

Many Experts, Many Audiences: Public Engagement with Science and Informal Science Education

A CAISE Inquiry Group Report

March 2009

Many Experts, Many Audiences: Public Engagement with Science and Informal Science Education

CAISE Public Engagement with Science Inquiry Group Participants

Ellen McCallie*	Director, Center for Advancement of Informal Science Education (CAISE) and PhD candidate, Center for Informal Learning and Schools, King's College London
Larry Bell*	Sr. Vice President, Strategic Initiatives, Museum of Science, Boston (Co-Leader)
Tiffany Lohwater*	Public Engagement Manager, American Association for the Advancement of Science (AAAS) (Co-Leader)
John H. Falk	Sea Grant Professor of Free-Choice Learning and Science Education, Oregon State University
Jane L. Lehr	Co-Director, Theatre Workshop in Science, Technology & Society (TWISTS) and Assistant Professor, Departments of Ethnic Studies and Women's & Gender Studies, California Polytechnic State University
Bruce V. Lewenstein	Professor of Science Communication, Cornell University
Cynthia Needham	President and Co-Founder, ICAN Productions, Ltd.
Ben Wiehe	Outreach Project Director, WGBH Educational Foundation

Center for Advancement of Informal Science Education (CAISE) Washington, D.C. March 2009

*Corresponding authors: Ellen McCallie, emccallie@cox.net; Larry Bell, lbell@mos.org; and Tiffany Lohwater, tlohwater@aaas.org.



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About CAISE

The Center for Advancement of Informal Science Education (CAISE) works to strengthen and connect the informal science education community by catalyzing conversation and collaboration across the entire field—including film and broadcast media, science centers and museums, zoos and aquariums, botanical gardens and nature centers, digital media and gaming, science journalism, and youth, community, and after-school programs. CAISE focuses on improving practice, documenting evidence of impact, and communicating the contributions of informal science education.

Founded in 2007 with support from the National Science Foundation (NSF), CAISE is a partnership among the Association of Science-Technology Centers (ASTC), Oregon State University (OSU), the University of Pittsburgh Center for Learning in Out-of-School Environments (UPCLOSE), and the Visitor Studies Association (VSA). Inverness Research Associates serves as evaluator. CAISE is housed at ASTC's Washington, D.C. offices.

For more information contact:

Center for Advancement of Informal Science Education
1025 Vermont Avenue NW, Suite 500
Washington, DC 20005-6310
202/783-7200
www.caise.insci.org

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Foreword

This report is the result of work over the last year by the CAISE Public Engagement with Science Inquiry Group. We are grateful to all of the members of the group for their contributions and to Larry Bell, Tiffany Lohwater, and Ellen McCallie for serving as lead authors of this report.

CAISE Inquiry Groups help to strengthen and connect the informal science education community by catalyzing conversations across the field around issues and topics of common concern. Using NSF-funded projects, programs, and products as a primary focus of study, Inquiry Groups meet together to examine and discuss an issue or set of questions, gather and analyze evidence from practice and research, and synthesize their findings. They document their work with three audiences in mind: the informal science education (ISE) field as a whole, principal investigators (PIs) and prospective PIs of projects funded by NSF's Informal Science Education (ISE) program, and ISE program officers. Inquiry Groups have multiple uses. Their work products are intended to yield practical knowledge that can be put to work, provide evidence of contributions of ISE, and identify areas where more work and investment are needed.

As the authors note, the discussions that began among the members of the Public Engagement with Science Inquiry Group are intended to inform and spark further study, discussion, and reflection among colleagues from across the field. We look forward to continuing the conversation. To find out about online discussions and conference sessions, visit the CAISE web site (www.aise.insci.org) and subscribe to the CAISE newsletter.

We are grateful to the National Science Foundation for its support of CAISE and informal science education field.

Wendy Pollock
Principal Investigator
Center for Advancement of Informal Science Education
Washington, D.C.

CAISE Public Engagement with Science Inquiry Group Participants

Ellen McCallie served as Director of the Center for Advancement of Informal Science Education (CAISE) through March 2009. She collaborates with scientists, publics, evaluators, and ISE professionals to enhance dialogue, equity, and argumentation in ISE environments. As part of the Center for Informal Learning and Schools (CILS) at King's College London, McCallie's PhD research focuses on argumentation in Public Engagement with Science events in museums. She is Deputy Director of the Carnegie Museum of Natural History in Pittsburgh.

Larry Bell is Senior Vice President for Strategic Initiatives at the Museum of Science in Boston, where he has worked in various exhibit and program roles since 1971. In 2002, he introduced forums that engage visitors in dialogue and deliberation about socio-scientific issues as part of the informal educational program of the museum's National Center for Technological Literacy. Bell also heads the Nanoscale Informal Science Education Network (NISE Net), which works to build partnerships between researchers and museum educators to raise public awareness, understanding, and engagement with nanoscale science, engineering, and technology. As a part of this effort he launched a working group of five museums across the United States that have worked together since 2005 to develop, present, and evaluate forum programs on the societal implications of nanotechnology. Bell served as Co-Leader of the CAISE Public Engagement with Science Inquiry Group.

Tiffany Lohwater is Public Engagement Manager at the American Association for the Advancement of Science (AAAS). Through its Center for Public Engagement with Science and Technology, AAAS provides a vehicle for boosting public awareness and understanding of the nature of science and the work of scientists. It also increases public input into scientific research and policy agendas by encouraging dialogue among policy makers, the general public, and the scientific community. Prior to joining AAAS, Lohwater worked with researchers, educators, and journalists as a public information officer at Johns Hopkins University and Rensselaer Polytechnic Institute. She served as Co-Leader of the CAISE Public Engagement with Science Inquiry Group.

John Falk is Sea Grant Professor of Free-Choice Learning and Science Education at Oregon State University (OSU) and Co-PI of CAISE. For over 35 years he has conducted research on free-choice science learning. He has investigated the ways that organizations involved with science, technology, engineering, and mathematics (STEM) informal education impact the quality and quantity of STEM understanding within and across the communities they serve. He has also studied the varied ways in which learners interact and engage with science across their lifetimes. Prior to joining the faculty at OSU, Falk founded and for 20 years directed the Institute for Learning Innovation, a free-choice learning research and development organization based in Annapolis, Maryland.

Jane L. Lehr is Assistant Professor in the Departments of Ethnic Studies and Women's & Gender Studies at California Polytechnic State University. She is also Founder and Co-Director of the Theatre Workshop in Science, Technology & Society (twists.sts.vt.edu). She received her PhD in Science & Technology Studies from Virginia Polytechnic Institute and State University. In 2005–06, she served as a Post-Doctoral Research Officer in the Center for Informal Learning and Schools (CILS) in the Department of Education and Professional Studies at King's College London.

Bruce V. Lewenstein is Professor of Science Communication at Cornell University. In his own research, he focuses on the history of public communication of science. In addition, he has been an active leader in initiatives connecting researchers and science communicators worldwide through the International Network on Public Communication of Science and Technology and as developer of several international education programs in science communication that were especially focused on the developing world. He was Co-Chair of a National Research Council study, *Learning Science in Informal Environments: People, Places, and Pursuits*, published in 2009. From 1998 to 2003, he was editor of the journal *Public Understanding of Science*. He is Chair-Elect of the AAAS Section on Societal Impacts of Science and Engineering and a member of the CAISE Steering Committee.

Cynthia Needham is President and Co-Founder of ICAN Productions, Ltd. Her most recent project, *Nanotechnology: The Power of Small*, explored a variety of platforms for encouraging public dialogue and deliberation about the ethical, social, and legal aspects of this rapidly emerging and broadly based field of scientific inquiry and technologic innovation. The multi-media project included a three-hour television series broadcast nationally on public television, an interactive web resource, and a series of face-to-face forums in partnership with regionally selected science centers. Needham left a 30-year professional career as an internationally recognized microbiologist to found ICAN.

Ben Wiehe is Outreach Project Director at WGBH Educational Foundation. Among other projects, he encourages and supports the growth of science cafés in the United States for the public television series NOVA scienceNOW. Science cafés are live events that bring the public and a scientist together in casual settings for a conversation about the scientist's work. Wiehe collaborates with scientific research communities, informal education professionals, and the public.

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Ellen McCallie
Larry Bell
Tiffany Lohwater
John H. Falk
Jane L. Lehr
Bruce V. Lewenstein
Cynthia Needham
Ben Wiehe

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Executive Summary

Introduction

Science and technology are embedded in every aspect of modern life. This report describes how Public Engagement with Science (PES), in the context of informal science education (ISE), can provide opportunities for public awareness of and participation in science and technology.

We face profound challenges and choices related to science and technology: *How should we respond to the possibility of catastrophic global climate change? How should the federal government fund stem cell research? Is nanotechnology safe?* To make the most effective and robust choices, we must draw on the best scientific knowledge that is available to us. However, ongoing controversies and uncertainties related to today's big issues—whether viewed locally, nationally, or globally—suggest that responding to these challenges is not simply a matter of utilizing the best scientific knowledge available. Increasingly we are required simultaneously to address complex social and moral questions: *How should limited scientific and technical resources be allocated? In what ways are controversies about science and technology actually conflicts over values, worldviews, and/or visions of the future? How do we make decisions about science and technology in our society? And who decides?*

As individuals, communities, and societies, our understanding of and response to science are shaped by the cultures and contexts in which we live, work, and play. This means that understandings of and responses to science are deeply informed by knowledge and perspectives from non-science domains, such as senses of ethics and morality, visions for society and future generations, and drives to explore and explain the unknown. Therefore, to address complex scientific questions and controversies in a way that fosters responsible and appropriate scientific knowledge production and decision making, we must create opportunities for an exchange of knowledge, ideas, and perspectives that involves the participation of all aspects of society—publics, scientists, and decision makers. This exchange can help create well-informed, empowered publics who are better equipped to contribute to our understanding of the world and to responsible decision making. (Note that the term publics, as opposed to public or the general public, is used frequently in PES to acknowledge the multiple identities and diversity that exist within the concept of the public. In other words, there isn't a single, unified public. Publics include ordinary people who may or may not have backgrounds in science who come in contact with ISE.)

PES is an approach that has developed in the last 10 years within academic settings and the science policy arena. PES refers to seeking public input into policy decisions about the development and application of science and technology in society. The implementation of PES in the science policy arena has helped to develop and articulate new understanding of and expectations for the relationship between science and publics in policy making and other contexts. For example, in the last several years, ISE professionals have begun to explore how the principles of PES as practiced within the science policy arena might be adapted to the practice of ISE.

In response to a request by the National Science Foundation, the Center for Advancement of Informal Science Education (CAISE) established a CAISE PES Inquiry Group to

- assemble and articulate the concepts, issues, tensions, and context of Public Engagement

with Science as it relates to informal science education

- broaden the conversation about Public Engagement with Science to include a larger and more diverse pool of ISE professionals and stakeholders, including funding agencies, the scientific community, and ISE evaluators and researchers, and
- expand the range of current ISE activities by promoting the use and study of Public Engagement with Science in informal science education.

This CAISE Inquiry Group Report seeks to serve as a prompt for discussion and exploration of PES in ISE, as opposed to being an authoritative sourcebook or how-to manual. Our goals in writing this report are to open up the conversation up further, to foster dialogue and interaction across our communities, to intentionally build on one another's work, and to push the boundaries of what PES in ISE could mean as well as to improve its effectiveness and impact. We also contend that there is a great advantage to viewing ISE as a spectrum of activities that spans two programmatic models for involving the public in scientific ideas—one referred to as Public Understanding of Science and the one that is the focus of this paper, Public Engagement with Science.

What Is Public Engagement with Science?

In the ISE field, the term “engagement” is often used to describe the involvement of audiences in learning about science. However, “engagement” as it is used in this report and in Public Engagement with Science literature and practice has a specific meaning that is characterized by *mutual learning* by publics and scientists—and, in some cases, policy makers. This orientation contrasts with a one-way transmission of knowledge from “experts” to publics. Specifically, PES experiences allow people with varied backgrounds and scientific expertise to articulate and contribute their perspectives, ideas, knowledge, and values in response to scientific questions or science-related controversies. PES thus is framed as a multi-directional dialogue among people that allows all the participants to learn. PES activities in the context of informal science education may—but do not necessarily—inform the direction of scientific investigations, institutions, and/or science policy.

It is important to note that we are not advocating funding PES activities at the expense or abandonment of currently successful ISE programs and activities. Rather, this report should introduce people to the strengths of PES and clarify how it fits in with goals of ISE. PES is a useful complement to the current ISE toolbox, and PES goals may be realized in current programs.

ISE generally focuses on increasing overall interest in, involvement in, and knowledge of scientific content and processes. In addition, the goals of PES activities in ISE for individuals or communities often include one or more of the following:

- Mutual learning by publics and by scientists, allowing everyone who participates to develop new or more nuanced understandings of issues and opportunities;
- Empowerment and the development of skills for participating in civic activities;
- Increased awareness of the cultural relevance of science, science as a cultural practice, and science–society interactions; and

- Recognition of the importance of multiple perspectives and domains of knowledge, including scientific understandings, personal and cultural values, and social and ethical concerns, to understanding and decision making related to science and to science and society issues.

The goals of PES experiences align well with the broader goals of formal and informal science education as articulated in two National Research Council reports, *Taking Science to School* (Duschl, Schweingruber, and Shouse, 2007) and *Learning Science in Informal Environments* (Bell, Lewenstein, Shouse, and Feder, 2009). The discussion here is focused in terms of how Public Engagement with Science can contribute to the following informal science education goals:

- Expanding access to science and science education;
- Increasing the relevance of science and science education to people’s lives;
- Improving science literacy;
- Increasing people’s participation in science and society;
- Building relationships with scientists; and
- Providing new models of learning and research.

Public Engagement with Science Mechanisms and Perspectives

PES in ISE takes two general forms, as *mechanisms* and as *perspectives*. *PES mechanisms* are ISE activities or experiences in which mutual learning occurs *as part* of the experience; people from varied backgrounds and perspectives listen, share, and build on what is being presented and learn from one another. Many of these experiences occur in person, for example at live dialogue events or forums, or through mass media channels with call-in, e-mail, or text messaging capacity. PES mechanisms in informal science education contexts can involve a time lag (asynchronous interaction), particularly when they occur through blogs and online forums.

The implications of PES in ISE are potentially profound. The incorporation of PES mechanisms and perspectives into ISE creates the possibility for ISE organizations to operate not only as storehouses and/or disseminators of knowledge, but as facilitators of the production of new knowledge and understanding through dialogue and interaction among publics, scientists, and policy makers. The integration of PES mechanisms and perspectives into ISE positions informal science education as a contributor to broader cultural change, fostering increased awareness of science and a sense of shared responsibility that leads to civic participation in science and decision making. This capacity has the potential to strengthen the presence of ISE organizations as vital participants in our 21st century communities.

An ISE activity or experience using a *PES perspective*, on the other hand, explicitly addresses one or more PES goals but does not facilitate direct interaction between publics and scientists. In practice, this means that ISE activities or experiences using a PES perspective assume that scientific knowledge alone is not sufficient to fully address the topic at hand and that publics, not only the scientists or “experts,” can make useful and valuable contributions to discussions and decisions about science and technology. Public contributions might depend not on scientific knowledge but on knowledge drawn from life

experience and personal and community values. While specific PES mechanisms in ISE are relatively new, some ISE practitioners have been incorporating PES perspectives for many years. For example, in a story on rainforest logging, a science television program may include perspectives from ecologists, farmers, loggers, policy makers, and others, but it does not facilitate direct interaction between these participants and the program's television viewers.

Opportunities for Incorporating Public Engagement with Science into Informal Science Education

The final section of this report addresses particular opportunities for adding PES to ISE. These opportunities are organized into four categories: (1) overall opportunities, (2) opportunities for funding agencies, (3) opportunities for ISE institutions and professionals, and (4) opportunities for scientific institutions and individuals. Four opportunities that apply overall are summarized here:

- Become more familiar with PES, how it aligns with an organization's mission and scope of work, and how it could enhance and push the boundaries of current work. This opportunity also suggests being more intentional about the use of the words *engage* and *engagement*.
- View PES activities as opportunities to expand and diversify the audiences that programs serve, the content areas of activities/portfolios, and the models of learning that are supported.
- Support research and evaluation on impacts, indicators, opportunities, and challenges in PES.
- Create opportunities for internal collaborations among departments, divisions, or directorates as well as external collaborations among institutions.

Part 1: Introduction

Goals and Purpose

The Public Engagement with Science Inquiry Group was convened by the Center for Advancement of Informal Science Education (CAISE) to

- assemble and articulate the concepts, issues, tensions, and context of Public Engagement with Science as it relates to informal science education (ISE)¹
- broaden the conversation about Public Engagement with Science to include a larger and more diverse pool of ISE professionals and stakeholders, including funding agencies, the scientific community, and ISE evaluators and researchers, and
- expand the range of current ISE activities by promoting the use and study of Public Engagement with Science in informal science education.

In large part, this report draws from our experiences as individuals seeking to “do” Public Engagement with Science in informal science education contexts as well as to study PES in ISE. These experiences have led us to believe that PES has much to offer informal science education both in terms of current and new programs. We also argue that there is a great advantage to viewing ISE as a spectrum of models that spans both the Public Understanding of Science and Public Engagement with Science approaches to publics² and science. In addition, it is important to note that (1) because incorporating PES into ISE is relatively new, this report should be considered a prompt for further conversation and exploration of PES in ISE, as opposed to an authoritative sourcebook, and (2) we are not advocating funding PES activities in ISE at the expense or abandonment of currently successful programs and activities.

Questions of Interest and Further Inquiry

The following questions are intended to guide the reader through the key issues relevant to Public Engagement with Science that are explored in this report. We anticipate that these questions may also offer opportunities for further inquiry into PES theory and practice in informal science education.

- What is PES? What does it offer to science education?
- What are the differences in meaning for the terms “engagement” and “public engagement”?
- How does PES relate to ISE? How do PES activities contribute to the ISE field?
- In what ways is it productive to think about a spectrum or continuum between Public Understanding of Science (PUS) and PES? How does PES relate to PUS?

1 A note on terminology: To differentiate our references to the National Science Foundation Informal Science Education Program from our references to the field of informal science education, we have adopted the following convention: The “NSF ISE Program” refers to the former, while “ISE” and “the ISE field” refer to the latter.

2 The term *publics*, as opposed to *public* or *the general public*, is used frequently in PES to acknowledge the multiple identities and diversity that exist within the concept of *the public*. In other words, there isn’t a single, unified public. Publics include ordinary people who may or may not have backgrounds in science who come in contact with ISE.

