experts and stakeholders, b) a facilitated model that experts use to explain phenomena, or c) interface-driven model designs which involve the use of game-formats and simplified models that can be run in real-time.
3) The participation of stakeholders can occur at multiple stages in the information-building and decision-making process. These include defining the problem; designing research strategies; creating results; and applying results to decisions.
4) To date, PIAs have tended not to influence policy decisions but instead are used to inform the research process and provide inputs to decision-making in the form of reports and other outcomes. Process-related outcomes, including social learning and trust building, are also important outcomes of PIAs.
5) The importance of interactivity is highly relevant to PIAs, emphasizing the need to move from transmission models of communication to co-development of knowledge.

Sheppard, S.R.J…Cohen, S. (2011). Future visioning of local climate change: A framework for community engagement and planning with scenarios and visualization. Futures, 43(4), 400-412.

This paper describes the Local Climate Change Visioning (LCCV) project conducted in British Columbia as well as a broader framework for generating holistic, coherent localized climate scenarios and visualizations in collaboration with local stakeholders and scientists. Participatory processes are necessary for various reasons. The availability of scientific data is often too complex for decision-makers to use; most information is biophysical, with little focus on socio-economic scenarios; information is often not salient for local users; and there are often few structured processes for community outreach related to climate change. In order to overcome these barriers, expert organizations need to invest in improved public awareness and opportunities for community level involvement in climate change solutions. This requires an engaging, accessible process; understandable information; locally salient information; and affective engagement that is personally relevant and motivating.

The Local Climate Change Visioning (LCCV) project incorporates these components via what they call "scenario cube" and "participatory visioning" processes, which both integrate advanced visualization tools.

- The scenario cube provides a working space for scenario development delineated by time, emissions, impacts, and response scenarios, which include low vs. high mitigation efforts, and landscape type case studies.

- Participatory visioning integrates existing local climate knowledge and engages scientists, local experts and community stakeholder perspectives via working groups and workshops. It can include simple 2-D photographs (showing current or possible future conditions), 3-D images and 4-D images across time. Images are then shown in public settings.

Key Takeaways:

1) Evidence suggests that advanced visioning activities maintain high levels of public engagement, boosting awareness of climate impacts, types of response options available, and feelings of efficacy.
2) Visioning based on wide-ranging, localized scenario building exercises can lend credibility in public communication settings, allowing people to connect climate change to their own life experiences.
3) A key goal should be to bring climate information down to the local level and engage local stakeholders in the process. Holistic scenarios should be used that combine multiple problem aspects including a focus on impacts and responses, and adaptation and mitigation strategies.

Introne, J., Laubacher, R, Olson, G., Malone, T. (2011). The Climate CoLab: Large scale model-based collaborative planning. International Conference on Collaboration Technologies and Systems, 10.1109/CTS.2011.5928663

Climate CoLab (CCL) is a web-based platform developed by researchers at MIT that provides users an opportunity to share and co-develop ideas to combat climate change. The system allows users to interact with others through online debates and project voting as well as to use model-based planning to explore possible projects. CCL is one among numerous examples of a new wave of open-, crowd-sourced approaches to solving large-scale problems maladapted to resolution through traditional forms of political and policy action. Climate CoLab, Wikipedia, Linux and other such social-computational systems can be thought of as “collective intelligence” systems, as they tap into the vast intellectual resources available in large communities of engaged participants.

To keep engagement in the system high (a factor necessary for success), three challenges need to be overcome. First, community members need a way to predict what will happen in the future as a result of ideas proposed by others in the community. CCL provides community members with computer-based modeling tools they can readily use to make predictions about the future impacts of solutions proposed by the community. Second, the system needs to encourage respectful dialogue among members who may disagree strongly with one another. CCL provides moderated debate opportunities via argument mapping tools to provide this communication capability. Third, community members need a way to keep track of the most promising ideas amongst many (possibly thousands) of competing proposals. CCL achieves this through a member-driven voting and rating system.

CCL uses a hybrid expert-moderator-user approach to maintain quality and coherence on the platform. Moderators are volunteers who monitor the site, facilitate community interaction, delete spam, and "prune" comments to reduce repetition and fracturing across the many proposals and ideas being floated. Experts are also included to provide advice on the structuring of debates and review specific content.

