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Comment

Identifying What Matters: Science Education, Science Communication, and Democracy

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Many people believe that both public policy and personal action would improve with better access to "reliable knowledge about the natural world" (that thing that we often call science). Many of those people participate in science education and science communication. And yet, both as areas of practice and as objects of academic inquiry, science education and science communication have until recently remained remarkably distinct. Why, and what resources do the articles in this special issue of *JRST* give us for bringing together both the fields of practice and the fields of inquiry?

Disciplinary boundaries are not fixed. As new knowledge emerges, fields shift focus, adopt new research modes, elaborate new theoretical models. In some fields, such as history or literature, the academic discipline (as defined by university departments) stays the same but the questions change. In other fields, new disciplines and departments emerge: molecular biology, information science, or biostatistics. Some fields change name, such as the shift at many universities from "chemistry" to "chemical biology." But we know that all these changes are not simply logical shifts in focus. Rather, they demonstrate the socially-constructed nature of (academic) boundaries, the push and pull of different groups laying claim to particular areas of inquiry (Hilgartner, 1990; Star & Griesemer, 1989).

In this case, as both Davis & Russ and Feinstein note, science education and science communication as disciplines emerged from different arenas of social practice, at least in the United States, the context I know best. (Notably, they did not develop as offshoots of other areas of social science investigation, such as psychology or sociology; they are inextricably linked with their practical origins.) As the professionalization and study of education grew in the 19th and 20th centuries, concerns about how best to define and offer a science curriculum grew as well (Cuban, 1999; DeBoer, 1991; Jenkins, 1994). Meanwhile, as science journalism grew in the mid-20th century, journalism educators and researchers began to explore issues of science communication (Friedman, Dunwoody, & Rogers, 1986; Krieghbaum, 1957,1967). Only after science museums also took on education as a mission (Rader & Cain, 2014) did researchers who focused on learning science in informal environments – a field often distinct from research on education in schools – begin in the late 20th century their attempt to define a field (Crane et al., 1994; Falk and Dierking, 1995; Falk, Donovan, & Woods, 2001; Rahm, 2014).

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By the end of the century, a few researchers had begun to notice the similarities across the fields (Druger, 1988; Evered and O'Connor, 1987).[1] The social boundaries prevented easy exchange, especially among the academic analysts. Education researchers, journalism scholars, and museum studies workers sat in different departments and schools, published in different journals, attended different meetings, relied on different intellectual models and traditions. But increasingly, the researchers (if not the practitioners) found each other – at meetings of the American Association for the Advancement of Science (Friedman et al., 1986), in a British research community responding to funding unleashed by a 1985 Royal Society report on "public understanding of science" (Gregory & Lock, 2008), at specialty meetings organized around topics of mutual interest (personal anecdote: I'm a historian of science who studies the history of science journalism; I first met John Falk, a psychologist interested in free-choice learning, at a 1997 meeting on public opinion about science organized by political scientist Jon Miller on the occasion of the 40th anniversary of the Sputnik launch).

In the late 1980s, as results emerged from the projects that the 1985 Royal Society report had engendered, researchers discovered that few journals would publish full research reports on work addressing science and public. Because the research focused on "science," rather than on theoretical questions in education or communication, it was of little interest to the increasingly professionalized academic disciplines. But as social science, it was of little interest to the science journals. By 1992, the journal *Public Understanding of Science* had been created to provide a venue for these publications (Durant, 1992). Within two years, the journal *Knowledge: Creation, Diffusion, Utilization* had changed names to *Science Communication* (LaFollette, 1994). A 1989 meeting in Poitiers, France, on "Communication Publique Scientifique" had become, by the mid-1990s, the International Network on Public Communication of Science & Technology (PCST), with conferences by 1996 in Spain, Canada, and Australia (Catapano, Fayard & Lewenstein 2003).

The social networks were growing, but the intellectual connections still required work. The PCST Network, for example, explicitly rejected "education" topics at its early meetings, arguing that it was focused on "the public," not on schools. Then, in 2002, the PCST meeting was held in Cape Town, South Africa. The organizers there, just a decade after the fall of apartheid, argued that we couldn't draw such a clear line – some of the best science education in the country came from science museums and aquariums, and from science journalists who explicitly wrote about what people needed to learn to move the country forward (Lewenstein, 2003). By the mid-2000s, the potential for linking museum studies, science education in informal environments, and media studies appeared ripe, leading the U.S. National Science Foundation to fund the study *Learning Science in Informal Environments* (Bell, Lewenstein, Shouse, & Feder, 2009). According to a recent commentary in this journal, that report and a companion volume (Fenichel & Schweingruber, 2010) were "fundamental in helping define a field that has a complex history and remains ill- defined" (Rahm, 2014).

The articles collected here are among the first to explicitly take up the challenge of moving beyond definition to intellectual engagement. One feature of work at the socially-contested boundaries between fields is that shared terms may be used as if they mean just one thing, though in fact the different fields may mean different things. In some cases, the ambiguity inherent in the creole of these "trading zones" (Galison, 1997) allows for progress; in other cases, the discovery of a lack of shared meaning prevents progress. The articles in this issue identify both of these situations.

Some of what these articles add is scope: from the micro-reading of individual science journalism articles by Davis & Russ to the broad social theory of democracy covered by Feinstein's account of the Lippmann-Dewey debate. Some of what they add is conceptual rigor,

using theoretical tools like Theory of Planned Behavior (by Besley et al.) or framing (by Davis & Russ). The articles point to the importance of methodological rigor, as Blanco-Lopez et al.'s description of the Delphi method demonstrates.

On two issues – science literacy, and the difference between "education" and "communication" – these articles highlight challenges that have been faced again and again, with little resolution; indeed, one might conclude (as I have) after the detailed expositions here that continued attention to these questions is not productive, for it becomes the equivalent of rearranging the deck chairs on the Titanic.