- What goals are implicit and explicit in PES activities?
- How do PES goals relate to science policy?
- What is a “PES mechanism”? What does it mean to employ a “PES perspective”?
- How does PES relate to “broader impacts” and outreach?
- How does PES fit with informal (free-choice) science learning theory?
- How might PES activities be evaluated?
- What opportunities and challenges does PES present to ISE practitioners, to ISE institutions such as science museums and universities, and to scientific communities?
- Should PES be applied only to topics that are potentially controversial, or to all topics that are relevant to science research and policy decisions?
- What motivates people to participate in PES activities and platforms?
- What are the opportunities and challenges of PES in broadening the reach of ISE to underserved audiences?
- In what ways does PES address adult audiences?
- How might PES be made more relevant to youth audiences?

Target Audiences for this Report

The report is intended for four main audiences:

- 1) ISE funding organizations and agencies that are developing investment strategies with respect to Public Engagement with Science in informal science education.
- 2) ISE professionals and other interested individuals who are new to Public Engagement with Science with respect to informal science education as well as those who are already actively engaged with PES and want to continue to explore, react to, and build on work in the field.
- 3) Scientific institutions that already participate in PES in ISE and individuals who do so as well as those who are interested in learning more about PES perspectives and mechanisms in terms of ISE as possibilities for future work.
- 4) Formal education practitioners and institutions that are interested in incorporating PES approaches into their practices as well as those interested in partnering with ISE practitioners involved with PES.

Part 2: Defining the Domain

Pizza ovens suffuse the dimly lit restaurant with the rich aroma of wood smoke and charred dough. A capacity crowd fills the long booths; strangers introduce themselves and wait staff hurry to fill drink orders.

A quick introduction from the host of the evening quiets down the room some, but it takes a bank of TVs above the bar to really grab everyone's attention. The video, a short clip from the PBS television series NOVA scienceNOW, introduces the subject for the night: genetic testing.

Seated at the bar are nine of the first ten participants in the Personal Genome Project, including the project's leader, George Church. They have all spent the day reviewing an analysis of their DNA sequence with a physician. Each has just agreed to make the information publicly available online, along with photographs, medical histories, ethnic backgrounds, and descriptions of personal characteristics.

The Personal Genome Project (personalgenomes.org) will eventually include 100,000 volunteers in its study. This database will be a treasure trove for researchers, opening up a world of free, widely available data that may lead to important new discoveries.

But is our society ready to usher in the new age of genetic testing? George and the institution he works for take this issue seriously. One of the project's goals is the education of participants and the general public about the risks and potential alternative pathways that genetics can take. The project hopes to discover what individuals, clinicians, and researchers might want, not want, and why.

While still at the bar, the nine participants pass a microphone and quickly describe what motivated them to join the project. Then they hop off their stools and head into the "audience" for face-to-face conversations. Later in the evening, the host of the event temporarily stops the energetic discussion to see if anyone wants to share comments with the room. One of the first hands to go up asks George a new question. "If I volunteer, can you ensure that my information will *always* be publicly available? I don't ever want a company to own a piece of my genetic code."

George laughs in surprise at the question. He's talked about this topic with scientists for years. His primary concern has always been about protecting the project's volunteers. Although their anonymity is protected in many ways, it is difficult to absolutely guarantee it. And once their information is made public there is no turning back. His (and other scientists') assumption was that participants' concerns would revolve around maintaining privacy, not around maintaining widespread access over time. It took a patron at a pizza parlor to articulate this new issue before the project took it into consideration as they mapped out new territory in terms of genetic testing, privacy, and public access.

In order to conceptualize and discuss Public Engagement with Science in informal science education, this section of the report provides background information about the field of informal science education, including

- a definition of *informal science education*
- a description of the various ways in which *engagement* is used in ISE contexts
- descriptions of approaches to understanding the relationship between publics and science in informal science education.

With this background in mind, we return to a working definition of PES in ISE and address the contributions that PES can make to ISE. We specifically focus on ISE’s relationship with science policy, research, learning, audiences, motivations, and contributions.³

Getting a Jump Start on PES

Organizations new to PES may want to start by examining their mission statements and current activities to see how they align with the goals of PES in ISE. It’s then possible to design ways to push programming boundaries and try something that is more PES-oriented. Like all activities, PES programming both opens opportunities and presents challenges. (See Appendix A for suggestions as to what to consider when designing PES experiences in ISE).

A Working Definition of Public Engagement with Science in Informal Science Education

Public Engagement with Science in terms of informal science education refers to activities, events, or interactions characterized by mutual learning—not one-way transmission from “experts” to publics—among people of varied backgrounds, scientific expertise, and life experiences who articulate and discuss their perspectives, ideas, knowledge, and values. A PES activity may—but does not necessarily—directly inform the direction of scientific investigations, institutions, and/or science policy.

ISE generally focuses on increasing overall interest, involvement in, and knowledge of scientific content and processes. In addition, the goals of PES activities in ISE for individuals or communities often include one or more of the following:

- Mutual learning by publics and scientists, allowing all participants to develop new or more nuanced understandings of issues and opportunities;
- Empowerment and the development of skills for participating in civic activities;
- Increased awareness of the cultural relevance of science, science as a cultural practice, and science-and-society interactions; and
- Recognition of the importance of applying multiple perspectives and domains of knowledge, including scientific understandings, personal and cultural values, and social and ethical

³ As informal science education has developed as a field (Falk, Randol, and Dierking, 2008), colleagues have argued that we need to be cognizant of and explicit about our approaches, assumptions, and intentions (Stockmayer, 2005) and thoughtful about building a foundation of related theory and practice for the field (Center for Informal Learning and Schools [CILS], n.d.). Defining the domain and identifying the approaches to science and publics employed in ISE are critical to the growth of ISE and to the role of Public Engagement with Science within the overall context of informal science education.

concerns, to understanding and decision making related to science and to science-related societal issues.⁴

A key characteristic that distinguishes Public Engagement with Science from other approaches in informal science education is that PES values and facilitates participation and mutual learning among publics, scientists, and others with respect to the development and application of science and technology⁵ in modern society.

We will return to this definition and discuss it at length. Next, however, we provide some overarching context about ISE and PES in order to set the stage for this fuller discussion.

What Is Engagement in Informal Science Education?

Informal science education⁶ is about learning. Broadly defined, ISE encompasses the vast majority of experiences people have with science across their lifetimes (Bell et al., 2009; Falk, Storksdieck, and Dierking, 2007). These experiences, which generally occur outside of formal school time, are based on exposure to and interactions with film and broadcast media; science centers, museums, zoos, aquariums, botanical gardens, and nature centers; digital media and games; science journalism; and youth, adult, community, and after-school

Must PES Activities in Informal Science Education Inform Science Policy?

Some of the most burning and controversial questions with respect to PES in ISE revolve around whether or not PES activities must inform science policy: *Are knowing and discussing enough? Should PES in ISE be dedicated to finding ways for publics to strongly influence science policy?* Currently, there are not uniform or unequivocal responses to such questions. For example, Chris Toumey, cultural anthropologist at the University of South Carolina Nanocenter, argues that PES that informs science policy is “worthwhile, but extraordinarily difficult to achieve” (personal communication, January 13, 2009). In the working definition provided in this report, the sentence “A PES activity may—but does not necessarily—directly inform the direction of scientific investigations, institutions, and/or science policy,” was subject of much discussion. Some of us took the view that getting people to talk to and learn from one another was sufficiently empowering and was a large enough shift from accepting and deferring to science knowledge as presented by experts. Others felt strongly that even if such interactions led to future civic behaviors, PES activities in ISE needed to provide direct and explicit mechanisms for influencing science policy.

4 This goal draws on the insights into the relationships of science and society developed by scholars in the field of Science and Technology Studies, such as Hackett, Amsterdamska, Lynch, and Wajcman (2007) and Bucchi (2008).

5 While we have chosen to use the term Public Engagement with Science (PES), we include technology, engineering, and mathematics in the concept of PES. The inclusion of these fields suggests introducing the term PE-STEM or PESTEM, neither of which is currently in use. While the term Public Engagement with Science and Technology (PEST) is more inclusive than PES and is in use, it still lacks the overall inclusivity of PE-STEM. Thus, although we used PES in this report, we are open to considering using more inclusive terms such as PEST or PE-STEM as the ISE field moves forward.

6 The publication *Learning Science in Informal Environments* (Bell et al., 2009) is a consensus study that synthesizes what is known about learning in ISE contexts. A companion volume for practitioners is forthcoming. These are resources on theory, knowledge, practice, research, and evaluation in informal science education that can provide a strong background for people interested in PES in ISE.

programs.

During conversations in preparation for this report, it quickly became clear that many ISE professionals see themselves “in the engagement business” and consider ISE to be “all about engagement.” What engagement means, however, varies from person to person, and, more importantly, the daily usage of engagement by ISE professionals differs significantly from the meaning of engagement generally used in Public Engagement with Science.

In terms of informal science education, *engagement* is a loosely defined term generally referring to behaviors that demonstrate interest in or interaction with a science-related activity or experience. Engagement is often considered an integral part of participation in or learning about science, or as a stepping stone to further participation or learning. However, how the term *engagement* is being used in a specific instance is rarely well defined.

When ISE practitioners talk, we often talk in terms of engagement: creating *engaging* experiences, programs, and media or *engaging* people with ideas, programs, or media. As ISE evaluators and researchers, we often seek to measure the *level of engagement* so that practitioners can *increase engagement*. Jolly, Campbell, and Perlman (2004, p. 5), for example, define engagement as “having an orientation to the sciences and/or quantitative disciplines that includes such qualities as awareness, interest, and motivation.”

In a review of literature on engagement in informal science education, Rowe (1998)⁷ documents engagement being used in four ways, to which we have added some more references:

- Engagement as actions or behaviors (e.g., being engaged in a television program) (Hein, 1998; Hooper-Greenhill, 1994);
- Engagement as learning style preferences (e.g., preferring to engage in hands-on activities rather than to reading books to learn physics concepts) (Cszikszentmihalyi, 1990; Oppenheimer, 1968; Serrell, 1996; Their and Linn, 1976);
- Engagement as a part of the larger process of learning (e.g., one is more likely to learn if one is engaged in a topic or activity) (Blumenfeld, Kempler, and Krajcik, 2006; Hooper-Greenhill, 1994; Stocklmayer, 2005); and
- Engagement focused on either the individual or social group, specifically, as the unit of analysis for research and evaluation (e.g., the specific person who is doing the engaging and the level of that person’s engagement) (McManus, 1990; Rogoff, 1994; Stocklmayer, 2005).

Because of its diverse usage in the field of informal science education, the term engagement is not restricted to a specific model describing the relationship between publics and science. Instead it is an all-purpose term used to describe the diversity of activities within the ISE community, c.f. *Learning Science in Informal Environments* (Bell et al., 2009). However, all of the conceptualizations of engagement listed above with respect to ISE contrast with the usage of engagement in the term *Public Engagement with Science*.

⁷ Note that the types of *engagement* in this section refer to its use in terms of informal science education. Rowe and Frewer (2005), on the other hand, present a typology of engagement mechanisms with respect to Public Engagement with Science.

While we recognize that it is problematic that (1) there are various meanings for engagement within the ISE community and (2) engagement within Public Engagement with Science has a specific meaning, we have intentionally chosen not to create another term to describe PES with respect to ISE. Instead, we use *Public Engagement with Science* to acknowledge and maintain its roots within the policy arena. One implication of this decision is that until this conceptualization of engagement with respect to PES becomes well-known within the ISE community, there may be miscommunication and misunderstandings regarding the specific meaning of PES and PES in ISE.

Thus, in this report, we seek to acknowledge the multiple meanings of the term *engagement* and to clarify *engagement* in terms of Public Engagement with Science. In fact, in Part 6 of this report, our first opportunity for all audiences suggests that throughout our practice in ISE we become more cognizant of and specific about what we mean when we use the terms “engage” and “engagement.”

Diverse Understandings of the Public’s Relationship with Science

On the basis of our readings and experiences, there are diverse ways in which publics ideally (or actually) interact with science. However, we limit our discussion to the predominant approaches to understanding publics’ relationships with science in ISE—Public Understanding of Science (PUS) and Public Engagement with Science (PES)—as well as a wide variety of hybrid approaches between them. This creates a spectrum or continuum of approaches between the two “poles” of PUS and PES.

In the following section, we review the use of PUS and PES approaches both in the science policy arena and within the field of ISE. These approaches are further elucidated in Part 4 of this report. (In addition, Appendix B lists additional terms that are commonly used to describe various activities and interactions between publics and science.)

Public Understanding of Science (PUS)

Public Understanding of Science (PUS) represents one approach to framing the relationship between publics and science. ISE practices informed by PUS focus on increasing publics’ knowledge of scientific content and processes. This increase in knowledge is understood to occur via the transmission of scientific knowledge from the scientific community to individuals in society,⁸ often with the ISE as an intermediary. ISE practices informed by PUS focus on public mastery of scientific knowledge (Durant, Evans, and Thomas, 1989; Lehr et al., 2007; Rennie and Stocklmayer, 2003; Thomas and Durant, 1987; Trefil, 1993). Three commonly acknowledged goals of ISE practices informed by PUS are

- to make science accessible to all and increase science literacy (Miller, 2006; Stocklmayer, 2005)
- to make apparent the relevance and importance of science to everyday life and society (Bransford, Brown, and Cocking, 1999; Coalition on the Public Understanding of Science, 2008)
- to increase the pool of people entering science-related careers (Lewenstein, 2003; Miller, 2004; Stocklmayer, 2005).

Thus, the overarching purpose of PUS is to make quality scientific knowledge accessible and engaging to everyone in order to help people learn science and enhance their lives. A claim often associated with

⁸ Most formal education is premised on such a PUS model.

PUS (although it is not necessarily supported by data) is that as people acquire scientific knowledge and become more scientifically literate, they increasingly accept and support the enterprise of science (Coalition on the Public Understanding of Science, 2006; Lewenstein, 2002; Ziman, 1991).⁹

The situation is a bit more complicated—there are at least two competing understandings of PUS. In the first, PUS-informed practices are viewed as providing a public service to individuals and society. This public service is the increased access to quality scientific knowledge that empowers publics with respect to science. From this viewpoint, PUS activities are understood to serve informal science education by providing public programming and opportunities for individuals to supplement and extend their formal educational experiences. It also includes motivating people to participate more fully in science both within and outside the formal education context.¹⁰ These PUS activities include a wide range of programs and services—particularly in broadcast media, print journalism, and museums—that have provided previously unprecedented access to science, scientists, and science-related information (National Science Foundation, 1982). Advocates of this PUS model point to the innumerable interesting, engaging, and valuable informal science education experiences that it has produced.

However, there is a second view of PUS that draws from a more critical perspective and that is more common in academic fields such as science communication and Science & Technology Studies (STS) as well as in science policy contexts. This view rejects the idea of PUS as a method for empowering publics. Instead, PUS is considered to be a “deficit” model premised on the assumptions that (1) much of the public is ignorant of scientific facts and processes, (2) science is neutral and objective and thus has the wisdom and answers to fill the deficit, and (3) ignorance of science is detrimental to a thriving society (Brossard, Lewenstein, and Bonney, 2005; Coalition on the Public Understanding of Science, 2006; Gregory and Miller, 1998; Lewenstein, 2002, 2003).

In response to this second view of PUS—particularly with regard to the positioning of publics as ignorant, passive, or “an empty vessel waiting to be filled”—some have rejected PUS as a model for public–science interaction. They support their position by pointing to a body of case studies that document that, in fact, publics can be critical consumers and even producers of science for their own purposes (Davies, McCallie, Simonsson, Lehr, and Duensing, 2008; Falk et al., 2007; Irwin, 1995; Irwin and Wynne, 1996; Layton, Jenkins, Macgill, and Davey, 1993; Michael, 1992, 1998; Wynne, 1992).

While these two contrasting views on PUS cannot be reconciled here, it is important to understand that some people involved with ISE view PUS as an empowering and fundamental component of ISE, while others view PUS less favorably. This second perspective critiques PUS as an effort to get non-scientists to accept science without empowering publics to act or think critically.

9 Recent research suggests that the assumption that if people know science, they will embrace and support it, does not hold up (Allum, Sturgis, Tabourazi, and Brunton-Smith, 2008).

10 In fact, Public Understanding of Science, which was previously referred to by the acronym PUOS, has been conceptualized in terms of the NSF PUOS program, the forerunner to the NSF ISE Program. The NSF PUOS Program argued that “to maintain a vigorous and widely representative pool of potential talent for the technological professions; to assure a base of awareness and understanding among the decision makers of industry, government, and the press; to encourage the interest and familiarity that are needed to recognize and address the personal and public decisions related to technology; and to meet the Jeffersonian idea of an informed electorate... interest and [a] background of experience with the principles and activities of science is critical” (National Science Foundation, 1982, p. 6). The NSF PUOS recognized that “there is no single ‘public’, but a great variety of audiences with differing needs, motivation and levels of sophistication” (National Science Foundation, 1982, p. 6). The NSF PUOS Program sought to serve those who were not served elsewhere or by the private sphere.

The PES approach to publics and science emerged initially from those who critiqued PUS—that is, those critical of understanding PUS as primarily a matter of educating the public about science. For some proponents of Public Engagement with Science, PES is explicitly to be understood in contrast to PUS. But as the discussion of PES has been taken up by people throughout the ISE community, this “critical” origin of PES has often been lost, and many people in the ISE community who are advocates of PUS now seek to include PES within their understanding of PUS. We believe that this confusion over the meanings and assumptions associated with PES is one of the key barriers to further developing the ISE field. As authors of this report, we acknowledge that the use of PUS approaches in informal science education has resulted in many high-quality, accessible, and enjoyable science learning experiences for a broad audience. However, we also believe that successful development of the ISE field requires ISE practitioners to think deeply and critically about how publics and science are positioned in ISE practices. In this report, we consider ISE to be composed of a spectrum of models, including Public Understanding of Science and Public Engagement with Science. We continue our discussion of PUS, PES, and the wide variety of hybrid approaches located between PUS and PES in Part 4 of this report.

Public Engagement with Science (PES)

Public Engagement with Science (PES) is usually presented as a “dialogue” or “participation” model in which publics and scientists both benefit from listening to and learning from one another—referred to as *mutual learning*. The model is premised on the assumption that both publics and scientists have expertise, valuable perspectives, and knowledge to contribute to the development of science and its application in society (Burns, O’Conner, and Stockmayer, 2003; Kerr, Cunningham-Burley, and Tutton, 2007; Leshner, 2003).

The PES model does not reject that there can be a need for publics to learn science in order to participate in modern society; however, it argues that the focus should be on the valuable perspectives and knowledge publics bring from their lives that enhance the discussions of science and issues of science-related societal issues. PES often focuses on current research in STEM or controversial science-based issues,¹¹ for which life experience and personal, cultural, or societal values naturally play a role in decision making.