Key Takeaway:

1) CCL is a useful prototype and model for developing web-based platforms that enable discussion, learning, co-production of knowledge, and collaboration specific to climate change and other science-related issues.

ENERGY TECHNOLOGIES AND GEOENGINEERING

Wiersma, B., & Devine-Wright, P. (2014). Public engagement with offshore renewable energy: a critical review. Wiley Interdisciplinary Reviews: Climate Change, 5(4), 493-507.

There is often a gap found between nationally-measured support for offshore renewable energy technologies such as tidal power and offshore wind, and local support for specific projects. This gap is only partially explained by NIMBY factors. Case study approaches have identified several factors as important in explaining opposition to local siting of offshore projects, including: visual impacts, ecological impacts, noise concerns, wider anti-wind sentiments, anti-developer sentiments, and lack of procedural fairness. This research finds that support is generally related to perceived economic benefits, attracting tourists, enhanced energy security, and climate change mitigation.

Survey studies show strong national-level support, differing across socio-demographic variables. Women, younger adults, and higher income individuals tend to be more supportive. Concerns over justice including siting decisions and noise; perceived process-related fairness may also be an important predictor of support. Contrary to expectations, worry over the impact of offshore wind on the visual aesthetics of a shoreline does not appear to be a consistent predictor of opposition. Instead, concerns related to development impacts such as those on wildlife are important, particularly for certain affected subgroups such as fishermen.

Social interaction, negotiation, and arguments among stakeholders are all important drivers of support and opposition. Some studies have found that fishermen tend to feel stigmatized and stereotyped in consultations over offshore renewables projects, contributing to acrimony. Developers' and regulators' perceptions of the public influence their engagement activities, which in turn can influence public perceptions. In this case, these actors tend to assume that the public is generally supportive. These actors also often believe that communicating the benefits of the projects to local stakeholders is all that is needed to increase public support.

Key Takeaways:

1) Marine spatial planning processes, which are analogous to onshore land planning efforts for offshore regions (e.g., management of marine areas over time by multiple agencies), are one route to involving local stakeholders, but almost no work has been done to assess these types of strategies. In this case, it is important to keep in mind that participatory planning processes have shortcomings, including the potential for key stakeholders to dominate decision-making and the uncertainty around the prioritization of environmental and other objectives.
2) Public understanding of offshore renewable energy technologies is wide-ranging and often poor. It is important to gauge public support in project-specific and context-specific ways. The visibility of projects is not always a negative predictor of support; it depends on the type of project and the prior experiences of the local stakeholders.

Pidgeon, N., Demski, C., Butler, C., Parkhill, K., & Spence, A. (2014). Creating a national citizen engagement process for energy policy. Proceedings of the National Academy of Sciences, 111(Supplement 4), 13606-13613.

The authors review a mixed-methods project conducted in the U.K. to encourage deeper public engagement with national-level policy change and planning on energy-related issues. National-level engagement processes involve all of the challenges present in more familiar local-scale activities, but also have special needs and present special opportunities. In addition to local factors, national-level citizen engagement activities also need to consider national policy drivers for change, large-scale alternatives, and wider systems-related concepts and issues.

Engaging citizens with large-scale topics like climate change or disposal of radioactive waste is particularly challenging for science communicators in part due to the public's lack of direct experience with these issues. National level deliberative processes can be helpful in this respect, though engaging more than a handful of individuals via intensive workshops is expensive and time-consuming. National-level deliberation faces several key challenges:

- Citizens need an appreciation of the nature and scale of the systems being discussed as well as a sense of how much latitude for change exists.
- Sufficient information needs to be provided to allow people to grasp complex social and technical issues, without being overwhelmed.
- It is often difficult to maintain open dialogue and space for diverse publics.
- Methods are often needed to facilitate complex negotiations and new contingencies that crop up. Participants also need an appreciation of the nature and scale of the systems at hand, and the degrees of freedom available for change.

Open approaches to deliberation maintain uncertainties and encourage open-minded exploration of possibilities. Closed approaches try to help constrain and contain what can be sprawling, complex issues, to keep people considering options that are relevant. Either approach can be appropriate, based on the context.

Mixed-methods approaches can be productive in this respect, combining insights from expert interviews, in-depth workshops or focus groups, and more representative surveys. In their study, the authors used all of these approaches, as well as interactive scenario planning tools such as visualizations and models to elicit a robust picture of expert and public perceptions of national-level energy system change in the U.K.. In-person workshops used both model-based scenario tools and scenario narratives, and the same scenario planning tool was also used in the nationally representative surveys, making the surveys somewhat more interactive than a traditional poll of public opinion.

