

Engagement and Uncertainty: Emerging Technologies Challenge the Work of Engagement

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Abstract

Universities' increasing applications of science and technology to address a wide array of societal problems may serve to thwart democratic engagement strategies. For emerging technologies, such challenges are particularly salient, as knowledge is incomplete and application and impact are uncertain or contested. Insights from science and technology studies (STS) are incorporated to examine the challenges that emerging technologies present to public engagement. Four distinct case summaries of public engagement in the emerging fields of nanotechnology and bioenergy are presented to demonstrate how the emergent character of the technology can stifle engagement. Specifically, the article explores issues related to emerging technologies and (1) defining and engaging with publics, (2) experiential variability among publics, and (3) frame contests. The goal is to sensitize engagement scholars and practitioners to these challenges as a way to minimize obstacles or tensions that may do harm rather than bolster meaningful and democratic engagement processes.

Introduction

Over the past two decades, American universities have demonstrated increasing commitment to advancing a civic mission in higher education. Across the disciplines, students are experiencing opportunities to cultivate civic skills through coursework and practicums; faculty are encouraged to design civic curricula and facilitate external initiatives with various publics; and academy doors are opening to citizens to foster collaborative, symbiotic relations, all for the stated purpose of “connecting the rich resources of the university to our most pressing social, civic, and ethical problems” (*Boyer, 1996, p. 32*). In the 21st century, however, the “rich resources of the university” are frequently touted as those linked to the university science and technology infrastructure.

During the same time, American universities have also demonstrated a commitment to partnering with industry to foster technological innovation and entrepreneurialism, creating a cen-

tral role for universities in “fostering societal development and national economic prosperity” (Tuunainen & Knuuttila, 2009, p. 687). Commercial development of scientific knowledge is facilitated by university technology transfer offices (Carlsson & Fridh, 2002), research sponsored by industry (Lee, 2000), and incubator and start-up business development (Gregorio & Shane, 2003). The alignment of scientific research and industry has numerous consequences identified in a well-regarded body of scholarship (Busch, 2000; Gibbons et al., 1994; Guston, 1999; Kleinman & Vallas, 2006), yet we know little about how to engage publics on issues pertaining to science and technology. In this article, we argue that science and technology present often overlooked challenges that can stifle effective public engagement. Unsuccessful engagement may fracture citizens’ bond with their university, furthering an erosion of trust in science or the university itself.

Such challenges are particularly salient in the case of emerging technologies. O’Doherty and Einsiedel (2013) wrote that

the development of new technologies has been increasing at a rate that is difficult to fathom. Not only do these new technologies and the science that they are based on have inherent complexities, but they also raise novel and often unanticipated challenges related to their integration into society. (p. 1)

For the purposes of this article, emerging technology refers to a developmental stage in which scientific and technical knowledge is uncertain, ill-defined, and in its infancy. Such technologies may be innovations where science is partial or incomplete, or where scientists’ or the publics’ understanding of scientific innovations and their impacts is not yet fully formed. Because of their emergent nature, such innovations are often characterized more by promise than by expedience. As a function of their embryonic stage, their practical contributions to society may be vague, in flux, or contested by scientists and publics (Bijker, Hughes, & Pinch, 1987; Latour, 1991). Is biofuel carbon neutral or does it generate the same amount of greenhouse gases as fossil fuels per unit of energy? Should stem cells extracted from embryonic tissue be used to treat such conditions as Alzheimer’s or Parkinson’s disease? How will a community change when a biorefinery moves into town? Such questions linger as a result of the unsettled nature of scientific knowledge and present opportunities for tension and struggle as both producers and users of emerging technologies grapple with the unknown.

Such tensions are common to emerging technologies, but it is less clear how engaged scholars are to respond to these unknowns in our efforts to connect the university's "rich resources to our most pressing problems" (Boyer, 1996, p. 32). The scholarship on public engagement does not explicitly consider problems associated with engaging publics around scientific issues (Kleinman, Delborne, & Anderson, 2011). We use this opportunity to reflect on our own experiences with engaging publics on emerging technologies to consider implications of this developmental stage of science and its potential impediments to successful public engagement. We define successful public engagement as that which brings together a diverse set of actors—such as natural and social scientists, engineers, development officials, policy makers, interest groups, artists, educators, and citizens—for the purpose of planning and decision making intended to foster meaningful and equitable exchange, serving the common good in a just and ethical manner without doing harm to others or the environment.

Incorporating insights from science and technology studies (STS), we examine the challenges that emerging technologies present to public engagement. We present four distinct case summaries informed by our own scholarship on emerging technologies in the fields of nanotechnology and bioenergy. These case summaries are offered not as "best practices" to emulate but as sketches illustrating some of the most nettlesome areas or opportunities for improvement. These cases demonstrate how the nature of emerging technologies themselves incorporates into engagement difficulties that we were unable to effectively remedy. We specifically explore issues that emerging technologies present related to (1) defining and engaging with publics, (2) experiential variability among publics, and (3) the contested framings of technologies around perceived benefits and risks. Drawing upon our own professional engagement experiences, we hope to sensitize scholars and practitioners to these challenges so that their journey when working with publics around the theme of emerging technologies is not fraught with unnecessary obstacles or tensions that may serve to do harm rather than to enhance engagement processes. Although some of these challenges have no clear corrective, we offer possibilities for reducing such limitations where possible.