The PES model has its roots primarily in Europe and specifically in the UK in reaction to “crises of trust” around science and science policy (Coalition on the Public Understanding of Science, 2006; Davies et al., 2008; Irwin, 2006). In general, many of today’s policy contexts embrace PES and reject PUS. From a science policy perspective, the PES-based dialogue model can potentially produce more robust, effective policy because it takes into account the views and knowledge of multiple stakeholders (House of Lords, 2000; Jackson, Barbagallo, and Haste, 2005; Toumey, 2007; Wilsdon, Wynne, and Stilgoe, 2005).

Many people involved with Public Engagement with Science talk about PES as leading to cultural change. For example, the Center for Advances in Public Engagement views publics as a “vital resource or potentially powerful partner in problem solving.” This new role for the public can occur because

What Do We Mean by Mutual Learning?

Mutual learning takes place when people listen to, respond to, refute, and build on one another’s contributions in the process of exploring an issue, helping all participants experience a change in understanding or perspective. This may lead to new understandings—referred to as co-constructed knowledge (Sawyer, 2006) or co-produced knowledge (Bucchi, 2008). This concept of mutual learning is premised on (1) the idea of “framing for deliberation” as opposed to “framing to persuade” (Center for Advances in Public Engagement, 2008, p. 2), and (2) exploring and clarifying an issue from multiple perspectives and domains, instead of debating to “win.” During mutual learning, knowledge, experience, and values from various domains are brought together and viewed not as antagonistic, but as essential and integral components of understanding and decision making around complex issues (Bucchi, 2008).

For example, PES includes publics doing more than merely asking questions of experts. PES also includes experts doing more than just presenting their knowledge and perspectives. PES in ISE brings scientists and non-scientists together, either in real time or asynchronously, to learn from one another (Davies et al., 2008; Lehr et al., 2007; McCallie et al., 2007; Reich, Bell, Kollmann, and Chin, 2007). In PES, publics are “learning science as well as shaping science” (Einsiedel, 2007). Thus, *learning* in PES isn’t limited to participants accepting or mastering the perspectives and knowledge presented by experts. Instead, the model of learning in these mechanisms views understandings and learning to be created, directed, and determined by participants as they are participating. Therefore, knowledge generation is possible as an integral part of PES mechanisms (Davies et al., 2008). (See more about PES and learning in Appendix C.)

A key question for research and evaluation related to PES in ISE is: *How often and in what circumstances does mutual learning take place?*

¹¹ Examples of controversial science-related societal issues include global climate change, stem cell research, and vaccinations for young children.

PES strives to “creat[e] legitimacy and a sense of shared responsibility by involving the public and diverse stakeholders early and often in a change process, rather than after decisions have been made” (Center for Advances in Public Engagement, 2008, pp. 1–2). The goal for the Center for Advances in Public Engagement and other PES practitioners is “to have lasting impact...beyond the ‘project’ phase, to become an evolving set of civic practices and habits among leaders and the public that become embedded in the life of the community...[and] to foster a culture of decision making in which citizens and leaders share responsibility for addressing problems of common concern” (Center for Advances in Public Engagement, 2008, p. 2).

While PES developed out of the Science & Technology Studies (STS), science communication, and science policy contexts, it is now being explored in other contexts. For example, since about the year 2000, ISE professionals have been applying the concepts of PES and employing the term PES with respect to their own practices.

Public Engagement with Science in Informal Science Education

As we stated previously, PES in terms of informal science education is a relatively new model with a growing body of theory and practice (Davies et al., 2008; Gammon, 2003; Gammon and Burch, 2006; Lanzinger, 2007; Lehr et al., 2007; McCallie et al., 2007; Mesure, 2007; Reich, Chin, and Kunz, 2006; Reich et al., 2007; Rodari and Merzagora, 2007; Schwarzer, 2007; Toumey, Reynolds, and Aggelopoulou, 2006). Thus, the following sections explore the concepts, terms, and practices within PES in ISE.

Starting from the position that the CAISE Public Engagement with Science Inquiry Group and the ISE field needed something concrete to discuss and build upon, we created a working definition of PES in terms of ISE (see p. 18): an activity, event, or interaction characterized by mutual learning among people of varied backgrounds, scientific expertise, and life experiences. We then sought to articulate the complexities, tensions, and opportunities for PES within the ISE context. This explication is consistent with our group’s commitment to acknowledging the complexity of the topic and to sharing points of resonance and dissonance within our group and across the field. It also acknowledges that ISE and PES operate as part of a larger society as illustrated in Figure 1 (see p.26).

Incorporating PES into informal science education creates possibilities for ISE organizations to operate not only as storehouses and/or disseminators of knowledge, but as facilitators of the production of new knowledge and understandings through dialogue and interaction among publics, scientists, and policy makers. As PES is incorporated into ISE, it may contribute to broader cultural change by increasing public awareness, sense of shared responsibility, and civic participation in science and decision making (Bell, 2008). PES in ISE also strengthens the presence of ISE organizations as vital participants in our 21st century communities.

What Does It Mean to Value Multiple Perspectives?

Valuing multiple perspectives and expertise is not the same as saying or implying that the “quality” of the science will decrease. Instead, the science that results should be thoroughly informed, grounded, and reflective. In terms of publics, people should have a greater understanding of our world and society and have the motivation, empowerment, and skills to actively participate.

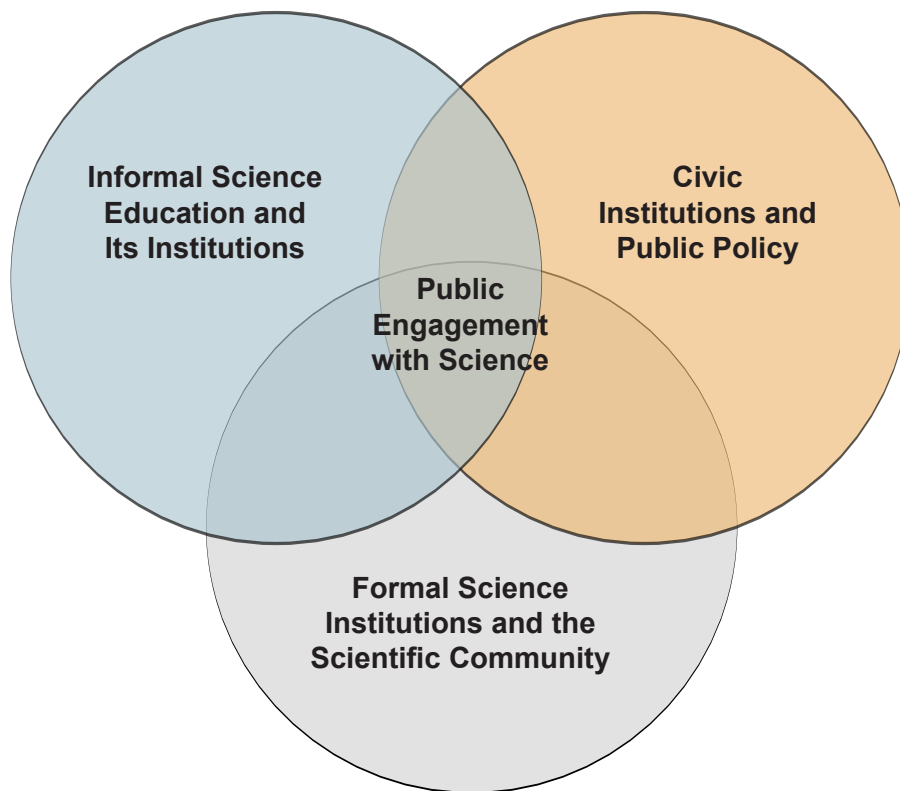


Figure 1: Relationships among various institutions and Public Engagement with Science.

Specifically, PES in ISE seeks to bring together experts in science and informal science education as well as publics who, perhaps unknowingly, serve as experts with respect to experiences of science and ISE in daily life. Through the discussion of the social, cultural, and ethical aspects of science, PES in ISE becomes more than a means for transmission of scientific knowledge or an acceptance of scientific authority. PES activities serve as platforms for discussion and examination of knowledge to improve understanding of issues and make decisions. The learning that occurs in PES in ISE is expected to be a complex process of scientific, social, cultural, and ethical understanding that may change attitudes about and understanding of science and individual roles in society.

An overarching learning outcome for participants in PES in ISE that was articulated by Lehr (2008) is gaining the resources and knowledge to clarify and articulate both their own—as well as others’—perspectives on science-related societal issues. Learning objectives include gaining an increased ability to identify and account for competing perspectives (knowledge, awareness, and understanding) and an increased ability to craft a strong argument—a position with supporting evidence—about an issue (skills) (Friedman, 2008). Other objectives may include changes in interest and behavior, such as giving increased attention to an issue in daily life or increasing participation in interpersonal and/or public decision making related to an issue (Lehr, 2008). As proficiency within ISE grows with respect to PES, a main challenge may be figuring out how to expand PES experiences, from designing individual experiences to fostering a larger PES culture (Merzagora and Rodari, 2008).

Much work needs to be done to articulate indicators and impacts of PES in ISE, not only to evaluate and improve practice but also to provide an overview of PES and its impacts in reports such as the *Science and Engineering Indicators 2008* (National Science Board, 2008). Needed data include impacts and indicators at the level of the individual, as described by Rowe and Frewer (2004) for PES in policy

contexts, as well as at the level of society, such as initiatives like NISE Net (nisenet.org).

In the course of preparing this report, the CAISE Public Engagement with Science Inquiry Group compiled a list of impacts that we use explicitly or implicitly in PES in ISE work. (See Appendix D.) These impacts are organized on the basis of the *Framework for Evaluating Impacts of Informal Science Education Projects* (Friedman, 2008) and use resources from the NSF ISE Online Project Monitoring System (caise.insci.org/news/40/51/briefCAISE---May-2008-Issue-2/d,Program-Item-Detail#05). This list is incomplete, however. A fuller articulation of impacts and associated indicators of PES is a much-needed resource to guide and improve practice, research, and evaluation. In addition, though substantial conceptual work supports the Public Engagement with Science model, more empirical analyses of PES in ISE are needed, including theoretically based assessments of specific activities.

Should All ISE Experiences Be Premised on a PES Model?

We suggest that PES be considered *a component* of the larger repertoire of ISE models and experiences. In other words, those in the ISE community and in funding agencies should not abandon other good work in order to adopt a singularly PES approach to ISE. ISE attracts participants and audiences of varying ages, interests, past experiences, and abilities, all with differing agendas, expectations, and intentions. This broad diversity of ISE target audiences suggests that no single approach will be successful for everyone. Thus, a necessary strength of ISE is its range of platforms and deliverables that offer diverse and valuable learning opportunities to multiple target audiences. There is a great advantage to considering ISE as representing not either PUS or PES, but rather a spectrum spanning both PUS and PES approaches to the relationship between publics and science. Part 4 of this report discusses this concept further.

PES Mechanisms vs. PES Perspectives

Within PES in ISE, it is worthwhile to distinguish between PES mechanisms, which are relatively new activities for ISE, and PES perspectives, which is new terminology to describe what some ISE professionals have long practiced.

PES mechanisms are ISE activities or experiences in which mutual learning occurs as part of the experience: people from varied backgrounds and perspectives listen, share, and build on one another's contributions in the process of learning from one another. Many of these experiences occur in person, through dialogue events or forums, or using mass media with call-in, e-mail, or text messaging capacity. Other PES mechanisms occur through blogs and online forums and can involve a time lag (asynchronous interaction).

In contrast with PES mechanisms, ISE experiences using a *PES perspective* are informed by the goals of PES but do not facilitate direct interactions between publics and scientists. This means that ISE experiences using PES perspectives are premised on the view that scientific knowledge alone does not allow people to fully address the topic at hand. In practice, PES perspectives may include knowledge and values drawn from multiple points of view, or may model publics participating in PES mechanisms, but they do not involve direct interaction on the part of the audience. A key feature of the PES perspective is an understanding that publics, in addition to scientists and other "experts," can make useful and valuable contributions to discussions and decision making about STEM. Such

public contributions might not depend on scientific knowledge, but rather on knowledge drawn from life experience and personal and community values. In practice, for instance, exhibitions or theatrical performances developed using a PES perspective may have been developed in the context of interactions between publics and scientists, or may model publics participating in PES mechanisms. While PES mechanisms in ISE are relatively new, some sectors of ISE are generally adept at incorporating PES perspectives, and some practitioners have been doing so for many years. Part 3 provides examples and further discussion of PES mechanisms and perspectives in ISE.

How Has PES in ISE Been Funded?

Much of the funding for PES programming in the United States has been provided on an issue-by-issue basis, focused on endeavors such as the Human Genome Project or on issues like nanotechnology. The strength of funding agencies soliciting proposals for specific, pressing areas of concern, is that they encourage sustained, multiple-site, proactive participation in the framing of emerging controversies and, potentially, involve publics in anticipatory governance (Guston, 2008). Another approach for funding PES in ISE is to support an activity or format that is implemented repeatedly with different focal topics. For example, science cafés and discussion forums are PES formats that are used to address a wide range of topics.

Does PES in ISE Need to Inform Science Policy or Scientific Research?

PES mechanisms in ISE environments are designed to achieve various outcomes. It is useful to distinguish between two major types of PES mechanisms. The first type of PES

What Kinds of Science and Societal Issues Are Appropriate for a PES Approach?

Most PES experiences focus on current science or science-related societal issues, such as “stem cell research and cloning; evolution and science education; science, technology and national security; bioterrorism; energy policy; sustainable development; the environment; climate change; genetic medicine; emerging infectious diseases; genetically modified foods; space exploration; and nanotechnology” (American Association for the Advancement of Science, 2008). However, PES is not just about the topical controversies in the headlines; it is also about allowing a greater segment of society to take ownership of and help direct scientific investment and application.

Learning and decision making around science-based societal issues require participants to recognize the importance of multiple perspectives and domains of knowledge, including science, values, and social and ethical concerns. The science involved often crosses disciplines, and the outcomes of scientific and technological research as well as science policy may impact everyone today and long into the future.

For example, Newton’s Laws and Ohm’s Law are not typically good topics for PES, although they may be for PUS. There is little controversy around them and therefore little room for discussion in a PES context or for public input. While study of and reflection on technical scientific controversies within the scientific establishment may be useful, these issues are not always good topics for PES. But current science-based issues or potential societal controversies such as those noted above require multiple perspectives and domains of knowledge for successful resolution (Dana Centre/Science Museum, 2003a).

mechanisms—in line with PES in the science policy arena—seeks to facilitate direct public participation in scientific and technical decision making that leads to institutional or science policy outcomes. The second type of PES mechanisms seeks to promote a broader culture of engagement through the interactions among scientific and technical professionals, policy makers, and publics, but without the intention of direct institutional or science policy impact (Lehr et al., 2007). Some ISE contexts are comfortable with both types; others find that only one type of mechanism is a good fit for their mission and goals. In either case, however, “someone must be listening” (Leshner, 2003). In other words, there is a distinct difference between PES and non-PES oriented experiences. In PES activities, people from varied backgrounds and perspectives listen, share, and build on one another’s contributions as they learn from one another. It is not enough to merely express different viewpoints and values.

Therefore, PES in ISE that is designed to inform scientific research or science policy should include ways for participants to know the extent to which they are being heard, who is hearing them, and what potential impact their perspectives may have. For PES in ISE activities that are not directly aimed at informing science policy, participants’ experiences should reflect new expectations in terms of when and how people and organizations interact to address issues, challenges, and opportunities (Davies et al., 2008). In other words, PES experiences should provide opportunities for learning knowledge, skills, and behaviors for further civic involvement, and for gaining new resources for personal and public decision making, all aimed at empowering individuals and communities to become more involved in the dialogue about science, technology, and society.

Contributions of PES to ISE

PES activities provide ISE with ways to respond to currently emerging and controversial issues, including topics like energy costs and alternatives, stem cell research, and neuroethics. At the same time, they provide opportunities for publics to become actively engaged in issues of science and society, social science, ethics, science policy, and related topics.

As learning-focused activities, PES experiences in ISE have goals that align well with the broader goals of formal and informal science education outlined in two recent National Research Council publications, *Learning Science in Informal Environments* (Bell et al., 2009) and *Taking Science to School* (Duschl et al., 2007). This section discusses how PES strengthens and expands current educational goals, including improving science literacy, building relationships with scientists, increasing relevancy of science to publics, providing new models of learning and research, expanding and diversifying audiences, and increasing publics’ participation in science and society.

Science Literacy

A major goal of science education has been science literacy (American Association for the Advancement of Science, 1993; Bingle and Gaskell, 1994; DeBoer, 2000). “Science literacy is considered an essential component of a democratic society, supporting a modern technology-based economy and promoting the cultural values of society” (Falk et al., 2007). Science literacy—or familiarity with basic concepts and processes in science as well as the ability to apply this knowledge in various contexts—is thought to improve individuals’ personal and public decision making, increase their involvement in science, technology, engineering, and mathematics (STEM) careers, and give them an appreciation of science and technology as cultural achievements (American Association for the Advancement of Science, 1993; Falk et al., 2007; National Research Council, 1995/1996; Nepote, 2007).

PES can help facilitate science literacy through ISE, even though PES does not specifically include science literacy as a goal. For example, PES in ISE allows scientists and publics to voluntarily participate in lifelong learning in science and to achieve fluency with topics that emerge after they complete formal schooling by exploring ideas, examining current societal issues, challenging the claims of others, and developing their own understanding of science and its relationship with their lives. In addition, PES in ISE strives to generate a more critical and equitable relationship between scientists and publics so that both learn and change as part of these processes (Lehr et al., 2007; Rowe and Frewer, 2004; Zembylas, 2005).

Thus, whether intentionally or inadvertently, PES in ISE has the potential to foster the type of science literacy articulated in the 2007 National Research Council report *Taking Science to School* (Duschl et al., 2007). This NRC report describes proficiency in science as being able to

- know, use, and interpret scientific explanations of the natural world
- generate and evaluate scientific evidence and explanations
- understand the nature and development of scientific knowledge
- participate productively in scientific practices and discourse (p. 2).

In addition, PES in ISE has the potential to develop people’s capacity to

- experience excitement, interest, and motivation to learn about phenomena in the natural and physical world
- think about themselves as science learners who know about, use, and sometimes contribute to science (Bell et al., 2009).