Key Takeaways:

1) A transition from traditional one-way forms of science communication and public engagement to more dialogue-based approaches can lead to decisions that are more reflective of diverse societal concerns.
2) People draw on shared cultural narratives regarding the relationships between science and society when engaging in participatory, science-based activities; they focus less on the science or technology and more on the societal implications and context for the issue.
3) Providing tailored information is usually insufficient to develop deep engagement. Instead, citizens need the right exercises and opportunities to use information in ways that are meaningful for them and for the issues being considered.

Buhr, K., & Wibeck, V. (2014). Communication approaches for carbon capture and storage: Underlying assumptions of limited versus extensive public engagement. Energy Research & Social Science, 3, 5-12.

The authors explore assumptions underlying more and less participatory approaches to communicating about emerging technology, using carbon capture and storage (CCS) as a case study. They identify different underlying assumptions regarding the social framing of CCS, public interest in the issue, and the importance of considering public opinion as a function of either a transmission or participatory communication process. Most communications-related work on CCS to date has used traditional, transmission-oriented approaches.

Many studies of CCS communication have focused on “outputs" such as public values, attitudes, beliefs, etc. Few studies focus on “inputs,” including organizations doing CCS communication. Work on more participatory CCS communication highlights the importance of proactive public engagement, beginning as early in the process as possible. Early input is ideal for multiple reasons: 1) doing so can meet ethical and legal requirements for public input; 2) increasing public support; 3) citizens may have useful input to provide. However, early CCS engagement could also lead to unnecessary alarm, if the issue is not usefully framed.

Transmission communication is a “from-to” process, rather than a “between” process of communication. It assumes that facts speak for themselves (once properly framed), and that all people will interpret received messages in the same way. It treats the public as passive recipients of information. It is a simple process and, if the messenger is trusted, can be seen as legitimate. But the approach also ignores the relationship between sender and receiver, ignores the context within which communication occurs, and can lead to misunderstanding.

Participatory approaches to communication assume a “between” process in which communication is an iterative back-and-forth process between different individuals or organizations. It assumes that there is more than one “correct” way to talk about and understand an issue. Receivers are active participants influencing what is discussed and are therefore are co-producers of knowledge. Advantages of this approach include the potential for greater perceived transparency and legitimacy, as well as enhanced buy-in of new technologies and social learning. Disadvantages include giving up control over the “message,” logistical challenges of involving many different stakeholders, and the potential to cause delays in technology development or implementation.

Key Takeaways:

1) There is no “right” approach to public engagement and communication with respect to emerging technologies and issues. Each approach has pros and cons and is suited to specific goals. If one aim is to increase the number and diversity of perspectives available when examining an issue or technology, more participatory models of communication are likely to be more successful.
2) Participatory approaches can be less productive than hoped for if care isn’t taken to consider who actually “comes to the table.” A participatory model that excludes certain voices or interest groups will not produce the full range of perspectives and ideas available for a given issue.

Longstaff, H., & Secko, D. M. (2014). Assessing the quality of a deliberative democracy mini-public event about advanced biofuel production and development in Canada. Public Understanding of Science, 0963662514545014.

The evaluation of deliberative democracy engagement activities is critical yet often not adequately performed. In this paper the authors assess evaluation criteria laid out in the 2008 NRC report on "Public Participation in Environmental Assessment and Decision Making" in the context of a 4-day deliberative democracy event on the topic of advanced biofuels, held in Canada to examine citizens’ views on advanced linocelluose biofuels. Based on the NRC report, the authors identify three core results that they track using pre- and post-event surveys:

- *Quality of assessments or decisions*: e.g., participant concerns are addressed; conclusions were based on and consistent with the best available evidence; innovative ideas were generated for solving problems.

- *Legitimacy of process and decisions*: e.g., pre-existing conflict was reduced or dissent clearly acknowledged and dealt with; mistrust among participants, including government agencies, was reduced.
- *Capacity for future decisions*: e.g., public participants became better informed about relevant environmental, scientific, social and other issues; participants gained skill in participatory decision-making.

Assessment of citizen engagement was achieved through the pre-post survey and small group discussions during the event itself. In-person activities included brainstorming lists of concerns, benefits, trade-offs, and consequences of the new technology.