An Engaged Scholarship of Science and Technology

Barker (2004) argued "that the scholarship of engagement constitutes a distinct, important, and growing movement in American

higher education that serves to broaden and deepen the connection between scholars and the public realm” (p. 124). Both scholars and practitioners now increasingly advocate that the university return from seclusion to Main Street for the purpose of collaborative problem solving (Barker, 2004; Boyer, 1990; Fear, Rosaen, Bawden, & Foster-Fishman, 2006; Peters, Jordan, Adamek, & Alter, 2005; Stanton, 2008; Wright, 2009). If we are to follow Boyer’s (1990) advice to broaden scholarly work from augmenting a solely academic canon to advancing public engagement that involves faculty and citizens in a mutually beneficial partnership, we must reflexively interrogate the potential impediments to this process.

Van de Ven (2007) identifies three challenges to the development of effective public engagement. First, engagement is fundamentally a relationship between humans that should be mutually beneficial. Achieving mutual benefit through engagement activities may require aligning disparate interests and visions. A second challenge is overcoming the assumption of value-neutrality in scientific work. Despite the widespread tendency to approach uncertain and complex matters objectively, values and power differentials are constants in scientific decision making. Drawing on feminist perspectives, Van de Ven suggests that engaged scholars reflexively assess their viewpoints and those of others, as well as the economic and political interests being served by particular agendas. A third challenge is establishing and building direct and personal relationships. Doing so requires that all partners be physically present to aid in the development of trust and mutual benefit.

The involvement of science and technology in public engagement raises other issues that complicate the process. First, it is worthwhile to note that the shift toward public engagement in science is contemporaneous with shifting societal perceptions that no longer uncritically associate science and technology with the public good (Callon, 1999). Publics are increasingly aware that much investment in science and technology does not align with their values and interests (Jasanoff, 2003), that work in these fields may be structured to advantage some at the disadvantage of others (Berry, 1977), and that contemporary democracies may not be equipped to handle technical controversies (Bucchi & Neresini, 2008). All of the above issues have led publics to advocate for a more democratically informed scientific agenda (Busch, 2000; Callon, Lascoumes, & Barthe, 2011; Sclove, 1995; Winner, 1986). Limited space prohibits a more developed overview of the social context in which efforts at public engagement in science and technology take place. Our

aim is to consider how emerging technologies complicate quality engagement. We begin with science itself.

The production of scientific knowledge complicates efforts at engagement due in part to the technical subject matter, which is characterized by high degrees of complexity, huge capital investments, and unknown consequences with potential to impact large numbers of people. Scientists involved in such topics erect boundaries to distinguish themselves, their subject matter, and their methods from “some less authoritative, residual non-science” (Gieryn, 1983, p. 781). Gieryn (1999) refers to this process as boundary-work and argues that it functions as “strategic political action” (p. 23) by denying challengers access to science and social legitimation. In other words, “real scientists” are set apart from charlatans, and epistemic authority is conferred on the former. Boundary construction is particularly problematic in public engagement because its function is antithetical to the pluralism and cooperation that engagement demands. Boundary-work separates and excludes, stratifying knowledge and privileging some actors and their knowledge over others. As a result of this boundary-work, science and its technological innovations are often scrutinized, contested, and politicized, resulting in uncertainty and dynamism.

Such uncertainty creates opportunities for more diverse forms of knowledge that publics can contribute. Examples include knowledge of a nontechnical nature, knowledge of social and political considerations such as social and ecological impacts, ownership arrangements, distribution and access, social acceptability, human and environmental risks, and other social and ethical concerns that exist in the realm of society rather than science (*van Est, 2011*). Public engagement in decision making or policy on the development of science and technology may also enhance citizenship and instill new bonds of trust while reducing risks (*Callon, 1999; Fischhoff, 1995; Renn, 2008*) and encourage a more socially responsive scientific and technological agenda (*Collins, 1986; Haraway, 1988; Harding, 1991*).

At the same time, uncertainty creates challenges for effective public engagement. It may obscure the identification of publics, especially in the case of emerging technologies. Kleinman et al. (2011) have written on the challenges of motivating public engagement around science and technology issues, but they confine their analysis to motivation for participation. They do not consider the absence of participants, or how the very subject matter may structure participation limitations. In the case of unsettled emerging technologies, *van Est (2011)* has argued that publics may

be unknown or unorganized, or multiple publics may be variously implicated with the emerging technology.

Effective engagement is also predicated on publics' experience with the subject matter under consideration. STS scholars use the plural form publics intentionally as a reminder that civil society is not homogeneous but is composed of diverse and dynamic social groups with variable interests, values, and economic and political resources. Various groups may also be in different cognitive stages of awareness of the technology. For instance, publics may be users or nonusers of the technology, consumers of technological products, or residents of communities located where new technological developments are proposed. More generally, publics may be altogether unaware of the ways scientific and technological innovations impinge on their lives (*Einsiedel, 2008*). Publics may articulate views and advocate positions relative to their evaluation of the acceptability of and potential for benefits or risks they associate with science and technology, or they may remain mute on such issues (*Frewer, 1999; Frickel et al., 2010; Hess, 2007; Slove, 1995*). Moreover, publics are engaged not only as groups with identifiable interests, but also as "imagined groups" (*Einsiedel, 2008, p. 174*). The overall insight is that we should not "flatten" publics into the categories of expert and nonexpert but rather find ways to accommodate the dynamism of publics and their interests and experiences (*Bucchi & Neresini, 2008, p. 463*).