Relationships with Scientists

Science and scientists have always been an integral part of informal science education. PES challenges ISE to continue to develop its relationships with scientists and science organizations. PES in ISE creates new models for STEM researchers to become involved in ISE to achieve “broader impacts” or “outreach”¹² for their work. For example, PES brings researchers into ISE practice to interact directly with publics. Through PES activities, scientists may develop new insights about how and where their work fits within the larger community. In addition, with time and over multiple experiences, scientists may see themselves as part of the broader community of ISE professionals. Connecting scientists and ISE is not always easy, however. Some “matching services” already exist. One example is the Office of STEM Education Partnerships at Northwestern University (osep.northwestern.edu). Other services are needed to facilitate STEM researchers working regularly with ISE professionals in order to meet “broader impacts” criteria of funding agencies.

In addition to creating new models for STEM researchers to become involved in ISE, PES in ISE can reframe how scientists participate in ISE experiences and with publics. For example, in addition

¹² *Outreach*, like *engagement*, is another term with multiple meanings. With respect to ISE and scientific communities, outreach is often used to refer to efforts to transfer knowledge from scientists to publics, particularly in terms of initiatives designed to develop and maintain young people’s interest in STEM and STEM careers. This usage is generally very much aligned with a PUS model.

to serving as “experts” or “teachers,” scientists are positioned in PES as a target audience for ISE practice—as learners. An implication of this learning may be that scientists think about their work differently and in terms of its larger social implications. Over time, scientists’ experiences with PES in ISE may shape science and become an integral part of scientific culture. Another aspect of reframing scientists as both experts and learners is that it creates the option to think of others in addition to scientists as “experts.” For example, PES challenges people to expand their definition of “expert” to include social scientists and publics.

Relevance to People’s Lives and Society

While science is often framed as a hierarchical and authoritative institution that creates and transmits “correct” knowledge to publics, PES in ISE fosters broader expectations and opportunities for publics and scientists (and policy makers) to participate in civic issues and society. PES topics are generally current issues that are directly or indirectly relevant to the lives of individuals, communities, and society. Addressing issues relevant to people’s lives can prompt collaboration among individuals, community organizations, and ISE professionals.

Publics, scientists, and others are not accustomed to bringing expertise to the table in order to create new knowledge or understandings together: It is more common to bring knowledge and expertise to the table in order to instruct, convince, or acculturate others. Publics, scientists, and others need practice moving beyond their typical roles. Research indicates that unless people make concerted efforts with sustained support, most generally fall back into patterns of interacting with which they are familiar.

PES activities can provide opportunities for people to publicly discuss scientific knowledge and social issues in order to work through the tensions between society’s simultaneous commitments to democratic action and its reliance on expertise. Thus, if such processes are well designed and implemented, PES in ISE has the potential to (1) provide people with authentic experiences, (2) potentially inform science policy, and (3) support the development of a “STEM-savvy culture” in which people understand and use the knowledge and tools of STEM to enhance their lives and as resources for problem-solving (DeSena, 2008). Such experiences support adults’ needs for lifelong learning to remain active in society and relevant in the workplace.

The lever for these impacts on science and society will not necessarily be new practices, outputs, and activities geared toward PES in ISE. In some cases, no more than a reframing and subtle change in orientation in current ISE projects is needed. (Appendix D lists potential impacts of PES in ISE projects.) By framing itself as a platform for authentic interaction around current and/or controversial science topics, ISE positions itself to be “truly engaged with and integral to ... diverse communities and [to stimulate] public dialogue” (National Science Foundation, 2008a, p. 7).

Audience Expansion

PES in ISE also has the potential to broaden ISE audiences to include underserved audiences and to expand the typical audience any individual ISE platform reaches. This is possible because PES in ISE promotes formats in which multiple perspectives and multiple types of expertise are expressed and valued. PES activities, like other ISE experiences, can be designed to create attractive, inviting, easily accessible platforms in the community or online. For some ISE institutions and platforms, underserved, underrepresented, and multilingual audiences are desired. For others, adult and/or non-family audiences

are also considered potential “new audiences” for PES activities to reach.

There are many models for broadening audiences. For example, efforts of the Human Genome Project, such as a conference in the year 2000, *The Challenges and Impact of Human Genome Research for Minority Communities*, specifically included opportunities for input by individuals from minority communities into thinking about ethical, legal, and social implications of genomics. Another example is the Science Museum’s Dana Centre in London, which is committed to broadening participation and provoking discussion through evening programs “connecting contemporary science, technology and culture” (danacentre.org.uk/aboutus). Several events have been co-created by the Dana Centre team in conjunction with leaders from the Chinese and Afro-Caribbean communities in London. These events attracted greater than normal attendance and featured participation by individuals from communities that are generally underrepresented at the Dana Centre.

In other words, PES in ISE helps people to see themselves as empowered, valuable, integral parts of their communities and society. If more people hear or recognize their own voices in the discussion of science and society, they may be more likely to view ISE opportunities, science, and civic participation as “for them”—as part of their identity (Strand 6 of *Learning Science in Informal Environments*; Bell et al., 2009). Again, science learning and identity building are not typical goals of PES activities outside of ISE, but they may be byproducts of PES in ISE.

Models of Learning and Research

At the core of informal science education is the commitment to learning, broadly defined, and to supporting learning through research and evaluation. With respect to learning and

What Impact Does PES Have on ISE Platforms, Experiences, and Institutions?

The incorporation of PES perspectives and mechanisms into an institution’s offerings creates the potential for the producers of informal science education experiences to operate as facilitators of the production of new knowledge and understanding. These PES processes position ISE platforms as integral to the vitality of communities. Specifically, they seek to contribute to broad cultural change affecting publics, scientists, and policy makers by generating increased awareness, sense of shared responsibility, and civic participation in science and decision making. As science center colleagues in Europe have asked:

“Are science centres today the first place citizens think to go, when they want their voices to be heard on controversial issue involving scientific expertise?...Are science centres today the first place scientists think to go, when they want to defend their viewpoints, to lobby, or to stage the competition among themselves for cultural and financial recognition?” (Merzagora and Rodari, 2008, p. 3).

“Can science centres really be ‘neutral platforms’ or should they acknowledge that they have a politically active role in society? These questions have been asked in our field—in one form or another—for more than a century, but they are becoming extremely pressing today with the democratization of the internet and the participatory nature of the web, where net-citizens take it for granted that their voice counts alongside that of the ‘established’ authority. “Without a clear commitment to listening and dialogue with the public, science centres put their relevance at stake, and risk becoming marginalized institutions seeking a ‘safe haven’ in a changing society” (Bandelli, 2008, p. 4).

research, PES in ISE provides opportunities for people to learn science content, skills, and behaviors that support and empower them. These opportunities can extend their experiences and affect their identities in terms of their relationship with science, science-related societal issues, society, and civic participation. PES in ISE also supports distributed cognition and an examination of who learns and who teaches. The challenge is to think of expertise differently on the basis of needs and opportunities. At the same time, the free-choice nature of ISE allows PES in ISE to further support “customized” or “individualized learning” through which science is connected with society and publics.

Given the controversial nature of current science as well as science-related societal issues, learning through PES in ISE is not just a process of committing to memory established scientific facts. Instead, it seeks to affect interest, attitudes, awareness, knowledge, skills, and behaviors around a topic (Friedman, 2008). In addition, science-related societal issues, which are natural topics for PES mechanisms, are understood, at least in large part, to be conflicts over values and worldviews, rather than conflicts caused by a lack of scientific knowledge. There is not an assumed singular “correct” (e.g., “scientifically literate”) perspective on such controversies. In fact, PES is one way that ISE can explore and address “how new knowledge is created and exchanged...[generating] new norms for sharing and access” (Hahn, 2008, p. 1162). (For more on PES, ISE, and learning, see Appendix C.)

Part 3: Current PES Activities in the Field of ISE

Informal science education is a broad field with many platforms, target audiences, modes of interaction, and impacts. This breadth and diversity are recognized as strengths of ISE. As PES is developed within an ISE context, a range of new mechanisms are likely. It will become evident that there are a number of trends—and gaps—in terms of PES in ISE. We do not claim that this document is a complete overview of current PES activities in ISE. Groundbreaking activities with which we are not yet familiar are likely occurring, and more will occur in future. Within this context, our goal is to describe the range of activities that have come to our attention through literature reviews, practical experience in the ISE field, databases of ISE projects such as NSF’s FastLane, and discussions with ISE practitioners, researchers, and evaluators. In Part 4, we then present a model of the PUS–PES spectrum that is based on a subset of these activities. We hope that others will reflect on and contribute to the case studies and model-building to help ISE develop a richer, more informed, and more innovative stance with respect to PES in ISE.

In What Platforms and as Part of What Activities Does PES Take Place?

PES in ISE may occur in specific physical spaces or in virtual locations, such as via public television or online communities. Thus, participants in any particular PES in ISE activity may range from local to worldwide and from a handful of people to potentially millions.

To discuss the range of PES activities in ISE, we have chosen to organize this section around the types of deliverables outlined in the NSF ISE Solicitation (National Science Foundation, 2008a): exhibit deliverables, media deliverables (television, film, radio), research deliverables, learning technology deliverables, and youth and community deliverables. We acknowledge that while many ISE projects and activities contain multiple deliverables, making this a somewhat artificial categorization, these deliverable types can be a useful format to structure the discussion.

Exhibit Deliverables (Exhibitions)

Exhibitions have long incorporated PES perspectives, including multiple points of view, various forms of expertise, and multiple domains of knowledge such as values and ethics into their products. More recently, exhibition developers and evaluators have sought to foster conversation among visitors as part of the exhibition experience (McLean and Pollock, 2007). In general—or at least to date—exhibitions that are stand-alone entities do not typically serve as PES mechanisms. While they may spark conversation and later action among people who view them, they rarely contribute to mutual learning among people who possess various forms of expertise at the exhibition site. However, mutual learning may take place at various points in the process of exhibition development. For example:

- Exhibitions can constitute a deliverable resulting from PES activities. Publics, ISE organizations, and other stakeholders such as scientists, social scientists, and/or policy makers may engage in multiway dialogue and mutual learning that leads to the production or revision of an exhibition.
- Exhibitions can lead to or support PES activities, similar to the way that television and film contribute. For example, exhibitions can provide a common experience and/or content knowledge on which to base mutually informing activities.

- Various PES components may be built into the exhibition. For example, exhibits can provide text, audio, or video components where visitors, exhibition designers, and scientists interact asynchronously. Individuals may or may not choose to have extended interaction, though subsequent contributors can see what earlier visitors contributed.

Media Deliverables (Television, Film, Radio)

Like exhibitions, media have a history of incorporating PES perspectives such as multiple points of view, various expertise, and multiple domains of knowledge. In terms of PES mechanisms, media currently seem to play four distinct roles: (1) informing a PES mechanism by providing content knowledge—a moment of PUS within a larger PES activity; (2) serving as a PES mechanism by fostering direct interaction and mutual learning through call-in, text-in, and email-in programming; (3) modeling the PES process of mutual learning by broadcasting people engaged in a PES mechanism, for example a television program of a consensus conference or scientists talking about how their research has been altered due to their interaction with publics; and (4) serving as prompts to participate in extension activities that occur after the media program, such as web-site–based discussion that extend the media experience.

As access to media production technology increases, video and audio media will continue to become better PES mechanisms. One example is the recent NOVA production *Car of the Future*, which provided footage shot during its making as open content. Students and publics were then encouraged to produce their own versions of the program, repurposing content to take original approaches to storytelling.

Research Deliverables

Research and evaluation deliverables in terms of PES in ISE are developing. Most of the known research about PES mechanisms in ISE focuses on face-to-face forums (dialogue events) in museums (Davies, 2007; McCallie et al., 2007; Reich et al., 2007; Reich et al., 2006; Simonsson, 2005, 2006). Work to date includes descriptions of motivations for attending PES activities, mechanism formats, types of interactions, evidence of mutual learning, subsequent effect on behavior, facilitation strategies, the framing of topics, and new audiences. Several articles have suggested frameworks for future research. This is an area ripe for both theoretical and empirical work, particularly across the spectrum of ISE platforms and deliverables. This work is particularly important as evaluation of the impact of PES projects requires PES-appropriate impact categories. (See Appendix D for ways the NSF ISE Program’s *Framework for Evaluating Impacts of Informal Science Education Projects* [Friedman, 2008] can relate to PES in ISE.)

Learning Technology Deliverables (Cyberlearning)

Learning technology deliverables, also referred to in terms of cyberlearning (National Science Foundation, 2008b), hold great promise for PES in ISE, both as primary experience and to extend other experiences. Web 2.0 technology has changed the expectation for the process and products of interaction (Holmberg, Sandstrom, and Soderqvist, 2008). People are more likely to expect to have a voice, to be

listened to, and to interact directly with people possessing diverse expertise as well as from varying communities. The Internet opens new doors for synchronous and asynchronous interaction, including interactions across vast distances and among small to very large numbers of participants.

Most sectors of ISE are working to leverage learning technologies to enhance and extend ISE experiences and thereby build and facilitate social and learning communities. Learning technologies are likely to greatly affect the directions and success of PES in ISE, particularly in terms of dynamically creating new means for knowledge creation, sharing, and access (Hahn, 2008, p. 1162).

In terms of the pervasiveness and potential for cyberlearning, a 2006 Pew study (Pew Internet & American Life Project, 2006) found that the Internet is second only to television among the American general population as a primary source for science information.¹³ For Americans with high-speed Internet connections at home, the internet is as popular as television for news and information about science. It is the most popular source for science news and information for young adults with high-speed connections at home. In other contexts, such as political campaigns and national disasters, technologies like online social networks and real-time text capabilities are being used to mobilize and motivate great numbers of people. Policy makers themselves are increasingly using web technologies to communicate directly with citizens. (See techcrunch.com/2009/01/24/how-obama-will-use-web-technology/ and newsweek.com/id/170347 for examples of how political leaders use Internet technology for fostering interaction.)

A great challenge for PES in informal science education is how to harness the power of Web 2.0 technologies to adequately provide access to new learning opportunities for a range of audiences. One example of connecting citizens directly to scientists conducting research using the Web is an Exploratorium project called Ice Stories (icestories.exploratorium.edu/dispatches/). This project encourages researchers to blog and to webcast their adventures and research while working from Antarctica. It also strives to prompt readers to comment and join science-related discussions with these scientists.

Youth and Community Deliverables

Perhaps the most visible and common type of PES mechanism in ISE is that of face-to-face forums, including science cafés, youth cafés, and dialogue events, that often take place in community venues, including museums. These formats seek to facilitate multiway dialogue among publics, scientists, social scientists, and policy makers about science and science-based issues. They are generally attended by adults and/or older youth. Current trends in practice and research focus on increasing equitable interactions among all participants, using various forms of ISE deliverables to establish common contexts for discussion, and finding ways of framing issues and facilitating events to promote desired impacts (Dana Centre/Science Museum, 2003b; Davies, 2007; McCallie et al., 2007; Reich et al., 2007; Reich et al., 2006; Simonsson, 2005, 2006; Toumey et al., 2006).

In terms of youth programs, it is common to use controversial science or science-related societal issues as “hooks” to stimulate youth interest and involvement in science-related activities. The challenge that youth programs often face is how to connect and/or sustain interactions with others, such as scientists.

¹³ In addition, this 2006 Pew survey (Pew Internet & American Life Project, 2006), conducted in collaboration with the Exploratorium, found that three in five American adults had visited a science center in the preceding year.

In addition, there are ongoing discussions of the ways in which Public Participation in Research (PPR) programs, such as citizen science and community action projects, are also Public Engagement with Science activities. In other words, in what meaningful ways do the experiences and views of publics inform the views and/or work of scientists and vice versa? For example, a recent assessment of learning impacts associated with Public Participation in Scientific Research projects has defined three models of PPR: Contributory PPR (participants primarily collect data); Collaborative PPR (participants are involved in multiple stages of the project development and implementation); and Co-Created PPR (participants jointly design and carry out a project).¹⁴ For more, see the discussion of PPR in Appendix B.

In addition to specific impacts for particular youth or community programs, extended impacts may occur as a result of PES mechanisms. Examples include conversations that occur subsequent to a PES experience at dinner tables, chat rooms, water coolers, boardrooms, grocery stores, or any place where people gather physically or virtually. These discussions may include mutual learning among people who have various forms of expertise and experience. (See potential PES impacts of PES in ISE listed in Appendix D.)

Five examples of different PES deliverables are postlighted in the pages that follow. Part 4 then provides a preliminary framework for representing the PUS–PES spectrum within ISE, based on a limited set of examples. Based on these, we present a model of the PUS–PES spectrum.

¹⁴ The CAISE Public Participation in Research Inquiry Group report, by Rick Bonney and colleagues, is due out in mid-2009.

In the Spotlight: *Race: Are We So Different?*

RACE: Are We So Different?, a traveling exhibition developed by the Science Museum of Minnesota, St. Paul, and the American Anthropological Association, aims to open public discourse on the subject of race and racism. The exhibition, which was funded by NSF's Informal Science Education program (#0307843), presents evidence that race is a social invention and that people are genetically more alike than different. It takes the position that racism is institutionalized in American society and that race is a factor in personal identity. Evaluation data indicate that the exhibition is achieving its goal of challenging preconceived notions that many people bring with them to the exhibition and helping them embrace new understandings of race (Korn 2007).

RACE is structured around three themes: race as an everyday influence in the lives of people, the scientific perspective on race, and the ways that race has affected U.S. history. Interactive displays, first-person accounts, and videos help to provoke viewers to think about race and their own lives, while comfortable seating and a carefully planned layout encourage people to linger and share their reactions with others. *RACE* was developed with the recognition that many people avoid confronting racial issues out of personal discomfort. It seeks to provide a common vocabulary and safe space for visitors to engage with the topic.

In order to extend the exhibition's reach and inspire visitors to form personal connections with the material, *RACE* is complemented by a suite of programs, including theater and dance productions, workshops and lectures, and facilitated conversations called Talking Circles. In Talking Circles, which aim to foster tolerance, a group sits in a circle and shares experiences related to race in a format that draws from Native American traditions. The experience has helped employees, school groups, and nonprofits confront the impact of race on their lives and those of others, according to Robert Garfinkle, who led the Science Museum of Minnesota team (Garfinkle 2008).

Garfinkle notes that one of the exhibition's most striking aspects is the number of visitors it attracts from underserved populations. In St. Paul, where the exhibition opened in 2007, *RACE* attracted three times the usual number of visitors who identified themselves in exit surveys as non-white. Many of the visitors had never before considered that the science museum might have an interest in social affairs or in the issues that particularly concerned them, such as economic disparity and health. Many were visiting the museum for the first time. People tended to spend an unusually long time at the exhibition and to return for multiple visits. Garfinkle says, "There was a buzz, an energy in the exhibit hall that few of us had ever witnessed."

Web sites

www.understandingrace.org

Exhibition review www.exhibitfiles.org/where_do_you_sit_in_the_cafeteria

Photo by Wendy Pollock



In the Spotlight: *The Power of Small*

Beginning in April 2008 millions of viewers tuned their television sets to *Nanotechnology: The Power of Small*, a three-part series that is providing its audience with an opportunity to examine in depth the implications of nanotechnology for privacy, the environment, and human health.