Key Takeaways:

1) Integrating assessment processes into public engagement activities is critical for various reasons, including for building legitimacy and supporting the development of best practices for future efforts.
2) Providing evidence that engagement activities and strategies are in fact working to engage the public requires an understanding and definition of what "effective engagement" actually looks like. The NRC report provides one set of criteria that can be turned into assessment tools for determining the quality, legitimacy, and capacity building effects of public engagement activities on participations.

Corner, A., Pidgeon, N., & Parkhill, K. (2012). Perceptions of geoengineering: public attitudes, stakeholder perspectives, and the challenge of 'upstream' engagement. Wiley Interdisciplinary Reviews: Climate Change, 3(5), 451-466.

The authors review existing studies on public perceptions and stakeholder engagement with geoengineering as a general concept and as a portfolio of possible technologies. Despite the challenges involved in engaging citizens with technologies that are still quite early in their development, the authors suggest that eliciting public and stakeholder perspectives is critical to understanding societal debate about these emerging technologies. In part this is because future acceptability and development of geoengineering is at least as likely to be driven by social, legal, and political factors as it is by technical and scientific ones. The authors review three key, widely used approaches to eliciting public attitudes towards emerging technologies that have and can be applied to geoengineering, emphasizing their relative advantages and trade-offs:

- Surveys allow a high level of control over the 'terms of debate' and the questions asked, but involve only superficial engagement with participants.
- In-depth interviews allow for closer probing of perspectives, but involve much smaller numbers of subjects, and are limited in terms of generalizability.
- Experiments allow testing of specific hypotheses about engagement, the evaluation of processes that shape perceptions and decisions, and can be qualitative or quantitative, but can also be limited in terms of generalizability.

Key Takeaways:

1) As measured in surveys and interviews, public knowledge and awareness of geoengineering technologies are generally low, in the U.S. and abroad (though likely higher now than in 2012 when the paper was published).
2) Carbon Dioxide Removal approaches tend to have stronger support than Solar Radiation Management approaches.
3) Participatory engagement activities to date around geoengineering are limited but reveal concerns about transparency and commercial interests as well as unease with intentional changes to the earth's climate system. Public acceptability is related to perceptions of particular technologies as more "natural" (as opposed to artificial or clearly human-made) as well as perceptions of who is responsible for taking action (e.g., individuals vs. governments).
4) Participatory engagement activities still suffer from the same challenges involved in surveys. Specifically, how information is presented and framed influences how people engage with the issue. For example, unintentionally referring to some technologies as acting in ways akin to natural processes biases people's favorability.
5) Examples of "upstream engagement" while different geoengineering techniques are still in development focus primarily on direct public engagement such as citizens' juries, scenario analysis with stakeholders, decision analytic techniques, and multi-stage methods.
6) These efforts at "upstream engagement" should not try to convince people of the acceptability of a technology or attempt to shut down dialogue. There are normative, substantive, and instrumental reasons for wanting to engage people openly.
7) Deliberative public participation and engagement activities must be embedded within meaningful evaluation processes and other structures that will allow for transfer of learning to powerful decision-makers.
8) More is known about specific stakeholder perspectives of geoengineering. Scientists are split on the topic, some supportive and others more cautious. Economists are also diverse in their opinions.

III. DIALOGUE-BASED AND UNIVERSITY-LED COOPERATIVE ENGAGEMENT

CITIZEN SCIENCE INITIATIVES

Shirk, J. L., Ballard, H. L., Wilderman, C. C., Phillips, T., Wiggins, A., Jordan, R., ... & Bonney, R. (2012). Public participation in scientific research: a framework for deliberate design. Ecology and Society, 17(2), 29.

The authors review a growing literature on and case studies about public participation in science and research, highlighting three predominant models of participation and key factors that influence project outcomes. Such projects have multiple potential positive outcomes, including development of new scientific knowledge, greater political participation by citizen scientists, and improved trust between the scientific community and the broader citizenry. Public Participation in Scientific Research (PPSR) efforts generally aim for outcomes of three types specific to research, individual participants, and social-ecological systems. PPSR is defined as "intentional collaborations in which members of the public engage in the process of research to generate new science-based knowledge."