A challenge for public engagement is negotiating these diverse interests and experiences and ultimately bringing together this plurality without undue tension and struggle that divides and segregates. This requires understanding and incorporating the multiple ways that publics experience these technologies. Experience also happens in both direct and intimate ways through the media and interaction with others (*Renn, 2008*). For instance, publics may have direct experience with technology development such as a bioenergy facility located in their neighborhood, or they may experience the same technology only indirectly, such as through interactions with friends, environmental activist campaigns, or via the local media. A common assumption is that increased exposure brings public acceptance or that people warm up to technologies over time. Publics residing near nuclear power plants have been shown to be more supportive of this technology than the general U.S. population (*Freudenburg & Pastor, 1992*). However, other research challenges this assumption, charging that previous experience may also heighten anxiety about new technologies (*Cutter, 1993*). Stoffle et al. (1991), for instance, find that previous experience with nuclear

power can cast a “risk shadow” over new technology proposals. Increasingly, direct personal experience with technologies that are relevant to people’s daily lives is being replaced by interaction with expert sources of information on technologies. As a result, the search for trustworthy and credible sources of expertise has replaced the search for personal control (Renn, 2008).

Experiences vary because the meanings we attribute to technologies are themselves variable (Benford, 1993). Whether or not emerging technologies become relevant in ways that motivate a desire to engage with others is critical. Therefore, the processes by which knowledge is constructed and technologies are made meaningful constitute the third challenge we must consider for effective public engagement with emerging technologies. How individuals—scientists, citizens, and other actors—“know” the issue at hand can be understood in part by how they frame the issue. Framing is the discursive act of making meaning about the world. Goffman (1974) refers to it as the process of locating, perceiving, labeling, and categorizing reality. Frames are filtering devices that are designed by emphasizing some aspects of reality over others (Jasanoff, 2000; Snow & Benford, 1988). In this way, frames help publics clarify what is important about emerging technologies and what ought to be done.

Framing processes contribute to differing interpretations of a technology, its uses, and its impacts. Differences in frames become the battle lines over which technological futures are fought. Questions such as “How might this technology help or threaten my community, my business, my family?” are responded to differently by groups who feel they have more or less control, decision-making capacity, or influence over the outcomes of technological innovations (Wildavsky & Dake, 1990). Moreover, emerging technologies are projects in which industry and government elites have made investments of time, money, and other institutional resources. Publics encounter technologies not as open-ended artifacts and processes but framed by elites as providing social goods (Tierney, 1999). In other words, “the struggle is thus not just technological, but also political (who has the power to decide?) and discursive (how is ‘benefit’ and ‘progress’ defined?)” (Freudenburg & Pastor, 1992, p. 391).

Collaborations between publics, universities, and scientists, however, have historically been plagued by power inequities (Tierney, 1999). These power inequities reflect a tension between the goals of public engagement with emerging technologies and dominant cultural scientific norms. For instance, the boundary-work of excluding laypersons from science is often framed in a

way that portrays citizens as lacking the scientific literacy to engage in meaningful deliberation and decision making. Citizens cannot be trusted because they are not sufficiently informed, goes the common exclusionary refrain. Using the same logic, however, it is conversely argued that citizens are not incapable but simply ignorant. Once enlightened, therefore, they are able to understand science and will share favorable attitudes toward science and technological innovation. In both cases, it is the public, not science, that is framed as problematic (*Bucchi & Neresini, 2008; Einsiedel, 2008; Wynne, 1992*).

Public or “lay” knowledge, however, is not inferior to scientific knowledge, but is instead qualitatively different in that publics often make decisions by weighing facts, values, experience, trust in scientific institutions, and the perception of capacities to use scientific information (*Bucchi & Neresini, 2008*). Moreover, the historical exclusion of certain groups such as women or people of color is of high value to science precisely because of these groups’ traditional disconnect from mainstream science. Marginalized publics, through their cultural embodiment of alternative experiences and knowledge, occupy a privileged position for knowing and experiencing inequalities firsthand (*Harding, 1991*).

Human interaction often involves uncertainty. We regularly confront the unknown and must adapt our behavior accordingly. The uncertainty that arises for engagement in emerging technologies involves incomplete information that results in power differentials whereby all publics are not equally equipped to appreciate the risks of the undertaking. Cook and Emerson (1978) found that when participants in an exchange were unable to compare risks and rewards, the use of power was magnified. Savage and Bergstrand (2013) came to the same conclusion, stating, “Having complete information about the distribution of benefits evokes equity norms that depress the use of structural power in exchange networks” (p. 318). This potential inequality is particularly salient in the case of publicly funded research and development as taxpayer support underlies not only the engagement process but also the science and technology under consideration. In short, when university resources are used to structure uncertainty, they simultaneously structure power inequality and stifle democratic engagement.

Taken together, the identification of publics and their variable experiences with technologies, along with the diversity of frames they construct and dispute, provides a framework to reflexively interrogate the challenges that emerging technologies pose for public engagement. In the next section, we present four case sum-

maries that animate these challenges. Drawing on our own efforts at engaging publics in the emerging fields of nanotechnology and bioenergy, we illustrate how the messiness of identifying publics, their variable experiences, and the frame contests to which they are exposed can complicate progress toward the successful public engagement that can enable problem solving for university–public partnerships.