Targeted to decision makers and opinion leaders as well as those interested in public policy and a general adult audience, the series employs an approach developed by pioneering newsman Fred Friendly. As executive producer of CBS Reports from 1959–64, Friendly encouraged informed conversations about significant issues like tobacco and lung cancer. He later launched a televised seminar series designed, he said, “not to make up anybody’s mind, but to open minds and to make the agony of decision making so intense that you can escape only by thinking.” His organization, Fred Friendly Seminars, produced *The Power of Small* in collaboration with ICAN Productions with support from NSF’s Informal Science Education program (#0452371) and the Department of Energy.



The series featured panels of policy makers, scientists, journalists, and community leaders who, with moderator John Hockenberry of National Public Radio, considered the societal, ethical, legal, and environmental implications of a series of hypothetical scenarios. In “Watching You Watching Me,” they explored applications of nanotechnology to national security and possible implications for privacy rights. In “Clean, Green, and Unseen,” the panel discussed the potential of nanotechnology for reducing environmental pollution, potential risks of environmental damage from loose nanoparticles, and the problems of regulating a technology whose long-term effects are essentially unknown. The third part, “Forever Young,” delved into issues of medical care, enhancement of the human body, and lifespan extension that may someday be made possible by nanotechnology.

The Power of Small was launched in conjunction with a series of regional deliberative forums and other outreach activities conducted in partnership with 12 science centers across the United States. The launch also occurred simultaneously with a week-long series of community-based educational outreach programs about nanotechnology, NanoDays 2008, organized by the Nanoscale Informal Science Education Network (NISE Net), also funded by the NSF Informal Science Education program (#0532536). The Center for Curriculum Innovation (CCI) and ScienceView at the University of California’s Lawrence Hall of Science developed a viewers’ guide and created a web site to complement the material presented during the television program and extend public deliberation. Radio spots on the nationally syndicated program Earth & Sky and a series of Clear Voices for Science podcasts have further extended the series’ reach.

As of September 2008, *The Power of Small* had either broadcast or had commitments to broadcast to a healthy 84 percent of the United States. Close to 75 million television households have had access to the series. Results of evaluation by Inverness Research Associates will be available in late 2009.

Web site

www.powerofsmall.org

Photo by Allen Sharpe

In the Spotlight: *NOVA scienceNOW* Science Cafés

NOVA scienceNOW Science Cafés are an outreach program of a science news and magazine television series produced by WGBH, Boston, funded in part by NSF's Informal Science Education program (#0638931). The series, which began airing in January 2005, aims to increase public awareness and understanding of cutting-edge science, while the related Science Cafés go further, aiming to engage a broad and diverse public in dialogue with scientists in casual, non-academic settings like pubs and cafés. Evaluations are showing that the program is succeeding in attracting the young adults who are its primary target audience and even helping to catalyze and connect more grassroots cafés across the United States.

In planning its *NOVA scienceNOW* Science Cafés, WGBH was inspired by the Café Scientifique movement that began in the United Kingdom in the late 1990s. Initial experiments proved encouraging. Events drew large numbers of young adults (aged 18-35) and also female participants, few of whom had watched the television series *NOVA*. When WGBH proposed the new television series, the Science Café was built in as a major outreach initiative.



As the television series launched, the first related Science Cafés were held in Massachusetts, California, and Washington. Each featured a local scientist or engineer, with different groups playing host. In Cambridge, WGBH hosted an event where robotics was the focus; in San Diego, Sigma Xi hosted a discussion of mirror neurons and autism; and in Seattle, the topic was hurricanes and climate change, with the local group Science on Tap playing host.

In a typical *NOVA scienceNOW* Science Café, clips from the show may be used to set the stage for a presentation by a local scientist, who then extends concepts presented in the video, shares related aspects of his or her own work, and engages participants in dialogue. Later, the room may break into small groups to continue discussion while a moderator circulates to keep discussion on track. Activities like trivia quizzes, panel discussions, or games sometimes enliven the event.

Evaluations have found that the vast majority of scientists who have presented at Science Cafés would participate again; some noted that their participation has changed the way they think about presenting their work to the public. Most participants also have carried out follow-up activities related to the topic. For local organizers and scientists alike, these events receive high marks, according to evaluators, for “engaging audiences, providing background information, setting the mood, and encouraging audience involvement” (Peterman, Pressman, and Goodman 2005, 2007).

Together with Sigma Xi, and with the help and input of other organizers of science cafés, *NOVA scienceNOW* now hosts a web site, www.sciencecafes.org, to support and encourage growth of science cafés nationwide.

Web sites

www.pbs.org/wgbh/nova/sciencenow/
www.sciencecafes.org

Photo by Ben Wiehe

In the Spotlight: Nanotechnology in the Public Interest

When the Museum of Science (MOS) in Boston partnered with the Science Museum of Minnesota and the Exploratorium in 2005 to develop the NSF-funded Nanoscale Informal Science Education Network (#0532536), MOS took the lead in organizing a group of science museum educators in the development of programs to engage the public in dialogue and deliberation about the societal and environmental implications of nanotechnology. In 2006 and 2007, the museum presented a series of these forum programs with speakers from two nanoscale science and engineering centers in the Boston area for which the museum serves as a public outreach and engagement partner—the Center for High-rate Nanomanufacturing, headquartered at Northeastern University (#0425826), and the Center for the Science of Nanoscale Systems and Their Device Applications, headquartered at Harvard University (#0117795, #0646094). Programs like these helped the Museum and its NISE Net partners develop ways to present and evaluate citizen forums.

The museum put its experience with public engagement to work in May 2008, when it joined forces with the Cambridge, Massachusetts, Public Health Department. In May 2008, the museum joined forces with the Cambridge, Massachusetts, Public Health Department to sponsor an initial forum, *Nanotechnology in Cambridge: What Do You Think?* The day began with presentations by MOS and the Woodrow Wilson Center's Project on Emerging Nanotechnologies. A Public Health Department representative then spoke about the city's historic commitment to involving the public in decisions regarding emerging technologies, including similar consultations during the 1970s about genetic engineering. Then forum participants broke into groups to discuss and make recommendations regarding three categories



of products that include nanotechnology in their make-up or manufacturing methods—among them clothing, personal care products like toothpaste, and food-related items like milkshake mixes. Throughout the discussions, forum participants used their cell phones to text choices among a variety of options, which ranged from taking no action to engaging in a public awareness campaign.

A second forum, held in January 2009, delved more deeply into issues of public access to information. The 60 attendees discussed what products needed to be labeled and whether signage and labeling should be implemented for products that carried environmental risks as well as those with risks for human health.

After both forums, participants reported feeling better informed about nanotechnology and its risks and benefits, according to evaluations. Nearly everyone found the forum enjoyable and said they would recommend it to others. And as one city official told the evaluator, "I found the fresh input of people who have not been steeped in these issues to be very valuable and even reassuring. ...the level of sophistication of the participants is always higher than I expect." (Kohlmann, n.d.) The museum is working with the Public Health Department to plan more forums on other topics.

Web sites

www.mos.org/events_activities/forum

www.nisenet.org

Photo by David Rabkin

In the Spotlight: Decide—Deliberative Citizens’ Debates

In recent years, science centers increasingly have embraced their role as public forums for discussion of science policy issues. Among European science centers, that effort has been given structure and focus by a program called Decide (Deliberative Citizens’ Debates).

Developed in 2004 by Ecsite, the European Network of Science Centers and Museums, with funding from the European Commission, Decide has engaged thousands of people in discussion of topics like stem cell research, genetic testing, and legal responsibilities of people living with HIV/AIDS. Inspired in part by earlier work by the New Economics Foundation, London, Decide currently consists of “game” modules on seven topics, which are available in 12 languages.



The rapid adoption of Decide has been facilitated by its use of low-tech tools—printed game cards and information sheets—that can be downloaded from the Decide web site.

In a typical Decide event, a science center hosts small groups that meet for 80 minutes. Game materials help the group get started by providing a set of hypothetical roles and perspectives players can adopt and suggesting alternative policy positions on the topic at hand. Following an initial information exchange, the group moves into discussion, then wraps up with a vote. A facilitator keeps the discussion animated, ensures that all participants have an opportunity to speak, and later uploads the group’s votes to the Decide web site so results can be aggregated with those of other groups.

Analysis of video and audio documentation, concept maps filled out by participants, and pre- and post-activity interviews indicate that participation in Decide is not only pleasurable, but effectively encourages people to interact with others around issues, to analyze their own and others’ views, and sometimes to adopt new positions (Duensing and Lorenzet 2007).



The Decide approach has been adopted by groups in India, Malaysia, South Africa, Brazil, and many other countries and used to facilitate dialogue between the public and policy makers about additional issues, ranging from climate policy to garbage disposal.

Web site

www.playdecide.org

Photo by Andrea Bandelli (top)

Photo courtesy National Council of Science Museums, India (left)

Part 4: A Framework for Discriminating among PUS–PES Activities in Informal Science Education

PUS and PES represent two different approaches for envisioning the relationships between publics and science. Current informal science educational activities often incorporate *some* characteristics of both and rarely *all* characteristics of either. Simply sorting programs into PUS and PES bins would not reveal the rich interactions that occur in actual practice between the two approaches to ISE activities.

The CAISE Public Engagement with Science Inquiry Group proposes that the three dimensions—role of the public, role of STEM-related experts,¹⁵ and the content focus of the discussion—be used to map current and proposed activities. The purposes of mapping are to (1) identify potential clusters of interest within the PUS–PES spectrum, (2) be able to discriminate among different types of PES activities, and (3) determine whether the technique involved in doing so is indeed useful to the broad ISE field and its funding agencies. This framework was developed in a working session of the CAISE PES Inquiry Group on the basis of our collective experience with PUS and PES activities. The group then applied the framework to an empirical test of its potential usability.

To explore this method for assessing and differentiating among a variety of activities and mechanisms within the PUS–PES spectrum, Inquiry Group participants as well as others active in PES in ISE contributed a number of “mini-case studies” about activities with which they were familiar. (See Appendix E for brief descriptions.) Within each of the three dimensions, we identified five types of participation, degree 1 being more PUS-like and degree 5 being more PES-like.

The first dimension relates to the question *How is the public involved in the PUS or PES activity?* Five different answers to the question form a rough continuum spanning the space between PUS and PES approaches. These five answers reflect the direction in which knowledge and ideas flow. In degree 1 they flow to the public participant and in degree 5 they flow from the public participant. Another way to say this is that in 1 the public receives ideas and in 5 they transmit ideas. Answers 2–4 represent different levels of involvement in influencing and generating the ideas that are communicated.

- 1) *Publics learn from watching, listening, and viewing lectures, media, and exhibits.* Publics receive information from a variety of sources, in a variety of formats. While individuals may be paying close attention to the presentation, they are, for the most part, passive receivers of a one-way flow of information. Examples might include watching and listening to lectures, presentations, theater productions, video, television, and books; looking at exhibits; and reading labels or online text.
- 2) *Publics ask questions of STEM-related experts and participate in interactive inquiry learning in programs and exhibits.* Publics are actively involved in interacting with the source of information in order to get information of interest to them. This participation may include asking questions of a speaker, interacting with exhibits and other interactive media, searching the web, and choosing topics to learn more about. While the flow of information is primarily one way, audience members choose the topic of some of that information.
- 3) *Publics share views and knowledge with other participants and with STEM-related experts,*

¹⁵ In this report, the term *STEM-related experts* refers to scientists, social scientists, ethicists, historians, policy makers, administrators, educators, and others with expertise in science, technology, engineering, and mathematics.

sometimes referred to as consultation. Publics contribute their own views, knowledge, values, or data. This happens face-to-face or online, synchronously or asynchronously. The flow of information is in many directions.

- 4) *Public participants deliberate with each other and engage in group problem solving.* Publics are guided to participate in deliberation or group problem solving on a particular subject or question. Facilitators or other mechanisms are in place to keep the discussion focused on the topic at hand, ensure that all individuals participate, and help discussions bring to the surface different views drawn from the personal knowledge and values of the participants. These interactions happen face-to-face or online. Information is sought and used to address issues at hand and is contributed by many people.
- 5) *Public participants produce recommendations or reports.* After finishing a deliberation or group problem-solving process, participants collaborate to produce end products representative of their experience. These products are generally aimed at achieving personal, institutional, or public policy change related to science and technology. These collaborations happen face-to-face or online, and range from a written report to a brief oral group report to a simple group vote on an issue.

A second dimension relates to the question *How are people with specific expertise related to STEM involved in the activity?* In this dimension, expert participation ranges from supporting the public communication efforts of others to incorporating the public's thinking into decisions about the experts' own work.

- 1) *STEM-related experts serve as advisors and provide input to the project.* Scientists, social scientists, ethicists, historians, policy makers, administrators, educators, and others with expertise in science and technology contribute ideas, scientific content, and expertise to the program, exhibit, or other informal science educational activity.
- 2) *STEM-related experts actively present their expertise to the public.* They develop and deliver public presentations, create exhibits, videos, or other informal educational materials, and may respond to questions and correct misconceptions. The experts' intentions are to communicate some of their expertise to the public.
- 3) *STEM-related experts work to become skilled and informed communicators.* Experts in science and technology learn to become better public communicators and how to work with public participants who have different knowledge, expertise, and ways of knowing. The experts' intentions are to learn how to become better communicators.
- 4) *STEM-related experts welcome and value participants' input and direction.* They actively seek knowledge from the public, including their thoughts, opinions, values, varying perspectives, and advice. They seek public input to help them solve problems or answer questions. The experts' intentions are to collect data from the public and to learn from these data.
- 5) *STEM-related experts act on participant input and direction.* STEM-related experts work together with publics to solve problems and reach conclusions. They include the voices of publics in their own work, personal thinking, and policy decisions. They recognize the role of publics in institutional and science policy issues.

A third dimension relates to the question *What is the content focus of the activity?* In this dimension, the answers range from understanding the natural world to understanding processes of societal decision making and public policy related to science and technology.

- 1) *The content focus is understanding the natural and human-made world.* This is what we normally think of as science content in disciplines like biology, chemistry, physics, geology, mathematics, electronics, materials science, evolution, physiology, astronomy, genetic engineering, and so on. The emphasis is on phenomena, facts, theory, physical laws, and overarching concepts.
- 2) *The content focus is the nature of the scientific process or enterprise.* The PES activity is about observation, description, classification, modeling, experimentation, engineering, inventing, innovation, and scientific habits of mind. The goals are not so much discerning the phenomena or facts as understanding the processes of scientific investigation or engineering design and understanding what scientists and engineers do and how they generate new knowledge.
- 3) *The content focus is on the societal and environmental impacts and implications of science and technology.* What impacts do applications of science and technology have on the environment, individual people, societies, and cultures? And how do the environment, individual people, societies, and cultures affect science and technology? What are the positive and negative impacts of science and technology?
- 4) *The content focus is personal, community, and societal values related to applications of science and technology.* What values do participants bring to considerations of the application of science and technology in their lives? What kinds of ethical issues are raised in discussions of science and technology? What stakeholder groups exist and how do their values affect their perspectives on the development and application of science and technology?
- 5) *The content focus is institutional priority or public policy change related to science and technology.* How are decisions made within institutions and science policy arenas? Who has a voice? How are diverse views and interests considered? How can better decisions be made? What considerations should be given most weight in decision making processes? What policies should society adopt?

Based on this framework, the contributors scored their own mini-case studies using the draft survey. (See Appendix F.) They assigned a number of 1–5 to each type of participation in each dimension, indicating where each case fell within the PUS–PES spectrum. (See Appendix G for charts of the scoring for 14 mini-case studies as well as exploratory representations of the data.) From this data, we calculated a single score per dimension and mapped the mini-case study results onto a three-dimensional scatter chart shown in Figure 2.

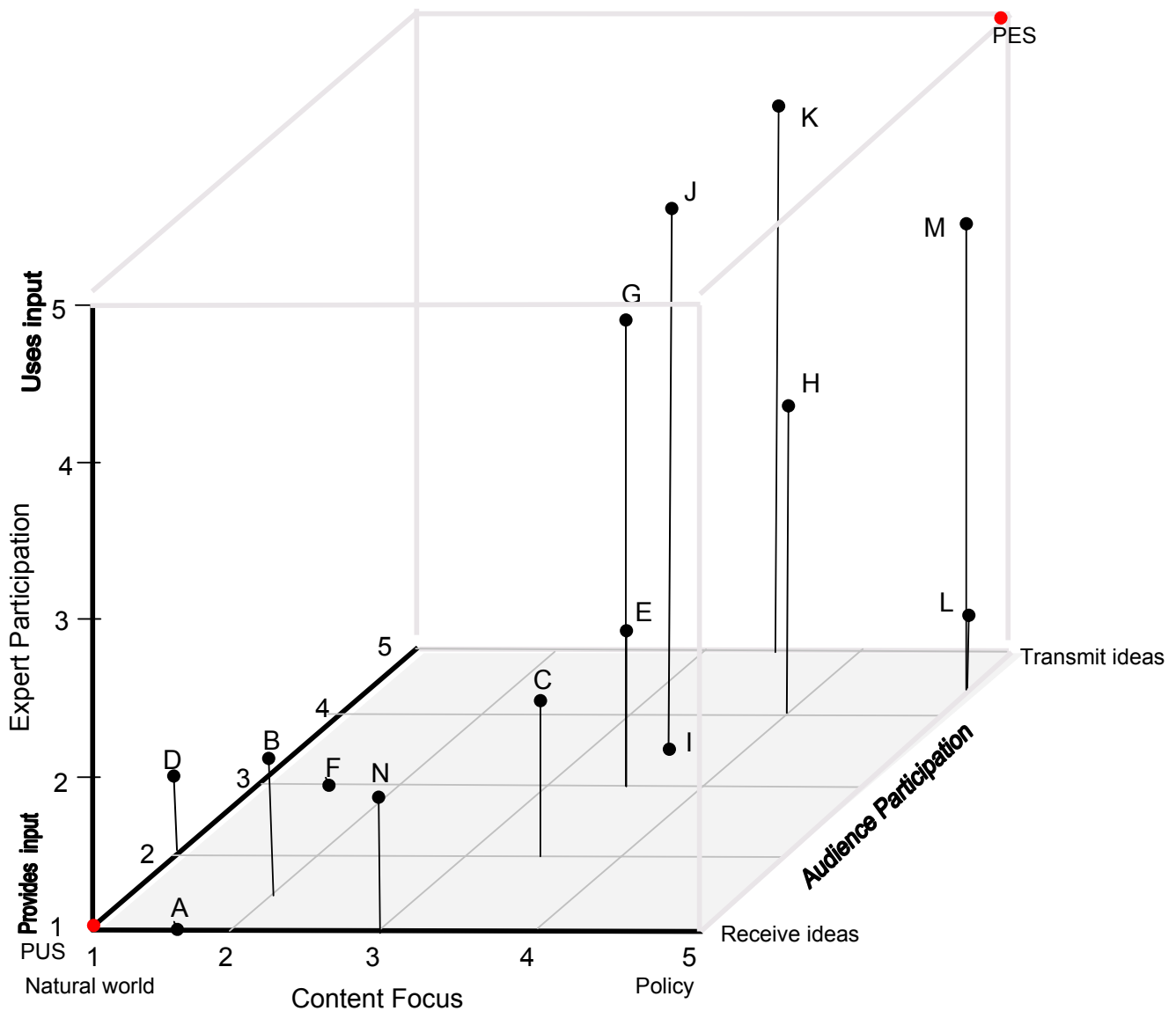


Figure 2. A depiction of the 14 case studies in three-dimensional space, based on the PUS–PES instrument.