The authors propose a framework to inform project design to maximize positive outcomes. The framework is based on quality of participation and management of interests addressed through a project. The degree to which the public participates in the research process and the quality of that participation are key determinants of project outcomes and which goals are achieved. The degree of participation can be measured multiple ways, including the duration of engagement, research effort, number of individuals involved, the diversity of participants, and the degree of power over the process. The authors note that citizens do not always need or want a high level of power; such feelings are dependent on the context of the project. Quality refers to other, often more subjective effects or outcomes, such as trust, fairness, responsiveness, and agency -- or the degree to which the projects align with and supports the needs of public participants. The authors discuss five models of PPSR projects which include:

- *Contractual:* communities ask researchers to conduct a specific project.
- *Contributory:* scientists design and the public contribute data.
- *Collaborative:* the project is designed by scientists, and the public contributes data and refines project, analyzes data, disseminates findings.
- *Co-created:* The project is jointly designed by experts and the public.
- *Collegial:* Non-experts conduct research independently with varying degrees of recognition by professionals.

The authors' PPSR framework highlights five key considerations:

- *Inputs* (e.g., desired objectives, goals, expectations) into activities should be collaborative in the sense that both the public and scientists are contributing during project design, thus shaping the direction of any subsequent collaboration.
- *Activities* (e.g., developing infrastructure, protocols, training materials, data entry technologies) involve the core bulk of the work required to design, establish, and manage all aspects of a project. These are usually conducted be a lead team, which may include scientists, members of the public, and others. Activities relate to the development of the structure that guides a project, rather than specific steps in the research process.
- *Outputs* (e.g., observations and experiences from/of participants) represent the initial products or results of project activities; these are both the data produced by a project as well as participant-related outputs, such as the number of volunteer hours worked or website visits.
- *Outcomes* (e.g., skills developed, knowledge gained) are the measureable elements that result from specific outcomes and occur in three primary categories: outcomes for science (e.g., new scientific knowledge), for individuals (e.g., development of new skills or sense of stewardship or responsibility), and for socio-ecological systems (e.g., improved relationships between communities and management systems). Outcomes are generally short-term impacts of PPSR projects.

- *Impacts* (e.g., empowered citizenry, resilient human and natural systems) are the long-term, sustained changes in conservation, resilience, and/or sustainability (if considering PPSR projects in the ecological realm) that support human well-being and/or conservation of natural resources and systems. Whereas outcomes are measured in the few months or years following a program, impacts are much longer term (decades after projects finish).

Key Takeaways:

1. Clear objectives and strong project design are at least as important for outcomes as the specific activities that participants engage in. Generating high quality data is not always a key concern, especially for improving public engagement outcomes such as participation in political processes.
2. Project design should start with a clear analysis of ultimate aims—what will a successful project produce? Ideal level of public engagement depends on goals of the participants. Need to consider whether a given degree of participation will achieve desired goals and if stakeholders have the capacity and interest in participating at that level.

Dickinson, J. L., Shirk, J., Bonter, D., Bonney, R., Crain, R. L., Martin, J., ... & Purcell, K. (2012). The current state of citizen science as a tool for ecological research and public engagement. Frontiers in Ecology and the Environment, 10(6), 291-297.

Authors suggest defining citizen science and the resulting data it can produce as public goods generated through collaborative tools and research that bring together diverse communities. Advances in information technology—from the ubiquity of smartphones to GIS-enabled web platforms—have vastly expanded the potential for large-scale citizen science initiatives to make meaningful contributions both to society and science. Citizen science projects, regardless of whether they are relatively more or less collaborative between scientists and citizens, engage affected populations from the very start, thus enhancing engagement and legitimacy. Citizen science provides a number of particular advantages for ecologists and the study of earth processes:

- Citizen science provides the ability to study landscape-scale change in real time and across large geographic spaces. Marshaling many volunteers to collect data is especially important with respect to measuring living organisms such as birds or specific mammals that don't otherwise lend themselves to remote sensing techniques.
- Citizen science provides a framework for studying coupled human and natural systems, because its data collectors are themselves embedded in those systems. These community-based projects can build and support local scientific capacity, social capital, and improved local decision-making by participants.

Yet deeper engagement, especially for large-scale contributory citizen science projects, is unlikely to occur on its own, without specific design decisions made to encourage such engagement. This entails more localized, direct contact with participants (e.g., workshops and trainings, field trips) in addition to web- or telephone-based data collection methods.