Engaging Nanotechnologies

Each of the following case summaries was developed by the authors of this article. The summaries were reflexively developed based on our personal observations and interactions with participants during four distinct engagement processes. It is important to note that although the degree of engagement varied in each instance, each author sought to directly engage publics on the topic of emerging technologies to ensure that public concerns and aspirations were consistently understood, disseminated or, where appropriate, integrated into decision making. We view engagement as a generic form of human interaction, ranging from citizen and expert forums to face-to-face interviews and community deliberations. Moreover, following van Est (2011), we see engagement as a broad, inclusive concept that may embrace initiatives ranging from research into the societal impacts of technological development to scholar-initiated formal citizen engagement to citizen grassroots organizing or protest. The diversity of engagement strategies represented in this article reinforces the validity of our conclusions.

Our first two case summaries deal with nanotechnologies. “Nano” refers to nanometers, 10^9 meters, or one billionth of a meter. In principle, nanotechnology refers to the ability of new techniques in the sciences “to control and restructure the matter at the atomic and molecular levels in the range of approximately one nanometer to 100 nanometers, [thereby] exploiting the distinct properties and phenomena at that scale” (Roco, 2010, p. xxxvii). At this scale, materials not only take on unique physical and chemical properties, but can be manipulated to adopt new or enhanced properties such as greater conductivity, durability, flexibility, reactivity, insulation, or catalysis, depending on the shape, size, and other characteristics scientists attribute to the particles. Such abilities are particularly attractive in a number of industries, from sunscreen and sporting equipment to fuel cells and artificial intelligence.

Engaging Experts on Nanobiosensors

Whyte's case summary is based on an expert forum that he coorganized during a 2010 workshop on nanotechnology. The expert forum method is modeled on scientific committee processes in which scientists and industry and government representatives with complementary domains of specialization convene to develop an integrated statement of what is known about a given issue, identify key areas for further research, and disseminate authoritative knowledge to publics. The forum was specifically designed to engage experts in the early stages of development of an emerging technology around the ethical implications of the technology. In this case, nanotechnology has been integrated into biosensors to enable real-time tracking of the identity, location, and properties of livestock in the U.S. agrifood system. The experts in this forum were engineers, technology designers, industry officials, and other nanobiosensor developers. Experts contend that these innovations will improve national food traceability, which in turn will lead to economic and public health benefits. Developers of nanobiosensors see the tracking capabilities as holding the potential to empower a number of actors in agrifood supply chains to exert more control, such as ranchers being able to monitor animal temperatures more effectively and health officials being able to quickly determine the origin of a disease outbreak.

Given the historical impacts of agricultural technologies on social equality (*Friedland, Barton, & Thomas, 1981*), we expected to see challenges for meaningful public engagement regarding the adoption of nanobiosensors. These insights yield two pertinent considerations for engaging with emerging technologies. First, for publics that may eventually become users of the technology, these arguments raise important ethical questions on such topics as privacy, exploitation, marginalization, environmental injustice, and distributional inequities to data access. Whyte and colleagues organized the forum precisely because these issues are rarely part of the expert discourse, the purpose being to engage experts on these technical/ethical issues as early as possible in the hopes that such problems could be reduced when and if the technology is more broadly adopted.

Second, this case illustrates that emerging technologies are linked with emergent publics. As technologies move from secluded laboratories to public spaces, they enroll future publics that are targeted as consumers, end users, adopters, or subjects of new innovations. It is difficult to achieve public engagement at early phases of technological innovation as potential user publics of a given tech-

nology are largely unformed and, therefore, have not yet articulated which risks or rewards they perceive. The groups most commonly aware of these technologies are those whose interests and occupations are tightly linked with the success of a technological application (e.g., early adopting livestock producers, engineers, and government and industry representatives) and the specialists to whom they have access. Groups with access to inside information initially develop knowledge and make claims concerning the range of risks and benefits of the new applications. Such knowledge, however, is itself emergent as long as specifics of applying the technology or its effects on the lives and work of other publics remains unknown.

To address this issue for nanobiosensors, Whyte and colleagues aim to engage in a long-term effort to extend the inclusiveness of participatory decision making by bringing in more publics. This intention demonstrates that, in the present, the range of application possibilities for nanobiosensors is open. Promoters and decision makers are in the process of framing and marketing the technology's potential applicability, yet how this will play out within the supply chain remains unknown. Moreover, it remains unknown whether or how the initial forum shaped subsequent activities.

Organic Engagement with Nanotechnologies

Gehrke's case summary on the public understanding of nanotechnologies uses a method he terms "organic engagement," which is meant to reflect the ways groups initiate their own engagement around emergent technology issues. From 2009 to 2011, Gehrke and colleagues set out to study as well as help facilitate publics' self-initiated engagement with nanotechnologies and nanosciences in order to better understand not only current knowledge of nanotechnologies but also how citizens gather information on developments in nanoscale technologies and make judgments about those developments. They asked, how do groups of people, who are not experts in the sense that they do not have privileged access to information or professional experience with nanotechnologies, make sense of technologies? The technology issues here are similar to those in Whyte's case in that publics have limited access to knowledge and information about, as well as influence over, nanotechnologies. However, whereas Whyte's goal was to engage with experts in order to introduce the ethical concerns of potentially emergent publics, Gehrke's project intentionally sought out preexisting publics who had begun to familiarize themselves with the subject.