Figure 2 shows a cluster of projects (A, B, D, F, N) that have characteristics closer to PUS. Another group (C, E, I, L) has more PES-like content focus and public involvement, combined with PUS-like STEM-related expert involvement. A few case studies (G, H, J, K, M) are much closer to PES than the other cases in our sample. Again, this work is exploratory and is based on an extremely small sample of case studies that does not yet include the breadth of ISE activities. It certainly needs more careful analysis before conclusions can reasonably be drawn. We present it here to suggest a way of looking at characteristics that span the spectrum between PUS and PES approaches to public involvement in learning about science and society. Our preliminary work may suggest an approach to future research in this area.

Part 5: Participants in PES Activities and Their Motivations

PES in ISE is designed to facilitate mutual learning among people of various roles and expertise. Understanding who participates—often referred to as audiences—and these individuals’ motivations for participation can provide useful insight and guidance for those designing, implementing, researching, and evaluating PES in ISE activities. This section discusses the two main groups of participants for PES in ISE, publics and scientists, and what is known about why they participate—their motivations. Research on informal science education indicates that every individual brings preconceived attitudes and perceptions to all ISE experiences, and that these preconceptions affect their motivations to participate (Falk et al., 2007). Because mutual learning by both publics and scientists is a key characteristic of PES in ISE, it is crucial to understand and build upon publics’ and scientists’ motivation to participate in PES.

Publics: Who Are They and Why Do They Participate?

In terms of PES in ISE, “the public” is actually composed of many subgroups who may sort themselves differently depending on the issue at hand. As mentioned in an earlier footnote, the singular “public” is misleading; it is more accurate to identify the various “publics” and their various kinds of interests (National Science Foundation, 1982). In terms of audiences for PES in ISE, publics include everyone who chooses to participate: parents, artists, students, senior citizens, scientists, or youth, just to name a few examples. Publics bring varied backgrounds, perspective, expertise, values, and life experiences to PES activities.

For any particular PES activity, public participants, as well as scientists, policy makers, and others, are the people interacting meaningfully. It is important to note that scientists (and policy makers for that matter) can be publics *concurrent* with their professional identity. Some practitioners, researchers, and evaluators have found it useful to differentiate between scientists who are involved in the planning or implementation of PES activity *as scientists* from those scientists who participate *as general participants (publics)* in a PES activity.

In the science policy arena, some PES mechanisms depend on the participation of people who take an interest in the topic without compensation. Other mechanisms provide a stipend to participants. Compensated mechanisms are often time-intensive or require specific types of participation, including face-to-face and Internet sessions.

In terms of PES in ISE, many informal science educational platforms have a loyal and curious core audience, who will try new formats and programs that ISE platforms offer. Research indicates that ISE audiences are motivated both by entertainment and enjoyment and by learning (Falk et al., 2007). PES activities may also appeal to different audiences that typically attend any particular ISE activity. The following are additional recommendations for motivating publics to participate in PES activities:

- Frame the focus of the PES activity so that it clearly touches people’s lives and values in a direct way (Dana Centre/Science Museum, 2003a). People generally invest time to learn about things when they are faced with a decision, even when it’s just whether or not to buy sunscreen that has nanoparticles in it for their children.
- Connect the topic directly to local, regional, or national policy decisions that have a clear impact on the participants. Even if the topic has no direct influence on policy, its “local relevancy” and the option of becoming knowledgeable and informed to act can still provide people with

an incentive to learn about it. Also, when people know that their voices will be heard and their concerns will be weighed in decisions, they are also more likely to spend time learning about a topic.

Scientists: What Role Do They Play and Why?

In Public Understanding of Science, scientists participate as experts whose purpose is to pass knowledge on to the public through lectures, videos, exhibits, web sites, or other means of communication. In Public Engagement with Science, scientists are generally positioned to share their expertise as one of many parts of the program. Specifically, this means scientists are supposed to listen and learn as well as contribute. Overall, scientists, publics, and others at PES in ISE activities are generally encouraged to work together to generate new (individual and shared) understandings based on contributions made throughout the activity.

The roles of scientists in actual activities vary. They may participate as any of the following:

- Invited scientific experts in experiences such as dialogue events, discussion forums, and science cafés (McCallie et al., 2007);
- A target audience for the activity, such as in the British Academy of Science’s Perspectives program (<http://www.britac.ac.uk/perspectives/index.cfm>) and the AAAS Communicating Science program (<http://www.aaas.org/communicatingscience>); and
- Voluntary publics. For example, in the first year of NISE Net forum programs, in addition to the formal speakers, 20 percent of the audience considered themselves scientists. In other words, being a scientist can be part of one’s identity, but it is not one’s full or only role or identity in society. In addition, the realm of science is sufficiently broad that being a scientist does not mean that one is scientifically knowledgeable or literate in science *writ large*.

In other words, scientists can be part of the *public* target audience. As scientists become more integrally involved in PES in ISE, and as they develop formats and programs that intentionally reposition the role of science in such activities, they directly contribute to the practice of informal science education. Thus, scientists can also be positioned as *ISE professionals* (part of the ISE professional audience).

Participating in PES in ISE is one way researchers can fulfill the “broader impacts” criteria required by various funding agencies. (See Relationships with Scientists, p. 32.) Additional motivations for scientists to get involved in PES activities include their desire for professional development, the benefit they gain from public guidance and inspiration for research, and personal impacts. Because mutual learning by both publics and scientists is a key characteristic of PES in ISE, involving scientists in PES is crucial. (Specific motivations for scientists are listed in Appendix H.)

According to one study, scientists’ intent to participate with publics in the future was positively associated with three factors: (1) previous positive experiences (attitude), (2) feeling that they were in control of their participation (perceived behavioral control), and (3) believing that their peers also participated (descriptive norms). Surprisingly, career recognition and time constraints were not significant factors affecting participation in PES (Poliakoff and Webb, 2007). Because expressed intentions may differ from actual actions, however, additional research is needed to understand actual behavior (MORI, 2000; Poliakoff and Webb, 2007).

Bringing People Together

A key to successful PES in ISE is bringing people together. It is therefore important to create opportunities for internal collaborations within organizations and external collaborations with other organizations or funding agencies that have potential or potential interest in PES. The goals of such collaborations are to (1) build widespread connections between publics and scientific research communities and (2) bring together the breadth of perspectives and knowledge that are needed in order to tackle complex issues meaningfully. Such collaborations can happen in many ways and have varied impacts. One of the challenges PES in ISE faces is finding ways to leverage current opportunities and incentivize additional opportunities so that bridges can be built or strengthened among publics, scientists across the STEM research fields, ethicists, social scientists, representatives of industrial groups, policy makers, and others.

In addition, introducing PES mechanisms into an organization's ongoing operations and priority-setting processes could lead to fundamental changes in how organizations work and the effectiveness of their interactions with publics. Other opportunities could come from infusing PES into funding agencies' solicitations, particularly if support is provided for both practice and research. Such initiatives could lead to building PES perspectives and mechanisms into a wide range of individual research projects as well as addressing broader impacts of scientific work and interests of publics.

What Age Groups Are Appropriate for PES in ISE?

While common PES mechanisms are likely to be oriented toward adults and older youth rather than to younger children, this may not be an inherent characteristic of PES in ISE. Youth and community programs have used PES perspectives or mechanisms as hooks to get younger people involved in learning science and understanding its relevance to their lives. In other words, we may be unnecessarily limiting the breadth of our audiences by saying that, because of the complexities of the issues and the active roles participants are asked to play, PES in ISE is only appropriate for adults and older youth.

Part 6: Taking the Next Step: Getting Involved with PES in ISE

An integral part of the CAISE PES Inquiry Group conversations about PES in ISE revolved around identifying opportunities for those who want to become more involved with or invest in PES in ISE. We identified ways for all interested parties as well as for three specific audiences to get involved. The specific audiences include (1) funding agencies of ISE-related projects, (2) ISE professionals and institutions, and (3) scientific institutions and individuals. (In addition, Appendix A provides strategies for pushing the boundaries of PES in ISE.)

The following is the set of opportunities that were identified as appropriate and open to everyone interested in getting involved with PES in ISE.

Opportunities for Everyone with Respect to PES in ISE

- 1) *Reflect upon ways to incorporate PES into one’s organization or activities.* Some ways to do this include the following:
 - a) Become familiar with the concepts of PES as described in this report and other literature.
 - b) Consider how PES perspectives and mechanisms could align with one’s organization or personal mission and scope of work.
 - c) Evaluate where one’s current offerings fall within the PUS–PES spectrum and take steps to push current boundaries. (See Appendix A.)
 - d) Use the terms “engage” and “engagement” more judiciously, recognizing their multiple meanings.
- 2) *View PES activities as opportunities to expand and diversify the audiences that programs serve, the content areas of activities or portfolios, and the models of learning that are supported.*
- 3) *Support research on and evaluation of impacts, indicators, opportunities, and challenges in Public Engagement with Science.* Though substantial conceptual work supports Public Engagement with Science, detailed empirical analyses are needed, including evaluation of specific mechanisms. A far-reaching goal for some may be to develop ways that PES activities can inform science policy and/or research directions.
- 4) *Create opportunities for internal collaborations among departments, divisions, or directorates as well as external collaborations among institutions.* Such partnerships can bring together a range of expertise and build widespread connections among the scientific research community, publics, and funding agencies. For example, collaborations between scientists and ISE professionals can create innovative PES mechanisms.

Opportunities for Specific Groups with Respect to PES in ISE

Funding Agencies

The following strategies and opportunities are intended to be relevant to current and potential funding agencies of informal science education, including governmental agencies, private foundations,

corporations, and others with interests in building bridges between publics and scientific communities.

- 1) *Add explicit support for Public Engagement with Science to solicitations and portfolios.* This support should be understood as an enhancement of current efforts in informal science education and not as a replacement or redefinition of those programs. Funding agencies that provide support in this area will be leaders in developing new models and platforms for science learning that is lifelong and relevant to individuals, communities, and society.
- 2) *Support issue-specific activities, such as neuroethics, and format-specific PES activities, such as online interactive projects between publics and scientists.*
- 3) *In addition to supporting projects that specifically advance mechanisms of Public Engagement with Science, assess all projects for their integration of PES perspectives into their content.* This opportunity challenges funding agencies and Principal Investigators to consider how PES perspectives may enhance project goals and appeal to broader audiences.
- 4) *Include expertise and procedures in proposal review processes such that Public Engagement with Science aspects of proposals are understood and appropriately evaluated.*

ISE Professionals: Organizations and Individuals

ISE professionals include all those involved in guiding, designing, implementing, researching, and evaluating learning experiences in science that take place outside of school. The ISE community includes professionals working in film and broadcast media, science centers, museums, zoos, aquariums, botanical gardens, nature centers, digital media and gaming, and youth, adult, community, and after-school programs.

- 1) *Connect with other organizations, within and outside one's normal communities of practice, in order to support PES work.* Some ways to do this include the following:
 - a) Support professional development opportunities for ISE professionals. Such support includes networking with others, training, experiencing PES mechanisms and perspectives, and considering how to provide for and document impacts such as awareness, knowledge, understanding, engagement, interest, attitude, behavior, and skills (Friedman, 2008). Professional development allows ISE providers to build on the previous work of others.
 - b) Support opportunities for partnerships with scientists, social scientists, ethicists, other experts, and policy makers in order to produce PES activities.
 - c) Connect with community organizations to codesign PES activities and/or expand audiences, relevance to local communities, and participant involvement.
 - d) Work with the evaluation community to assess outcomes of PES processes by developing specific tools and indicators to measure the impacts of PES.
- 2) *Reflect on one's role in the community and society more broadly as PES mechanisms and perspectives are incorporated into practice.* ISE professionals may find that the roles and identities of their institutions evolve toward serving as a platform for knowledge generation, mutual learning, negotiating, and problem solving. Develop language to express these roles and identities.

Scientific Institutions and Individuals

Scientific institutions include universities, for-profit companies, independent research centers, hospitals, government agencies, scientific societies, professional associations, and some museums. Here we list some ways that scientific institutions and individuals may increase their involvement with PES in ISE.

- 1) *Create a supportive environment for PES mechanisms and perspectives within scientific institutions and activities.* Some ways to do this include the following:
 - a) Identify and network with staff at institutions that have the capacity to coordinate PES experiences, such as staff of ISE organizations and staff of outreach offices of higher education organizations.
 - b) Seek out opportunities to work with organizations that are familiar with PES, including those in the ISE field.
 - c) Develop a process that enables researchers to connect to PES opportunities through their institutions.
 - d) Develop a process for recognizing and rewarding PES participation within the formal institutional structure.
- 2) *Increase capacity for participation in PES in ISE.* Some ways to do this include the following:
 - a) Build skills in public communication for scientists.
 - b) Experiment with implementing various PES activities.
 - c) Build PES perspective and/or mechanisms into the research design and funding proposal stages of research projects.
 - d) Ensure that there are procedures in place that link scientists to PES resources, including those in the ISE field.
- 3) *Develop ways to integrate the information that is shared and learned in PES activities so that the activities can inform science policy and/or research directions.*

Conclusions

Public Engagement with Science in informal science education has many potential benefits—bringing meaning and richness to the lives of publics, contributing to the fulfillment of some of ISE’s pressing goals, keeping scientists energized and involved in their work, and even inspiring the direction of scientific research and science policy making. By bringing together a variety of expertise and skill sets, PES in ISE facilitates opportunities to address complex issues that scientific knowledge alone cannot resolve.

The CAISE Public Engagement with Science Inquiry Group developed working definitions for key terms including PES, ISE, PES in ISE, and publics that may be useful in continuing discussions. We also distinguished between PES mechanisms and PES perspectives, and between PES and PUS. Our group identified ways that PES can benefit informal science education, considerations and factors to take into account when designing and evaluating PES activities, a spectrum and dimensions by which to examine PUS and PES, and opportunities for various stakeholders (funding agencies, ISE professionals, scientists, and publics) to become more involved in PES endeavors.

Many of us in the ISE field have been tinkering with and talking about concepts and practices related to PES in ISE for many years. There are many “right answers,” and this report is intended to serve as a prompt for further discussion, not as an authoritative sourcebook. We seek to push the boundaries of what PES in ISE could mean as well as its effectiveness and impact. We do so by offering up the consensus of a small group of people interested in and committed to broadening dialogue and mutual learning between publics and science. We anticipate that the ISE community will build from this document over time to enhance the usefulness and relevancy of PES in ISE as we collectively seek to serve individuals, communities, and our society.

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Appendix A

Pushing Boundaries: Strategies for Including PES in ISE

There are many ways that ISE providers can push the boundaries of the programs they currently offer to include Public Engagement with Science mechanisms and perspectives. Options to consider include the following:

- 1) Project focus
 - a) Include relevant and controversial topics in your platform or projects.
 - b) If you currently present such topics without using PES mechanisms and/or perspectives, develop ways to include experimenting with them.
- 2) Public involvement
 - a) Support interaction among people as part of normal programming, fostering talk among participants.
 - b) Create mechanisms for exchange and mutual learning. The mechanisms should encourage interaction among publics, scientists, and others.
 - c) Communicate how publics can get involved further and extend their experiences, including means for civic participation.
- 3) STEM-related expert participation
 - a) Think broadly about whose expertise and what expertise relates to the topic of interest.
 - b) Create mechanisms for publics and STEM-related experts to interact in mutually informing ways.
 - c) Incorporate STEM-related experts into projects so that they become equal partners in programming as well as problem solving. This may require training for scientists and staff.
 - d) Ask STEM-related experts to include their personal views of issues and consider societal consequences of their work when they make their presentations. Ask them to reflect on how interactions with other people affect their work.

Appendix B

Commonly Used Terms Describing Public and Science Activities

This appendix describes terms that are commonly used to describe public–science models of interaction. PES and PUS are not included here as they are discussed within the main body of this report.

Public Participation in Science (PPS)

The phrase public participation in science refers to various public–science models. PPS is used in a similar way to PES, particularly in the UK, to indicate public input into policy-related decision making with respect to science-based issues (Joss and Durant, 1995; Rowe and Frewer, 2000). Public participation in science is also used more broadly, particularly in the United States, to refer to any time a non-scientist engages with or participates in science, science-based activities, or decision making around science. PPS activities span the PUS–PES spectrum with respect to the relationship between publics and science.

Public Understanding of Research (PUR), also Public Understanding of Current Research

In the late 1990s, a Public Understanding of Research initiative at NSF sought to educate publics about the content, processes, and societal (social, ethical, and policy) implications of current research in order to promote and increase support for contemporary science (Field and Powell, 2001; Lewenstein and Bonney, 2004). PUR was generally premised on a PUS model of the relationship between publics and science, in which publics learn about science, specifically current research, and from science (Storksdieck, Stein, and Dancu, 2006). One aspect of PUR, learning about the process of science, includes public participation in scientific investigation, such as collecting data for research studies (Ucko, 2004). In some cases, PUR includes dialogue activities aligned with a PES model (Farmelo, 2004). An NSF-funded conference, “Museums, Media, and the Public Understanding of Research,” led to an edited volume, *Creating Connections: Museums and the Public Understanding of Current Research* (Chittenden, Farmelo, and Lewenstein, 2004). This volume provides an extended report on some public–science models.

Public Participation in Research (PPR)

The CAISE Public Participation in Research Inquiry Group¹⁶ suggested defining Public Participation in Research as adults and children taking part in the various aspects of the scientific enterprise that are listed below. This includes projects typically classified as citizen science, community science, and community action projects. This CAISE Inquiry Group has proposed a framework by which to examine PPR projects and to evaluate their impacts. This framework categorizes PPR projects as contributory, collaborative, and co-created. Thus, PPR is considered to span the PUS–PES spectrum and can include various combinations of steps involved in the science enterprise. Because science is often a nonlinear, iterative, and reflective process, the list as presented should not be considered to be in a step-by-step order.