Key Takeaways:

1) Citizen science projects are a form of guided public participation and engagement in the scientific process; in this way, they both engage the public in the production of science and, at least in some cases, provide citizens with opportunities to shape the research agenda of the scientific community.
2) Combing research and public education allows for authentic and novel ways to engage members of the public in large ecological, technical, and societal issues.
3) Emerging information science technologies and software, including advanced handheld devices, easy-to-use graphical user interfaces and web-based data management systems, have allowed citizen science to grow both in scope and quality over the past two decades.
4) Prioritizing citizen science projects remains a challenge, especially from a funding perspective, as data quality issues (either real or perceived) and other barriers continue to limit full integration of citizen science into mainstream production of scientific knowledge.
5) Making citizen science projects "easy, fun and social" is a useful starting point, but targeting projects to particular audiences is especially important for smaller-scale but more intensive or longer-term projects. Building the capacity for social interaction is critical for maintaining volunteer engagement over time.

SCIENCE CAFÉS AND FESTIVALS

Jensen, E., & Buckley, N. (2014). Why people attend science festivals: Interests, motivations and self-reported benefits of public engagement with research. Public Understanding of Science, 23(5), 557-573.

The authors examined the impacts of attending science festivals on participants. Mixed methods research finds that development of interest in and curiosity about new scientific issues is a major self-reported impact of attendance. Attendees also appreciate the opportunities afforded by science festivals to interact with researchers as well as to engage with science in novel ways. Science festivals serve as one conduit for relatively informal interaction between scientists, researchers, and members of the general public, building relationships and mutual understanding and appreciation. Science festivals are a relatively new phenomenon (though their origins go back to the 19th century) but appear to be rapidly growing, at least in the U.K. and Europe. Festivals generally bring together temporary exhibits, museum type activities, scientists, art organizations, students, and members of the general public and attract upwards of 5,000-50,000 visitors. Festivals are transient and evolve from event to event.

They review Irwin's (2008) taxonomy of first, second, and third order science engagement. First order aims to promote science learning, awareness, and interest among the public (participants learn from scientists, but not other way around). Second order aims for two-way dialogue and exchange of perspectives between scientists and public. Third order aims to connect sciences with wider societal context and needs; this is a pluralistic framework in which all stakeholders engage in reflexive informed discussion and debate about how science can inform and support a flourishing society. Most science festivals are first order, sometimes second order, and infrequently third order.

Key Takeaways:

1) Science festivals are a somewhat unique venue for engaging the public in issues of science and society. Their transience is both an advantage (encouraging people to really participate heavily, invest a lot of time in a short time period) and a disadvantage (less likely to encourage long term engagement and community building, as participants go back to their own worlds after the event ends).
2) Festivals often require significant effort by volunteers (scientists, event organizers, etc.) to be pulled off, often on small budgets. One result is that festivals are often free for the public, encouraging participation by a diverse audience.
3) Because events/offerings at festivals are often extremely diverse and decentralized, and attendees self-select into particular experiences, measuring impacts on public engagement can therefore be extremely challenging for researchers.
4) Being large events, science festivals can create “buzz” that excites the public in a way that more traditional science communication media don’t.
5) The opportunity for informal interaction with a scientist is a major selling point for these sorts of events.
6) Often members of the public are looking for a first order engagement event—they don’t necessarily need or want to be more involved in co-production of knowledge or events, but rather want to be informed, enthused, and educated; communicators should recognize these as legitimate motivations and outcomes.

Navid, E. L., & Einsiedel, E. F. (2012). Synthetic biology in the Science Café: what have we learned about public engagement?. Journal of Science Communication, 11, 4.

The authors discuss the use of science cafés as upstream public engagement platforms to examine emerging scientific and technological issues. They discuss a case study in which they conducted five science cafés in Canada on the topic of synthetic biology. Science cafés are live forum events that “host conversations between scientists and the public about current science topics.” They are generally small in size (ranging from a couple of dozen to 100 participants), taking place in cafés, restaurants, bookstores, or similar venues, and they are open to everyone regardless of scientific knowledge or training. They are informal events that provide an opportunity to engage citizens who otherwise might not participate in societal discussions surrounding emerging technologies or issues. A typical science café is approximately 90 minutes long and involves both expert speakers (e.g., scientists) and a moderator. Usually speakers give short presentations without visual aids, aiding connection with the audience. Little is known about participants’ experiences during science cafés, hence the purpose of this initial case study. They gave post-event surveys to participants at five synthetic biology science cafés around Canada, asking about:

- Level of participation
- Previous knowledge
- Responses to the expert presentations
- Views of the technology
- Comments on the technology
- Comments on the event format

Participants were diverse, including students, educators, non-profit workers, and government agency employees. Learning about the technology was the primary motivation for attending the cafés for most people. By and large, participants enjoyed the presentations and they were both excited about the technology and concerned about possible risks. All participants were extremely positive about the format of the events and their willingness to encourage others to participate in future science cafés.