Eleven groups from across the United States, including a local church group, civic associations, advocacy groups, and more informal networks, agreed to let scholars observe their learning process. In each case, the cooperating group built its own event on a topic in nanotechnology that appealed to members and related to the group's self-defined purposes. In most cases the group chose a topic, found one or more speakers, and selected a format and venue. In all but one event, speakers external to the group were chosen as guests or experts. In two cases, panels of multiple speakers were assembled; in eight cases a single speaker was brought in; and in one case the members of the organization educated themselves and held their own informational meeting and discussion.

This case reveals three insights about public-initiated engagement with emerging technologies. First, despite barriers to information, few if any social ties with nanotechnology specialists or experts, and a lack of tactile or "hands on" experience with nanotechnology, publics can construct new knowledge and understandings of emerging technologies. Second, when publics develop an interest in nanotechnology, they seek out and rely on information from familiar, trusted sources, which implies that prior relationships are essential in the development of public opinion. Third, even while participants interpreted technologies as removed from their daily lives, they could see potential for detrimental effects from their use. For instance, the collective group discussion reflected an overwhelmingly negative disposition toward nanomaterials in cosmetics and sunscreens, particularly motivated by the lack of labeling for nanoscale ingredients. The absence of labeling heightened the perception of risk by increasing uncertainty around incorporating unfamiliar technologies in items that are not only commonplace but intimate in that they are applied directly to the body. Even those advocating for free market solutions tended to support labeling regulations to enhance consumer information and democratic choice (*Gehrke, 2013*).

For scholars, participation with these public groups sheds light on the ways groups of people construct understandings of new everyday technologies over which they may have little direct control. The aim of participation for engagement scholars, therefore, can be to support publics who self-select as opposed to acting as sponsors who initiate public engagement. For publics, engagement with emerging technologies proceeds first and foremost along familiar, trusted lines.

Engaging Bioenergy Technologies

Bioenergy technology refers to a group of distributed energy technologies that use renewable sources of biomass, such as trees or agricultural crops, to produce heat, electricity, or liquid fuels. Using methods similar to those in coal-fired power plants, bioenergy electricity and heat are produced when biomass is combusted, providing steam used to turn a turbine, which creates electricity for the electrical grid (Tabak, 2009). In recent years, attention to bioenergy technologies has increased as new energy and environmental policies are enacted to support alternatives to conventional fossil fuels. One result has been numerous proposals to site new bioenergy facilities in communities located near biomass resources. However, as the two following case summaries illustrate, at the local community level, bioenergy means different things to different groups of people. For some community members, bioenergy is a renewable energy technology through which communities can develop their struggling economies. For others, however, bioenergy technologies may raise political, health, and environmental concerns or, despite agendas promoting its implementation regionally, be of low importance.

Bioenergy Community Voices

Eaton and Gasteyer's case summary on the community experience of proposals to site new bioenergy facilities follows a project intended to uncover, document, and share attitudes and perceptions of community residents regarding the uncertainties that accompany new technology development. During 2010–2011, Eaton and Gasteyer identified four northern Michigan communities where bioenergy facilities were proposed. Thirty-seven interviews with citizens, activists, and local elites were conducted while the communities were debating the appropriateness of bioenergy technologies. The goal of the engagement project was to better understand the ways communities make sense of and act on possibilities for local renewable energy development (cf. Devine-Wright, 2007). This goal was premised on the notion that a better understanding of these processes might help empower communities to more democratically chart their energy future. Achieving such a comprehensive understanding required that scholars give explicit attention to the claims of marginalized groups whose voices easily become lost under the discourse of economic development articulated by local elites and their partners in government and industry.

Interviews revealed that bioenergy siting can evoke acrimonious responses, dividing those for and against bioenergy (*Eaton, Gasteyer, & Busch, 2013*). At least two pertinent issues in regard to engaged scholarship around such technology disputes became evident. First, frame disputes demonstrate that there is little agreement over what is at stake with emerging technologies. In this case, mobilized residents framed local elites as biased, claiming that they were apologists of industry, able only to toe the pro-industry line and incapable of seeing potential shortcomings. Moreover, residents accused local elites of viewing bioenergy as offering the only path to job creation, industrial development, or renewable energy, and exhibiting no willingness to consider alternatives. At the same time, some residents reported that their pleas to participate in the decision making process were ignored. When citizens pressed decision makers to pursue alternative means to achieve the benefits advocates argued bioenergy would supply, decision makers responded that experts had already vetted alternatives. Local elites argued that the possible paths forward were clear: continued reliance on out-of-state coal or developing a new bioenergy system that would make use of local resources and labor. Clearly, they claimed, bioenergy provided the only reasonable solution. Some questioned this conclusion. Although bioenergy was seen by some as supplying much needed employment and local tax revenue, others argued that the potential collective goods actually benefited those outside the community at the expense of local residents and resources. When questions were raised about the potential for negative environmental, health, and economic consequences, local elites responded by diverting attention away from questions related to the technology and toward the credibility of residents (*cf. Freudenburg & Alario, 2007*). In this way, attention was turned from a discussion of potential impacts on the community to the way refusal to accept the local siting itself would lead to higher energy prices, continued reliance on coal, and a loss of much needed jobs.