¹⁶ The CAISE Public Participation in Research Inquiry Group report, by Rick Bonney and colleagues, is due out in mid-2009.

- 1) Choosing or defining scientific questions (observing natural patterns; considering answers to previous questions)
- 2) Gathering information and resources
- 3) Developing explanations (hypotheses) about possible answers to questions
- 4) Designing a data-collection methodology (experimental or observational)
- 5) Collecting data
- 6) Analyzing data
- 7) Interpreting data and drawing conclusions
- 8) Disseminating conclusions or publishing results
- 9) Discussing results and asking new questions.

Appendix C

PES and Learning

“...the American public has consistently demonstrated a deep and abiding interest in personally relevant science and technology topics (Falk, 2002; Falk, Brooks, and Amin, 2001; Jones and Stein, 200; National Science Board, 2002), suggesting that many people find science and technology interesting enough to pursue in their free time and that they engage in many kinds of activities that hold the potential for learning about science” (Falk, et al., 2007).

Learning can be defined as a personally and socially constructed way for making meaning in the world. Learning represents changes in an individual’s or group’s cognition, attitudes, beliefs, feelings, and/or behavior. Typically learning involves changes in several of these dimensions. This multi-dimensional conception of learning is supported by the *Framework for Evaluating Impacts of Informal Science Education Projects* (Friedman, 2008), which examines the common types of learning impacts: (1) awareness, knowledge, or understanding; (2) engagement or interest; (3) attitude; (4) behavior; (5) skills; and (6) other.

In terms of informal science education, learning tends to be strongly influenced by personal motivation and identity. It is virtually always a cumulative process. Most ISE experiences are free-choice learning driven by the needs, interests, and motivations of the learner. Some of these experiences can be extremely deep and long-lasting because they involve significant commitment on the part of the learner (e.g., many weekends involved with a citizen science effort or spent studying a science policy issue like nuclear power or genetically modified foods). The deeper the participation, the deeper the identity-related nature of the experience.

Given that many PUS–PES experiences are short-term immersions into science, it is important to appreciate that learning is likely to be a long-term additive process in which an individual takes bits and pieces of information from many sources and continuously adds them to his or her store of understanding. For example, a young woman who attends a science pub night might find that her curiosity is sparked about a subject and might later pay more attention next time she sees a related show on TV or a relevant article in the newspaper. Or, the skills and behaviors a man learns while he participates in an online discussion about global climate change may encourage him to participate in a consensus conference or to consider political candidates’ views on global climate change next time he votes. Hence, what was “learned” at a specific time needs to be “measured” over the long term rather than the short term. This measurement is a challenge for PES practitioners just as it is for most other ISE experts.

PES fits well into ISE learning theories that focus specifically on learning through social interaction, such as socio-cultural approaches to meaning making and social constructivist theories of learning. Because PES experiences in ISE focus on multi-way communication, the pedagogy associated with PES aligns well with the work of learning science researchers and practitioners, science educators, and museum learning experts who have increasingly highlighted the need for “dialogue,” “talk,” and “discourse” as necessary components of learning as well as processes of learning (Alexander, 2005; Andriessen, 2006; Ash, 2004; Bransford, Brown, and Cocking, 1999; Mercer, 2000; Sawyer, 2006). The central idea in much of this research is that people articulate, build on, and solidify their understanding by expressing themselves and actively engaging with others.

Although so far there is little research on PES in ISE environments, recent research and evaluation of PES dialogue events and forums in science museums indicate that participants attend these events because they want to learn about the topic and the current science related to it. Analyses of speech during these events document that participants ask for data and explanations. Participants identify conflicting claims and data and seek explanations or ways of integrating such information (Lehr et al., 2007). In other words, PES mechanisms in ISE can provide resources and opportunities for people to take personal and public action that they can apply to decision making.

In fact, for discussion of controversial science-related societal issues to continue productively, it is crucial for the public to have access to science content. Understanding scientific knowledge and processes is an integral part of exploring, understanding, and eventually making personal and/or societal decisions on science-based topics. Research supports the connection between relevance and learning—people tend to be more willing and more effective learners when they have a direct, personal interest in the topic (Falk et al., 2007), and they are adept at searching out and applying science when it is relevant to their lives (Irwin, 1995; Layton, Jenkins, Macgill, and Davey, 1993; Wynne, 1996).

Appendix D

Potential Impacts of PES-based ISE Projects

As part of the ISE field's overall commitment to research and evaluation, the CAISE Public Engagement with Science Inquiry Group developed this list of potential impacts of PES-based ISE projects. To do so, we drew on the NSF ISE solicitation (National Science Foundation, 2008), the *Framework for Evaluating Impacts of Informal Science Education Projects* (Friedman, 2008), and resources from the NSF ISE Online Project Monitoring System.

Three types of impacts are addressed in the NSF ISE solicitation: target audience, impact evaluation, and strategic impact (National Science Foundation, 2008, p. 14). Target audiences and implications, which are related to strategic impact, have already been addressed in this report. This appendix addresses impact evaluation, that is, the specific impacts of a project on learning.

The following list identifies potential impacts of PES activities.

Behavior

Publics

- Attend or participate in ISE PES activities and contexts
- Attend or participate in non-ISE contexts related to ISE PES topics or activities they've previously attended
- Make decisions or take action based on knowledge and skills
- Make decisions or take actions in situations where there is uncertainty
- Take up STEM-related hobbies or careers. (A wider diversity of people participate in STEM-related hobbies and enter STEM careers because PES mechanisms and perspectives make STEM more relevant to a diversity of people.)

Scientists

- Fulfill "broader impacts" requirements by participation in PES mechanisms and perspectives
- Seek out or bring up how non-science knowledge affects science and science processes
- Seek out non-science colleagues for collaboration, discussion, or conceptualizations of issues related to science
- Seek out or design platforms for PES mechanisms and perspectives
- Acknowledge or analyze issues in terms of multiple perspectives and knowledge bases.

Others

- Policy-makers gain skills similar to scientists
- PES practitioners establish new mechanisms for public input
- Scientists and policy makers establish and use response mechanisms that explicitly include and

respond to public input

Skills Gained

Publics

- Ability to seek out and productively participate in platforms to meet own needs and interests
- Ability to inform policy or to identify opportunities to inform policy and/or research directions related to the development and application of STEM
- Ability to articulate questions or issues of interest
- Ability to interact with multiple participants
- Ability to make more robust personal decisions
- Ability to enter science discussions on own terms
- Ability to reframe discussions about science and science-based issues in terms of other perspectives in addition to science
- Ability to generate knowledge and co-construct meaning
- Demonstrate perseverance when presented with conflicting knowledge claims or uncertainty
- Ability to make decisions in situations of uncertainty or risk
- Ability to think critically about the value and appropriateness of arguments and evidence

Scientists

- Ability to communicate perspectives other than science
- Ability to value and integrate non-science perspectives in terms of science-based issues
- Ability to reflect on or think reflexively about science
- Ability to distinguish or evaluate strengths, relevance, importance of various frameworks, and perspectives related to a science-based societal issue

Others

- Policy makers learn and develop skills similar to scientists

Attitude

Publics

- Value PES experiences and its framing of publics and science
- View science and science-based issues as “for me” and related to “me” (identity) (A wider diversity of people see science as being relevant to them and socially relevant.)
- Expect to participate (or are open to participating) in science and science-based societal issues
- Demonstrate increased trust in science and science policy

- Demonstrate increased skepticism for science and science policy
- Feel empowered to act
- Think of science and non-science knowledge as valuable in times of uncertainty

Scientists

- Value the PES experience and its framing of publics and science
- Take public accountability and implications seriously
- Value multiple perspectives
- View science as a part of a larger culture
- Express that they have learned and changed as part of the PES process
- Are able to move past the construction of “scientists as experts” to “scientists with expertise” who contribute to and learn from a larger community with various insights and expertise. See scientists as part of a larger community and a part of finding solutions, not just sources of “unbiased” information and “answers”
- Show collaborative spirit
- Believe that other forms of knowledge besides scientific data and facts have value
- Want to participate in PES activities
- Have awareness, understanding and knowledge of competing worldviews.

Interest/Engagement

All groups

- Recognize and are interested in science and science-based societal issues
- Are interested in multiple perspectives
- Have a desire to learn new skills

Appendix E

Descriptions of PES Case Studies

1) Fusion Science Theater

Fusion Science Theater (FST) in Madison, Wisconsin, creates lively, engaging, educational science theater events that combine science investigation, demonstrations, theater characters and themes, and participatory segments. The public impacts of these events are (1) documented learning gains and positive attitudinal shifts with respect to interest and sense of empowerment concerning science, and (2) excitement about, interest in, and a desire to learn FST techniques among university science extension/outreach personnel and community organizations staff. Fusion Science Theater events take one of two forms: Science in a Box and the Amazing Circus. The former are mobile shows that run 15–30 minutes, focus on a single learning objective, and are performed by a science educator and actor. The Amazing Circus events are composed of three sets (acts) of science demonstrations/learning objectives performed by a science educator and hosted by circus characters played by community actors. Both forms of FST include Act-It-Out participatory segments that invite the audience onto the stage to physically model the underlying science concepts. To disseminate this ISE technique/event, the Madison FST team recruits and trains cross-disciplinary teams to perform or develop these events in communities across the country.

2) Car Talk

This national call-in show invites listeners to ask car questions of “expert” mechanics. The atmosphere is jovial and almost irreverent. The communication of information is basically one-way, although the choice of topics comes from the members of the public who have car problems. This show aims to solve practical, relevant problems that publics identify for themselves and makes science and technology content accessible and relevant to people’s lives. There is also an occasional segment in which the mechanics ask callers if their “diagnoses” were correct.

3) BA Perspectives

This activity focuses on training and a poster competition for early career researchers on the social and ethical impacts of their research. It is coordinated by the Science in Society program of the British Association for the Advancement of Science and has been funded by Research Councils UK since 2003. It “aims to encourage postgraduate and postdoctoral scientists, engineers and social scientists to explore the social and ethical implications of their research” and trains them to interact with public audiences, specifically at a poster session that is part of a large public science festival. The training encourages scientists to reflect upon the impact that their research has on society and the way that their work has been shaped by society.

4) Flash Café

A science café is an open conversation between a scientist and publics in a casual venue. Many variations on this basic concept exist around the world. This case study focuses on a spontaneous form of the science café, a “Flash Café.” The defining feature of a Flash Café is an audience that did not plan to participate. The organizers of the event select a venue and time where people have gathered for other

reasons (e.g., people at a pub who have gathered there to drink and socialize). An example of a Flash Café is a discussion of genetic testing with an audience of 30 people who came in response to light promotion efforts, and another 35 people who happened to be in the one-room pub when the café began. A buffet of free appetizers and a short video grabbed the attention of those that did not plan to attend. The video was followed by a very brief introduction from a geneticist. The geneticist's presentation was interrupted by comments on the topic from the audience, and a dialogue involving the geneticist, a moderator, and the rest of the pub began. After about 25 minutes this group discussion ended and the geneticist and moderator moved from table to table to meet people face-to-face. The primary goal of a Flash Café is to reach new audiences for science and to shift these audiences' interest and comfort with science.

5) Dana Centre

The Science Museum's Dana Centre, London, implements audience-led processes to engage new audiences and to ensure that events are relevant and engaging public participants. During these processes, members of a target audience help inform the specific topic area, the angles from which the issues are approached, and the format of the event. For example, the Dana Centre held two focus groups to consult members of London's Afro-Caribbean community about a planned event on scientific racism. The publics gave input on speakers, marketing of imagery and text, and objects to display from collections. Consultation with the publics continued via an online discussion forum. One event, "Is Science Colour Blind?" considered whether science can ever be unprejudiced and how science can be inclusive in terms of race. Five speakers presented their work and invited the audience to share their views in group discussions. The event challenged visitors' perceptions about contemporary racism in science and invited them to reflect on the consequences of "scientific racism" today. Another event, "Scientific Racism: A History," considered where the concept of race comes from, how it developed, and the effect that this had on 19th century science. The event challenged people's perceptions about science and race and got people thinking from another perspective as discussion progressed. It also investigated the role of science in slavery and the social constructs of domination and power. This event included the views of historians and geneticists and considered scientific objects from history.

6) Citizen Science

The models for citizen science vary, but one common theme is that publics can make meaningful contributions to scientific investigations. Also referred to as a part of Public Participation in Research, these activities are usually directed by scientists. Publics collect data following scientists' instructions and provide the data to the scientists, who analyze them within their research study. In these cases, public participants are "merely" data collectors. Yet the data that publics find affect scientists and enable them to do their work. The common goal across all of these kinds of activities is to produce more science, but a secondary goal may also be to educate publics about nature or about how science is done.

7) Theatre Workshop in Science, Technology and Society

Theatre Workshop in Science, Technology and Society (TWISTS), based at Virginia Tech, Blacksburg, Virginia, develops mobile performances to facilitate dialogue about contemporary socio-scientific issues. TWISTS employs a novel workshop-based performance-development model that creates interactions between experts on the social and technical dimensions of science and technology (including lay experts) and theatre arts practitioners to generate content. Building on the success of a pilot project on

nuclear power (2006–08), upcoming cycles include Living Darwin (2008–10) and Eat Locally, Eat Globally (2010–12). The primary audience is adults in rural southwest Virginia. Data from pilot project performances suggest that this audience includes natural and social scientists, engineers, and educators, as well as “non-STEM-professional” publics. The objectives of the performances are to support public participants—through performance materials and community dialogue—to gain resources and knowledge to clarify and enunciate their own (and others’) perspectives on socio-scientific issues. The project is premised on the following ideas: (1) “non-STEM-professional” publics should be increasingly involved in upstream and downstream decision making related to science and technology development; (2) necessary scientific knowledge for “non-STEM-professional” publics is science that is connected to the immediate, everyday lives of these publics; (3) performances should also address public-driven contestation over the authority of science (or particular practices of science) in everyday contexts; and (4) science should be understood not as “a single normative framework for rationality but merely one of many resources that people can draw on in everyday collective decision-making processes” as they engage in the struggle to create a more just and equitable world.

8) Communicating Science

Scientists and engineers who foster information-sharing and respect between science and publics are essential for the public communication of and engagement with science. Although traditional scientific training typically does not prepare scientists and engineers to be effective communicators outside academia, funding agencies are increasingly encouraging researchers to extend beyond peer-reviewed publishing and communicate their results directly to the greater public. In response to this need in science communications, the AAAS Center for Public Engagement with Science and Technology has partnered with the National Science Foundation to help scientists and engineers communicate better with the public. “Communicating Science: Tools for Scientists and Engineers” resources include webinars and multimedia, how-to tips for media interviews, strategies for identifying public outreach opportunities, and workshops for scientists and engineers who are interested in learning more about science communication tools and techniques.

9) Decide at Dana

Decide is an informed discussion activity at the Science Museum’s Dana Centre, London, that is conducted in small groups (four to eight people) of friends or strangers. In a typical event, small groups read brief texts printed on cards and discuss issues, information, and stories on one of six different science ethics topics. Events generally last 1½ to 2 hours. The structure of the activity is the same for each topic and is described on a placemat that all participants have in front of them. Many events also have facilitators who introduce the event and informally circulate among the groups to offer assistance or clarification on the activity. People select one or two cards that they feel are key and take turns reading their selections out loud to the group and discussing why they feel they are important. In the later part of the activity, selected story, issue, and idea cards are grouped in clusters that represent key ideas of the discussion. During the final activity, everyone votes on four policy positions. The group decides whether to vote as a group or individually. Many of the DECIDE events conclude with a plenary session in which the small groups discuss and share with the whole group some of the notable outcomes they experienced from the event.

10) Community Science

Community science is similar to citizen science in that publics can meaningfully contribute to scientific investigations, but community science activities are generated by publics rather than scientists and are often called community action science. For instance, consider a town with a water quality issue, where public outcry prompts research into the water supply problems. In some projects publics are asked about their thoughts and views. In other projects they are not directly asked, but their insights are reported and these insights affect the current or future investigations. In still other projects publics “tell” scientists what to do or set priorities through fundraising. This is a switch in roles compared to citizen science, where citizens help a scientist carry out research that is on the scientist’s agenda.

11) Channel 4 Big Art

Channel 4 Big Art is an example of public engagement with art, not science, but it is worth examining here because it is multi-faceted, it happened over an extended period of time (over three years), and it involves multiple stakeholders and expertise, including publics of all kinds, artists, art critics, government, and television. Communities across the UK were challenged to present proposals about why they thought their community should receive public art installations. Applicants had to envision and describe what their community had to offer as a site, what they wanted, and how community members had come together to support the endeavor. These requirements resulted in stakeholders talking across communities that didn’t necessarily interface regularly. An online community forum developed where participants posted images and discussed a range of topics related to art, culture, and the role and value of art in British life. Seven sites were chosen to receive public art, and the Channel 4 Big Art Project plans to continue to explore and debate the questions around Public Art in Britain.

12) NISE Nano Forums

Five science museums in cities across the United States collaborated to develop and present forums for dialogue and deliberation about the societal implications of nanotechnology. The team was informed by characteristics of Danish Citizen’s Consensus Conferences as communicated by North Carolina State University, materials and training by the National Issues Forum Institute, and the Decide Project through discussion with Andrea Bandelli. The common characteristics of all of the NISE Net forum programs are preregistration, a question or challenge to engage the participants, one to three speakers—generally scientists, social scientists, ethicists, or regulatory experts—who give short talks (<15 minutes each), a question and answer period, discussion of the issue at tables of four to eight people (with a facilitator or facilitation tools), and some form of reporting each table’s conclusions back to the group at large. The questions discussed have included the role of publics in nano development and regulation policy, the conditions that should govern the availability of new medical and personal care applications, and how funding should be distributed between future nanotechnologies to solve energy problems and more immediate short-term solutions.

13) Cambridge Nano Forum

The Cambridge Nano Forum was a NISE Net Forum with a twist. For the most part, results of NISE Net Forums have been used to improve the programs. One way to make the programs better is to ensure that the views expressed and the conclusions reached by the participants actually influence science or

science policy. To do this, the programs could be developed in partnership with scientists or policy makers who actually want public input and intend to consider it in their own policy decisions. The Cambridge Nano Forum at the Museum of Science in Cambridge, Massachusetts, was intended to help the city as it considered whether to develop any policies around nanotechnology. The forum was organized around the potential policies Cambridge might put into place regarding consumer products. A representative from the city department of public health attended as a speaker, and a representative for the Commonwealth of Massachusetts attended as a public participant. A speaker and an observer from the Woodrow Wilson Center in Washington, DC, as well as an observer from Arizona State University, also attended. The program provided insight to scientists and policy makers as well as giving the public a role in the processes by which policy is developed.