Key Takeaways

1) Although small in terms of the number of citizens that can be engaged at any one time, science cafés appear to provide an intimate, informal venue for citizen engagement in emerging technological and scientific issues. Participants appreciate the small size, informality, accessibility of experts, and relaxed atmosphere.
2) Science cafés are inexpensive to hold, though they rely on time volunteered by local experts. Because they rely on local experts, they may not be ideal for engaging very diverse groups of citizens.

COOPERATIVE EXTENSION AND STAKEHOLDER ENGAGEMENT

Diehl, C., et al. Toward Engagement in Climate Training: Findings from Interviews with Agricultural Extension Professionals. Journal of Rural Social Sciences 30.1 (2015): 25-50.

The authors use in-depth interviews to explore the climate change perceptions of agricultural extension agents and related professionals and their beliefs about climate communication and training. Extension specialists can play an important role in engaging farmers with climate change, providing expert information as well as serving as conduits for farmers to do their own learning and adaptation. Adaptation strategies available to farmers are diverse, from sod-based rotation methods to using online decision support tools such as AgroClimate. Adaptation decisions are affected by many factors, including current production systems, resource management strategies, geographic location, and economic, social, and cultural characteristics of rural communities. Traditional extension services were one-directional; new approaches are interactive, providing learning for all involved. Many extension professionals lack formal climate training, making it difficult for them to increase climate literacy among farmers; many agricultural extension agents are also skeptical of climate change.

Key Takeaways:

1) Climate-related meetings, trainings, and workshops provide information but also build confidence among extension agents in terms of their ability to translate information for use by farmers.
2) Challenges for engaging stakeholders via the extension system include dispersion of audiences across large areas, competing time demands for extension professionals, and travel expenses.
3) Greater flexibility is needed in terms of integrating training and events into larger meetings; other opportunities for face-to-face interaction can increase engagement and opportunities to reach target audiences, even if settings are less focused on climate.
4) Building trust among all players is critical. With politicized issues like climate change as the backdrop, this requires starting with focused discussions of immediate implications of climate variability on farmer decision-making, only slowly and over time building up to the larger issue of anthropogenic climate change and its longer-term implications.

Wilke, A. K., & Morton, L. W. (2015). Climatologists' Communication of Climate Science to the Agricultural Sector. Science Communication, 1075547015581927.

The authors suggest that climatologists are well-positioned to help farmers (and other sectors) adapt to climate change by providing a bridge between science and practice. Little work has been done examining how climatologists see themselves as climate communicators, however. They present a simplification of Fischoff's (1995) seven-step model of uncertainty communication, which they collapse to three stages: communicating facts, communicating relevance, and building engagement. When communicating for engagement, the authors suggest that building trust with audiences is critical, as is actively participating in activities with audiences; encouraging data collection and input by stakeholders can also help.

The authors investigate how climatologists in the north central region of the U.S. currently communicate climate information to farmers and how they perceive the effectiveness of their current practices. Climatologists reported that connecting scientific research related to weather and climate to various publics was a key component of their work. They also perceived the public as generally unaware of their (climatologists') roles and expertise. Some also see themselves as public servants and the public as constituents. Some have a traditional view of themselves as only being able to communicate "the facts," letting decision-makers do what they will with the data, although others see communicating relevance as critical, too.

Key Takeaways:

1) State climatologists play a unique role in the communication of climate science for on-the-ground users (e.g., farmers), as they are trained scientists who can translate complex climate information into more relevant and useable forms for end users.
2) Distancing their communication efforts from political agendas is critical for building and maintaining trust and legitimacy with end users of climate information, though this can be challenging in a highly politicized science communication arena.

3) Presenting climate science and climate as ever evolving and changing is perceived as an important component of climatologists' jobs when communicating with the public.