Second, interviews also pointed to the importance of trust in technological disputes. Nearly everyone in the community expressed some level of concern for the uncertainties of bioenergy technologies. However, concerns were linked with the level of trust actors expressed for institutional authorities responsible for mitigating technological risks. Trust was evaluated in terms of previous experiences with more familiar technological projects, such as coal-fired power plants and waste incinerators. Overall, engaging with residents and elites by asking them to discuss the ways bioenergy is meaningful to them is empowering in the sense that the

dominant framings of bioenergy can more actively be interrogated and in the process, more localized and contextualized understandings can emerge.

Deliberative Dialogue on Bioenergy

Wright's case summary is based on efforts to engage publics via deliberative dialogue in order to catalyze community discussions on bioenergy development. As illustrated in Eaton and Gasteyer's research, proposals to site new bioenergy facilities can be highly contentious. The purpose of deliberative dialogue is to find ways to bridge such framing disputes and ultimately move toward the collective production of new ways of thinking about and responding to contentious issues. In this case, deliberative dialogue was intended to create a context where citizens could become informed on the technical aspects of bioenergy and also uncover and more broadly share their values and aspirations about energy development within their community. The intent was less about moving toward consensus on some pressing issue, such as bioenergy adoption in the community, than it was to learn how others viewed the issue and develop an appreciation for the diversity of perspectives. In other words, this exercise aimed to allow participants to develop the capacity to understand others' framings and link them to broader social values such as health, economic development, community well-being, and environmental risk. This deliberative process allows communities to eschew expert-driven knowledge and weigh possible lines of action against what the community considers most valuable, then move forward to make collective decisions that honor the geographic and normative values of the place and people who reside there (*Mathews, 2009*).

This engagement initiative had three steps. First, engagement scholars invited key actors in the bioenergy sector—foresters, loggers, nongovernmental organization representatives, environmentalists, community leaders, and renewable energy industry representatives—to a workshop aimed at identifying the salient opportunities, costs, risks, and challenges associated with bioenergy development in the region. Scholars amassed all points presented during the workshop and organized this information into an issue guide illustrating the various challenges and opportunities facing bioenergy and the various claims residents were making about the trade-offs involved in this project. The issue guide presented three scenarios or worldviews commonly offered by participants in the bioenergy debate. A brief video was also produced that showcased the range of views on this issue. These materials became tools to

help publics engage in informed and meaningful deliberation about bioenergy issues and their tensions and trade-offs. Second, Extension educators and others were trained in facilitating deliberative dialogue on bioenergy issues. For the final step, Extension educators held a deliberative forum using relevant materials and their new facilitation skills. Deliberative forums are intended to help community members engage through respectful dialogue, weigh complex and divisive issues, and find context-appropriate responses in a democratic fashion.

The deliberative forum points to the role experiential knowledge plays when engaged scholarship involves emerging technologies. Whereas residents of the communities in Eaton and Gasteyer's project encountered strong positive framings of bioenergy technology, this forum was held in a community where bioenergy issues were removed from the everyday experience of residents. There were no campaigns to champion bioenergy technologies or active proposals to site bioenergy facilities locally nor were there plans to do so in the near future. In this context, the perspectives raised in the issue guide were interpreted by participants as hypothetical and abstract, not as immediate possibilities demanding their attention. Bioenergy had yet to become a personal issue, unlike nanotechnologies in skin care products or the bioenergy proposals in process in other communities. Overall, the challenge was to make the issue less abstract and more relevant and significant to the community.

Discussion

These case summaries provide an empirical basis for identifying and understanding the ways emerging technologies present unique challenges for the successful navigation of engagement collaborations. Below we discuss three issues. First, the context of emerging technologies requires engaged scholars to take into consideration the emergent status of publics. Second, understanding how publics experience technologies requires attention to experiential variability among publics. And third, we discuss how framing disputes over emerging technologies call attention to power inequities. Our hope is that these tensions provide a valuable starting point for analysis of the potential pitfalls to successful engagement around emerging technologies.

Defining and Engaging With Publics

As discussed earlier, emerging technologies are in a state of flux and open to a myriad of possible paths forward. Our cases

demonstrate that the same is true for the publics whose lives are or will be shaped by new technologies. In other words, in the open and at times contested processes of designing, researching, developing, and implementing new technologies, relevant publics, such as users, citizens, farmers, and consumers, are also in various stages of emergence. This perspective contrasts with seeing publics as static groups that have already undergone the social processes of identifying, negotiating, and communicating their interests regarding the design or implementation of new technologies. Instead, these are ongoing processes. We see this in our first case summaries where engagement between scholars and experts on nanobiosensors raises questions concerning publics. When and how will publics encounter nanobiosensors? What will they identify as salient issues? Moreover, how can future interests best be taken into account now during the emergent state of the technology? This case suggests that publics fall along a continuum of emergence, which implies that important collaboration partners may have yet to emerge and therefore cannot assert their values and interests. Such is the central problem plaguing sustainability scholars who struggle to articulate a voice for unknown future generations. The insight for public engagement is that interests and responses of emergent publics may be unknown in much the same way that the future application of these technologies remains undetermined. Emergent publics and technologies therefore raise ethical complications for increasing public engagement as engagement is predicated on an ethic of mutual exchange, collaboration, and the weighing of various interests of publics (*Van de Ven, 2007*), all of which require publics to articulate developed interests.