14) Leukemia and Lymphoma Society Team in Training

Team in Training (TNT) began in 1988, when Bruce Cleland of Rye, New York, formed a team that raised funds and trained to run the New York City Marathon in honor of Cleland's daughter Georgia, a leukemia survivor. The team of 38 runners raised \$322,000 for the Leukemia and Lymphoma Society's Westchester/Hudson Valley Chapter. Team in Training has since grown into the world's largest endurance sports training program. More than 30,000 runners, walkers, cyclists, and triathletes participate in the world's major marathons, triathlons, and century rides each year on behalf of the Leukemia and Lymphoma Society, a major nonprofit public health advocacy, education, and research organization. Much of the parent organization's educational efforts are aimed at patients and doctors. In general, the educational efforts of the Society are very specialized and focused. However, through its Team in Training program the organization attempts to reach out to a much broader public and to increase awareness and knowledge about leukemia and lymphoma.

Appendix F

ISE Project Survey

Informal science education programs across the country engage audiences in diverse ways and at different degrees of participation. We are seeking greater understanding of how the various informal science education projects currently being implemented fit into this broad spectrum of involvement. Out of the many possible dimensions that projects have, we have selected three different dimensions to focus on that we feel help clarify this spectrum. For your projects, please assign a number from 1 to 5, with 1 = not present and 5 = major component.

As many projects have multiple audiences, please begin by specifying the target audience or audiences of your program, project, or activity. If you wish, you may fill out multiple surveys for the same project, each one for a different audience.

Name of the activity:

Submitted by:

Brief description of the activity, audience, and its goals:

For your project or activity, please assign a number from 1 to 5, with 1= not present and 5 = major component.

My project focuses on:

Understanding of the natural and human-made world

This is what we normally think of as science content in areas like biology, chemistry, physics, geology, mathematics, electronics, materials science, evolution, physiology, astronomy, genetic engineering, and so on. The emphasis is on phenomena, fact, theory, physical laws, and overarching concepts.

The nature of the scientific process or enterprise

This is about observation, descriptions, classification, modeling, experimentation, engineering, inventing, innovation, and scientific habits of mind. The goal is not so much the phenomena or facts as the process of scientific investigation or engineering design and understanding what scientists and engineers do and how they generate new knowledge.

Societal and environmental impacts and implications of science and technology

How do applications of science and technology impact the environment, individual people, societies, and cultures? And how do the environment, individual people, societies, and cultures impact science and technology? What are the positive and negative impacts?

Personal, community, and societal values related to applications of science and technology

What are the values that participants bring to considerations of the application of science and technology in their lives? What kinds of ethical issues are raised? What kinds of stakeholder groups are there and how do their values affect their perspectives on specific applications of science and technology?

Institutional priority or public policy change related to science and technology

How are decisions made within institutions and public policy arenas? Who has a voice? How are diverse views and interests considered? How can better decisions be made? What considerations should be given most weight in decision-making processes? What should our policies be?

For your project or activity, please assign a number from 1 to 5, with 1= not present and 5 = major component.

The audience is involved in my project in the following way:

Learning from watching, listening, viewing lectures, media, exhibits

The audience receives information from a variety of sources, in a variety of formats. While individuals may be paying close attention to the presentation, they are, for the most part, passive receivers of a one-way flow of information. Examples might include watching and listening to lectures, presentations, theater, video, television, and books; looking at exhibits; and reading labels.

Asking questions of experts, interactive inquiry learning in programs and exhibits

The audience is actively involved in interacting with the source of information in order to get information that is of interest to the audience. This may include asking questions of a speaker, interacting with exhibits and other interactive media, searching the web, and choosing topics to learn more about. While the flow of information is primarily one way, audience members are involved in choosing what some of that information is.

Consultation, sharing views and knowledge among participants and between participants and science experts.

The audience contributes its own views, knowledge, or data it has gathered to the activity, through discussion with other participants and/or science experts. Participants may share values, personal knowledge bases, and different ways of knowing about topics under discussion. This could happen face-to-face or online. The flow of information is in many directions.

Deliberation with other participants, and group problem solving

The audience is guided to engage in deliberation or group problem-solving on a particular subject or question. Facilitators or other kinds of mechanisms are in place to ensure that discussion remains focused on the topic at hand, that all individuals participate, and that discussions surface different views drawn from the personal knowledge and values of the participants. This could happen face-to-face or online. Information is sought and used to address issues at hand and is contributed by many.



Participants produce recommendations or reports.

After finishing a deliberation or group problem-solving process, participants collaborate to produce end products representative of their experience aimed at personal, institutional, or public policy change related to science and technology. This could happen face-to-face or online. This may result in actual policy change or leave participants empowered to participate fully in social and political processes that shape scientific and technological policy culture in their communities or in society as a whole.

For your project or activity, please assign a number from 1 to 5, with 1= not present and 5 = major component.

Experts in science or technology are involved in my project in the following way:

- Experts serve as advisors and provide input to the project
Scientists, social scientists, ethicists, historians, policy makers, administrators, educators, and others with expertise in some aspect of science and technology contribute ideas, scientific content, and expertise to the program, exhibit, or other kind of informal science educational activity.

- Experts actively present their expertise to the public
They develop and deliver public presentations, create exhibits, videos, or other informal educational materials, and may respond to questions and correct misconceptions. The expert's intention is to communicate some of their expertise to the public.

- Experts work to become skilled and informed communicators
Experts in science and technology learn to become better public communicators and how to work with public participants with different knowledge, expertise, and ways of knowing. The expert's intention is to learn how to become a better communicator.

- Experts welcome and value participant inputs and direction
They actively seek knowledge from the public, including their thoughts, opinions, values, varying perspectives, and advice. They seek public input to help them solve problems or answer questions they have. The expert's intention is to collect data from the public and to learn from it.

- Experts act on participant input and direction
They work together with the public to solve problems and reach conclusions. They give the public a voice in their own work. They incorporate public perspectives into their personal thinking and into policy decisions. They recognize a public role in institutional and public science and technology policy issues.

Additional information:

Appendix G

Dimensions of the ISE Spectrum: PUS to PES

Using the form shown in Appendix F, members of the CAISE Public Engagement with Science Inquiry Group scored each of 14 mini case studies from Appendix E. Most of the case studies included complex mixes of content focus, audience involvement, and scientist involvement. NISE Net Forums, for instance, focus on public policy that reflects personal and community values related to societal implications of nanotechnology. But since the focus is on policy, NISE Nano Forums (L in Table 1) was scored two points for natural and human-made world, two points for process of science, three points for societal implications, four points for personal and community values, and five points for public policy. The program has a mix of all of these things but the point and focus is on policy. (These scores are bolded in Table 1.) So each of the mini case studies has a profile across the three dimensions as shown in Table 1.

Dimension Degree	Focus					Audience					Experts				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
A Fusion Science Theater	5	5	1	1	1	5	2	1	2	1	5	4	4	1	1
B Car Talk	2	3	2	2	1	5	5	2	1	1	2	5	2	3	2
C BA Perspectives	3	4	5	5	2	2	5	3	2	1	5	5	5	2	3
D Flash Café	5	3	2	3	2	3	5	4	2	1	5	5	3	3	1
E Dana Centre	2	3	5	5	3	3	4	5	2	1	2	5	2	3	2
F Citizen Science	5	5	3	3	1	4	3	5	2	2	5	3	2	2	2
G TWISTS	2	2	5	5	1	3	2	5	2	1	5	1	1	5	1
H Communicating Science	2	3	3	5	2	2	4	4	5	1	4	1	5	1	1
I DECIDE at Dana	2	3	5	5	2	2	1	5	5	3	5	2	2	1	1
J Community Science	3	3	5	5	3	3	3	5	5	4	2	3	2	5	5
K Channel 4 Big Art	3	2	5	5	4	2	2	5	3	5	4	3	2	5	5
L NISE Nano Forums	2	2	3	4	5	2	2	4	5	5	5	5	3	2	2
M Cambridge Nano Forum	2	2	3	4	5	2	2	4	5	5	2	3	2	5	4
N LLS Teams in Training	1	2	3	2	1	2	1	1	1	1	2	2	2	1	1

Table 1. Case studies coded for three PUS–PES dimensions.

Using another case, Community Science (J), to illustrate, we chart the scoring for audience and expert participation. We can identify a peak of each curve and assign a single value for each dimension that indicates the location of the peak, in this case audience=3.5 and experts=4.5 (See Figure 3).

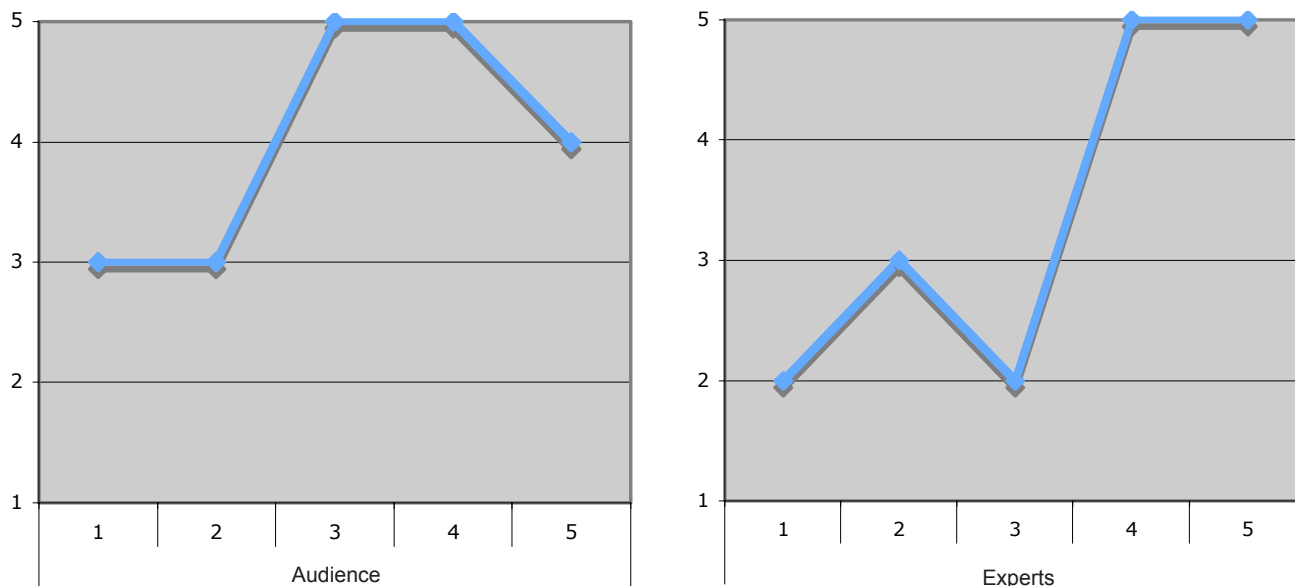


Figure 3. A representation of the Community Science case study (J) depicting how audiences and scientists are involved.

Using this process we can identify a single score for each of the three dimensions for each of the case studies.

Dimension	Focus	Audience	Experts
A Fusion Science Theater	1.5	1	1
B Car Talk	2	1.5	2
C BA Perspectives	3.5	2	2
D Flash Café	1	2	1.5
E Dana Centre	3.5	3	2
F Citizen Science	1.5	3	1
G TWISTS	3.5	3	4
H Communicating Science	4	4	3
I DECIDE at Dana	3.5	3.5	1
J Community Science	3.5	3.5	4.5
K Channel 4 Big Art	3.5	5	4.5
L NISE Nano Forums	5	4.5	1.5
M Cambridge Nano Forum	5	4.5	4
N LLS Teams in Training	3	1	2

These values determined the position of each mini case in the 3-D scatter plot in Part 4 above (Figure 2).

Note about the 14 case studies: If we return to the complex scoring for each mini case study shown in Table 1 and take the average of each column, we can characterize our 14-case sample in terms of the degree of PES-ness for each of the three dimensions. As the chart below shows, our sample is most PES-like in terms of content focus and least PES-like in terms of the nature of expert involvement.

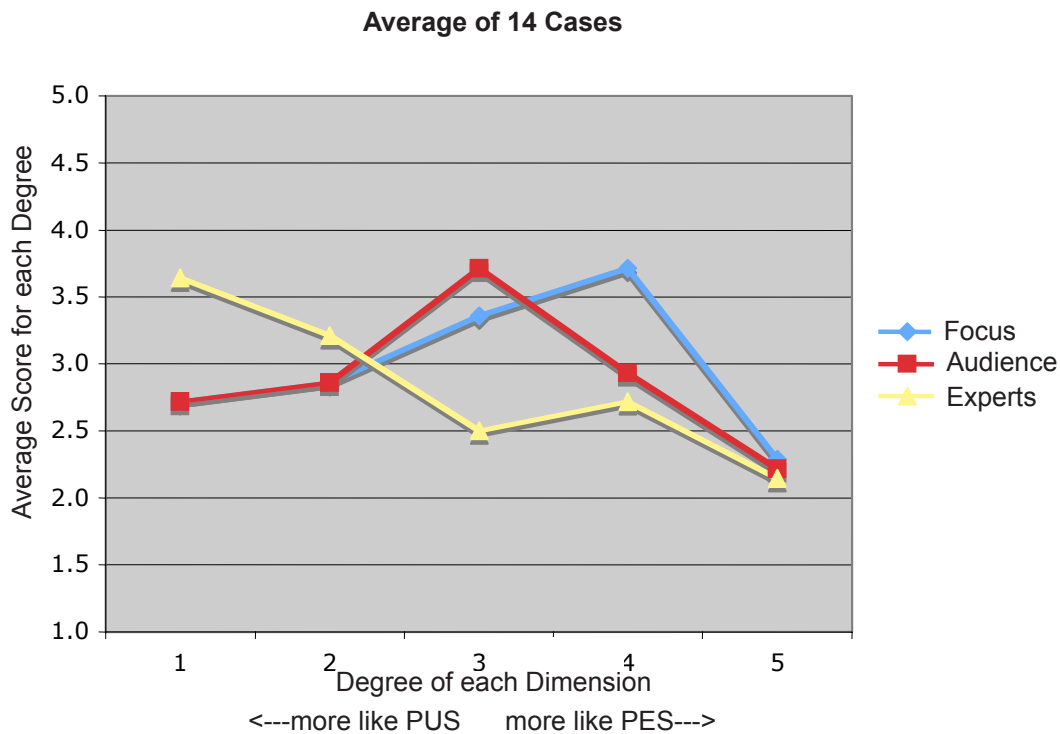


Figure 4: Depicting the mean values for each dimension (focus, audience, and experts) for the sample set.

The average score for audience participation is highest in the middle of the range, which represents sharing views and knowledge among participants and between participants and science experts. If, however, we look more closely at the scoring for the type of audience participation, we see that this sample is fairly evenly spread across different degrees of audience participation, except for the lowest degree, which corresponds to activities like an audience listening to a lecture. Since the case studies in our sample were chosen based on looking for activities that might represent PES in ISE to some degree, it's understandable that our sample is light in more clearly PUS-like activities. But even though we sought to identify PES-like case studies, the data suggests that our examples span the whole range of types of participation that we identified between the PUS side of the spectrum and the PES side of the spectrum

Dimension Degree		Focus					Audience					Experts				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
A	Fusion Science Theater	5	5	1	1	1	5	2	1	2	1	5	4	4	1	1
B	Car Talk	2	3	2	2	1	5	5	2	1	1	2	5	2	3	2
C	BA Perspectives	3	4	5	5	2	2	5	3	2	1	5	5	5	2	3
D	Flash Café	5	3	2	3	2	3	5	4	2	1	5	5	3	3	1
E	Dana Centre	2	3	5	5	3	3	4	5	2	1	2	5	2	3	2
F	Citizen Science	5	5	3	3	1	4	3	5	2	2	5	3	2	2	2
G	TWISTS	2	2	5	5	1	3	2	5	2	1	5	1	1	5	1
H	Communicating Science	2	3	3	5	2	2	4	4	5	1	4	1	5	1	1
I	DECIDE at Dana	2	3	5	5	2	2	1	5	5	3	5	2	2	1	1
J	Community Science	3	3	5	5	3	3	3	5	5	4	2	3	2	5	5
K	Channel 4 Big Art	3	2	5	5	4	2	2	5	3	5	4	3	2	5	5
L	NISE Nano Forums	2	2	3	4	5	2	2	4	5	5	5	5	3	2	2
M	Cambridge Nano Forum	2	2	3	4	5	2	2	4	5	5	2	3	2	5	4
N	LLS Teams in Training	1	2	3	2	1	2	1	1	1	1	2	2	2	1	1

Table 2: Case studies coded for three PUS–PES dimensions. The audience dimension is bolded.

Not surprisingly, expert involvement is least PES-like, as most of our case studies are ISE activities and few involve scientists actually seeking public input about direction or policy. This is an area in need of further exploration.

Appendix H

Motivations for Why Scientists Get Involved with PES in ISE

Scientists may be motivated to get involved in PES activities for numerous reasons, including professional development, the need for public guidance and inspiration to influence research, and a desire for personal growth. Because mutual learning by both publics and scientists is a key characteristic of PES in ISE, it is crucial to involve scientists in PES.

Professionally, scientists may be motivated to participate in PES for many reasons:

- To more broadly disseminate their work to fulfill the public accountability of their institution and/or funding agency (e.g., broader impacts of NSF awards);
- To better communicate their work to public audiences and/or other scientists;
- To achieve a better understanding of cultural perceptions of science in general and their work in particular;
- To reach new audiences, such as policy makers or other decision leaders; and/or
- To directly affect the STEM pipeline by serving as a role model or providing meaningful experiences for others who may enter the STEM workforce or encourage talented students to continue their studies in science and technology.

Scientists may also look to PES for public guidance and inspiration, which may influence research in the following ways:

- Acquisition of new, or shift to different, models and metaphors that shape thinking;
- Awareness and recognition of the cultural context that informs research assumptions, thought processes, or organizational structures;
- Altered research priorities;
- Inclusion of moral and ethical perspectives; and/or
- Information about what products of research are needed and valuable to consumers.

Finally, scientists may be motivated to undertake PES activities for personal impacts, including the following:

- Recognition that they are cultural actors (i.e., that there are broader impacts of research results and methodology) and new approach to understanding the world;
- Added meaning for work (personal validation, feeling of connection, rewarding exchange that sets work in a larger context);
- Emotive stories that shape personal/professional narratives (acquiring stories of others and realizing/refining their own story); and/or
- Gratification from clarifying complicated or confusing topics, particularly on controversial subjects, and an opportunity to personally set the record straight.