Furman, C., Roncoli, C., Bartels, W., Boudreau, M., Crockett, H., Gray, H., & Hoogenboom, G. (2014). Social justice in climate services: Engaging African American farmers in the American South. Climate Risk Management, 2, 11-25.

The authors report on multi-method research evaluating and supporting more inclusive provision of climate services to African American farmers in the southeastern U.S. They argue that the shift from 'loading-dock' to 'co-production' models of science, while useful, has not necessarily been equitable in its development or diffusion. The question of which users are engaged is an ongoing challenge. Extant work that considers equity has focused on women and developing nation stakeholders; race has been largely ignored, yet it powerfully shapes individuals' and communities' experiences with climate change and climate science. Moreover, poor, conflicting histories between African American farmers and climate service providers including extension agents and universities undermine trust and legitimacy, making it difficult to engage productively. In addition, accessibility to climate and extension services is considerably lower for African American farmers than for other groups, in part due to limited internet availability.

Research activities included surveys conducted by phone, in-person interviews, and a workshop in which farmers' experiences with past climate variability was elicited and formed the basis of discussion around which climate information can be useful to support adaptive management practices. Farmers had experience with climate extremes, including the 2007-2009 drought in the southeast U.S. There was desire among farmers to move from coping strategies to more proactive adaptation and planning activities. Extension and Internet sources were infrequently used for climate and weather information, however. Significant proportions use the Farmers' Almanac as a source of information for crop planning or for maintaining ties to older generations and traditions. At workshops, experienced farmers were better able to translate climate forecasts into farming strategies.

Key Takeaways:

1) Sociocultural context shapes how climate information is accessed, processed, and integrated into decision-making. Historical influences shape resource and technology availability and meaning-making that shapes perceptions of credibility, legitimacy, trust, and importance of climate information.
2) In difficult-to-reach communities (either due to geographic distribution, lack of internet access or historical and sociocultural reasons), farmer-to-farmer communication and existing social networks may be key for diffusing climate science and climate services.
3) Interpersonal communication and social interaction will be key in moving climate services into use in these communities, as well as moving information and resources through local, trusted organizations rather than traditional pathways. This requires understanding the landscape of relevant organizations and developing relationships over time with various groups.

4) Experiential learning is an important source of knowledge for farmers, and it should not be ignored by outside experts and communicators.
5) It is critical to consider historical interactions and injustices when developing programs to engage with various publics and stakeholders, as well-developed programs in terms of translating science may still fail due to lack of trust, legitimacy, etc.

Chambliss, E. L., & Lewenstein, B. V. (2012). Establishing a climate change information source addressing local aspects of a global issue. A case study in New York State. Journal of Science Communication, 11, 3.

The authors describe the development of a climate change information system for New York State, examining sectors likely to be impacted by climate change such as water-based tourism and agriculture. Because the U.S. lacks a top-down science communication structure, climate communication occurs among many different state and local agencies, corporations, non-profit organizations, universities, and others. The history in the U.S. of decentralized government and antipathy towards federal government-led education-related initiatives prevents coordinated response to climate communication needs and requires university-led or coordinated state and regionally-focused initiatives.

The case study focuses on a Program Work Team (PWT) formed through partnership with the state's extension program, aimed at improving climate change communication by building a team of invested stakeholders from many different sectors. This is a hybrid bottom-up, top-down model that tries to avoid boomerang effects and other negative outcomes associated with traditional science communication by developing and using appropriate framing techniques. These include storytelling, narrative, focusing on economic development, adaptation, and locally relevant information.

PWT members include: university faculty, extension staff, city officials, the New York State Department of Environmental Conservation, the New York State Department of Agriculture & Markets, stakeholder organizations such as the American Farmland Trust, farmers, landowners, and non-profit organizations such as The Nature Conservancy. The delivery of information occurred via a website, regional conferences and meetings, trade shows, webinars, fact sheets, and a university extension office. Materials focused on: economic development, safe and secure energy systems, health care, morality, and energy conservation.

Key Takeaways:

1) Local needs and knowledge must be an integral part of any successful public engagement efforts around climate change (or any issue); this requires including local stakeholders as partners in materials development from the start.
2) Flexible and diverse but coordinated networks need to be in place to disseminate information to end users as well as to receive input to update and modify efforts.
3) Continual updating and iterative processes for materials development and communication are critical for long-term success.