Additionally, these ethical complications suggest that rather than engaging directly with publics, scientists and scholars can only imagine who these citizens, users, and consumers might be and what interests they might have in the technology. The case of nanobiosensors shows that one way to grapple with this uncertainty is to engage with the technology development supporters in a manner that elicits explicit deliberation not on the specific concerns of future users—which are unknowns—but on historically informed ethical principles (e.g., privacy issues) that can be anticipated to reemerge in the context of new technological applications. This includes recognition that because the totality of ethical principles cannot be fully known or deliberated a priori, leaving room for adaptation is critical, as is commitment to an iterative, long-term engagement process.

Experiential Variability Among Publics

Publics experience technologies both directly, through such means as personal interaction, as well as indirectly, as in media coverage or public relations campaigns. Whether direct or indirect, experience is a precursor to a range of public responses, from support for technological development to motivation to learn more to heightened attention to both risks and resistance. Yet in order for publics to initiate or willingly participate in engagement collaborations, experience alone is not sufficient. Rather, people need to see technologies as relevant to and affecting their personal lives in some significant way. Sociologists use the term experiential commensurability in reference to the active construction of meaningful interest due to the perception of relevance and importance for one's life (*Benford & Snow, 2000*). The cases presented in this article, however, demonstrate that experiential commensurability as well as experience are not inevitable accomplishments. Instead, these cases indicate the need for an examination of the ways engagement around emerging technologies takes place across a continuum of magnitudes of experience and relevance. Most importantly, engagement around emerging technologies calls attention to various degrees of non-knowing or ignorance, terms we invoke in reference to an absence of certain types of knowledge, information, or experience as well as a sense of relevance for emerging technologies (*cf. Frickel et al., 2010*).

The case summaries of nanotechnology engagement illustrate this in two different ways. In Whyte's case we see that engagement between scholars and nanotechnology experts takes place at a point in time when publics have not yet experienced the technology because the technology itself is embryonic. This results in a complete lack of experience and awareness on the part of publics who, as discussed above, have yet to emerge in relation to potential applications.

In Gerhke's case, we can assume that nanotechnologies are indeed relevant as evidenced by the efforts of these publics to come together on their own to learn more about ways these technologies may affect their lives. The character of nanotechnologies, however, raises important hurdles for experiencing the technology. On the one hand, nanotechnologies are remote from everyday experience in the sense that they are invisible and intangible. Moreover, these publics, unlike the experts and specialists in Whyte's case, are excluded from industry and policy decisions about design, research, and application. Experience then is wrapped up with notions of potential risks and benefits to consumers and framings

that are manufactured by industry and scientific elites who decide nanotechnology applications. Despite the abstracted experience of nanotechnologies, these technologies are indeed deemed relevant by these publics. However, the lack of transparency in labeling heightened the sense of risk that these publics expressed regarding nanotechnologies that were introduced in unknown ways into everyday personal consumer products.

Experience and relevance are also important in another way. Irrelevance not only can stem from a lack of experience, as the nanotechnology cases underscore, but can also be a strategic response to technologies. This may include intentionally ignoring or distancing oneself from the technology. In other words, ignorance can function as its own way of understanding technical information. For instance, when sources of information are distrusted, seen as irrelevant, or considered beneficial only to others, publics may intentionally ignore scientific and technological information and projects (*Wynne, 1996*). This is illustrated in the deliberative dialogue bioenergy case, which occurred in communities that perceived bioenergy as distant rather than imminent. Without such factors as a proposed new bioenergy facility in the area, there was little incentive to begin the process of constructing meaningful understandings that would underscore the relevance of public engagement with others on the issue. The goal of facilitating a meaningful deliberation over the ways bioenergy might impact the community was thwarted by intentional ignorance when publics framed bioenergy development as something that happened elsewhere and to other people. Overall, the issue failed to resonate with participants because the problem lacked a sense of immediacy. Absent a grounded context in which to understand and interact with the technology, discussions of risks and benefits remained nebulous and remote. The implication is that encouraging dialogue on the subject will not bring about public engagement with emerging technologies in the absence of experiential commensurability.

This final case in particular suggests that successful engagement around emerging technologies may require looking beyond the role of experience and relevance and into the realm of ignorance. Engagement practitioners need to recognize the perception of irrelevance as providing its own distinct barriers to successful engagement. This includes not only a lack of awareness or challenges to direct or indirect experiences but also the intentional neglect of scientific information. In response, historically informed and relevant analogies can be marshaled to enhance the relevance of the technology.

Framing Contests Over Emerging Technologies

If emergent publics and the lack of a sense of immediacy point to a deficit of meaningful engagement opportunities, framing disputes reveal the opposite extreme. Framing, as demonstrated in the above cases, refers to established perspectives on emerging technologies. Moreover, framing contests point to attempts to impose one set of understandings at the expense of others. In this context, engagement is complicated by distrust, fear, or ambivalence toward authorities, experts, and others who seek to introduce new technologies and inform and educate publics on their applications (Wynne, 1996).

The controversy over bioenergy in Eaton and Gasteyer's case demonstrates the ways publics, experts, and other relevant actor groups develop competing frames to make sense of and describe the positive and negative prospects of bioenergy. However, the frames of publics and of scientists do not rest on an equal footing. They reveal challenges over the credibility and authority of scientific and technological knowledge. Although the frames of scientists and of industry and regulatory spokespersons often have the upper hand in terms of credibility and authority, publics such as community residents where new bioenergy facilities are proposed for siting often see reality differently. For instance, environmentalists and community organizers marshal counter-frames and competing science to challenge overly enthusiastic interpretations. Universities have often aligned themselves with science and industry, leaving publics deemed disparaging or critical, such as oppositional social movements, outside the engagement process. This has resulted only in increased resentment, distrust, and alienation—not the sort of social relations necessary for democratic problem solving. Promotional frames are constructed by actors privy to select information who may have personal or professional (or economic) stakes in a positive framing of new technologies and applications (Frickel *et al.*, 2010). In Whyte's case of nanobiosensors, experts claim that introducing these technologies into agricultural systems will enhance food traceability and therefore consumer welfare. At later points in time, when publics arrive on the scene, they will encounter nanobiosensors as technologies that provide widespread social benefits, a frame carrying the full weight of scientific and regulatory authority and credibility. In this context, introducing critical assessment will be difficult. The insight for successful engagement is that technologies cannot be divorced from the range of interpretations of them, nor can they be framed

in alternative ways without contesting the credibility of dominant frames and frame makers.

Engagement practices therefore must recognize the diversity of competing framings of technologies. This illustrates the ethical bind scholars must negotiate within the context of emerging technologies. On the one hand, engaged scholars need to be open to alternative framings and a broad range of understandings while remaining sensitive to the influence and inevitability of their own framings. Taking such a position could be seen as a positive attempt to remain objective and act as an honest broker of scientific knowledge (Pielke, 2007). On the other hand, in the absence of defining their own position on technology issues, scholars who attempt to remain neutral increase their susceptibility to being framed negatively by those with whom they engage. It is the uncertainty associated with emergent publics, the diverse experiences of publics, and the competing frames of emerging technologies that create this bind. Engaged scholars can respond to this impasse through the design and intent of their engaged work that foregrounds inclusivity of participation as well as the credibility of all frames. This includes placing scientific frames on an equal footing with non-scientific frames. As our cases demonstrate, different approaches embody assumptions about the best approach for different contexts, such as who to engage when publics are emergent; interests are obfuscated by issues of public ignorance or public perceptions of relevance; and frames and technologies are difficult if not impossible to separate.

Conclusion: Implications of Emerging Technologies for Engaged Scholarship

In this article, our objective has been to begin a discussion of the unique ways emerging technologies complicate the already difficult task of reenvisioning and shifting university resources toward public engagement practices. Our own experiences demonstrate that emerging technologies complicate the already difficult task of university–public collaborations in at least three distinct ways. Publics, like technologies, are emergent and fluid. Engagement may take place at different phases of the evolution of publics, including their cognitive awareness of a given technology. The experience of emerging technologies is also varied, and particular attention needs to be given to publics' views of technologies in their daily lives, which may include both relevance and ignorance. Diverse frames remind us that technologies are often contested and meanings varied. It is necessary to embrace multiple interpretations of

technologies and their implications for publics to achieve socially inclusive engagement.

Our findings have implications not only for engaged scholars but also more broadly for a scholarship of engagement. The issues raised by emerging technologies can be read as contributing new implications and insights into the challenge of encouraging civic responsibilities such as taking an active, participatory role in science and technology decision making and policy. There has been increased attention to shifting from a “rights”-based citizenship toward one that emphasizes civic responsibilities. However, the ways that emerging technologies may enroll emergent, unsettled publics; the difficulties of relying on experience for social evaluation of technological possibilities; and the ways that frames of emerging technologies are built on power and inequities present unique hurdles to increasing democratic public participation. Commonly assumed hurdles such as limited access to resources of time and money on the part of publics seem inadequate to explain publics’ varied approaches to emerging technologies. In this context, barriers to engagement are less matters of individual action than they are structural elements that stem from the emergent nature of the technology.

A second implication is the need for engagement scholars to pay closer attention to the growing diversity of perspectives on science, technology, and their associated frames within the modern university, especially within research universities. As universities devote ever-increasing attention to the economic potential of science and technology, the scholarship of engagement cannot continue to turn a blind eye to the associated political, social, and ethical issues hidden behind a cloak of objectivity. As we have argued above, a growing scholarship on public participation in science and technology takes a critical look at the way power, inequality, and privilege are woven into these fields. This scholarship is therefore well suited to address these important social issues. It is our contention that the scholarship of engagement should draw on this body of scholarship and, in doing so, develop a more nuanced critique of the role of university science and technology in society.

Because we have painted emerging technologies with a broad brush in this article, we have not attempted to discuss the nuances of various types of technologies. Surely all technologies are not the same and thus bring disparate challenges for engagement. We might expect more challenges when the technological stakes are higher, for instance. Publics may prove more easily engaged in medical decision making than in issues of energy or agriculture.

The theoretical implications of this study must be undergirded with empirical support. Future research should test the propositions put forth in this article with different types of emerging technologies.

A second fertile area of research is the way the modern university enables public engagement around emerging technologies. In a time of budget constrictions, the role of the university as economic actor is growing. How does this role contour public engagement? If we are to connect “the rich resources of the university to our most pressing social, civic, and ethical” (Boyer, 1996, p. 32) scientific and technological problems, we must begin by recognizing that the act of problem solving via public engagement is complicated by the emergent and unsettled state of the technology and the associated publics as well as by the discursive contests surrounding the technology that vie for our support. The role of the university in framing these contests and supporting some publics while obscuring others is a critical topic for investigation. More research is needed to examine the processes by which the university structures engagement opportunities in ways that may facilitate or inhibit democratic processes.

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