Consider science literacy. Both science education and science communication are motivated by science literacy. But their understanding of what that is or might be are substantially different. Initial attempts to define science literacy in the communication world focused on surveys of public knowledge, both in the United States and in other countries (Miller, 1983, 1998, 2004, 2011, 2014). While the data from these ongoing surveys constitutes an extraordinary longitudinal database of great value, interpretation stalled as the value of the surveys beyond polemical purposes became unclear (Bauer, Petkova, & Boyadjjewa, 2000; Bauer & Schoon, 1993; S. Miller, 2001; Toumey et al., 2013; Wynne, 1991). Current science communication research emerged from dissatisfaction with the "deficit model" the surveys seemed to represent and has focused on a "dialogue" or "engagement" model in response (House of Lords, 2000; Ziman, 1991, 1992). But beyond various programmatic statements and caricaturing of "science literacy" as being defined by simple measurement of scientific facts, science communication research until recently has made little attempt to more robustly characterize science literacy. A few recent studies have started to redress this problem (Allum, Sturgis, Tabourazi, & Brunton-Smith, 2008; Bauer, Allum, & Miller, 2007; Kahan et al., 2012; Stoneman et al., 2012; Stoneman, Sturgis, & Allum, 2012), but the conversation is not yet widespread in the science communication community.

Science education, on the other hand, has had a vigorous discussion of ways of defining and measuring science literacy, as both Davis & Russ and Blanco- Lopez et al. describe in such nice detail that I will not repeat here. Yet even their thoughtful surveys, with references to other reviews (especially DeBoer, 2000; Laugksh, 2000; Norris, 1997; Roberts, 2007), miss a key issue: the focus of science education almost exclusively on individual learners. A few efforts to explore family learning (Borun, Chambers, & Cleghorn, 1996) and the even broader concept of community learning (Roth & Calabrese Barton, 2004; Roth & Lee, 2002) point to the possibility of a more socially-oriented meaning of science literacy. Still, this plethora of meanings worries me: any attempt to definitively state the scope of science literacy will always be subject to differing conceptual frameworks. Future researchers will either have to choose particular meanings of science literacy or – more likely – abandon the label altogether. No single definition captures the richness of the ideas.

One could argue that a similar situation holds with the multiple meanings of "framing," for three of the articles here (Besley et al., Davis & Russ, and Feinstein) find the need to choose a particular definition of framing from among the diversity of definitions created by scholars. But I think their examples highlight the problem: while they have been careful to specify their meaning, they need to do so because most other researchers have missed the nuances and continue to muddy the waters about what "framing" means. The same situation holds, I fear, for science literacy, where failure to push hard on definitions means that important intellectual connections have been missed.

For example, few researchers in either science education or science communication have sought to trace the key idea of "deficit model," which is central to many discussions of public communication of science and technology. But seeking its origins is instructive, for the idea of deficit model was probably appropriated from the science education literature by those concerned

with science in public. Missing that appropriation means missing the ideal of democracy that ties together the fields. One of the earliest references to the deficit model in the science communication literature appears in Wynne's (1991) summary of research projects established in response to the Royal Society's (1985) "Bodmer Report" on public understanding of science, where Wynne refers to "a simple 'cognitive deficit' model of the public understanding of science." Some years ago, I asked Wynne if he recalled where he got the term; he did not, but thought it likely that it had been used in meetings of the various research projects working on public understanding of science at the time. Some of those projects, such as ones involving Layton and Jenkins (Layton, Jenkins, MacGill, & Davey, 1993), emerged from the science education world, where the cognitive deficit idea was already in use. A 1987 report on mathematics education, for example, referred to "a 'deficit' model of learning. . .reflecting what Paolo Freire (1970) referred to as a 'banking conception of education'" (Romberg and Stewart, 1987). The reference to Freire is key, for his conception of education was explicitly tied to Marxist ideals of overturning oppression of the masses, of seeking a better democratic society.

As Davis and Russ point out (as do Baram-Tsabari and Osborne in their editorial in this special issue), both science education and science communication as fields were originally motivated by a commitment to democracy. But while the science communication field has kept a focus on broad political goals, science education has moved away from political concerns toward the individual learner. Feinstein is explicit: The Lippman-Dewey debate about democracy is not part of the science education discussion, and neither Lippman's *Public Opinion* nor Dewey's *The Public and its Problems* have been cited in this journal,[2] highlighting the lack of interest in much of the science education community about political context.

Yet, as Blanco-Lopez et al. detail, concerns about civic responsibility are fundamental to most debates about science literacy (or "competences," the shift that Blanco-Lopez et al. describe). The failure of science education literature – and, indeed, most science communication literature, as well – to engage seriously with issues of democracy and democratic theory is a substantial failing. The only sustained work in this area comes from those in science studies who have theoretical apparatuses, such as "co- production," for connecting public, science, and democracy (Jasanoff, 2014; Wynne, 2007, 2008; Yearley, 2000). But the science studies community has few of the tools for implementation and assessment that science education and science communication offer. I will return to these issues of democracy below.

The second broad area that these articles fail to resolve is one that might seem fundamental: the distinction between education and communication. Nowhere in these papers did I see an explicit attempt to define the difference between the two fields. They were distinguished by domains (classrooms vs. media, mostly), rather than by function or achievement. Feinstein points to science education's attention to science *qua* science, while communication researchers have instead sought to understand the place of science in the daily lives and social settings (including national contexts) of individuals. That's a start. A couple of years ago, I tried to find a succinct distinction, and failed. Pasting together the lines various people sent me yielded:

> As a field of study, "Education" focuses on changing people's conceptualizations. The goal of education is to change thought processes, systems of thought, schemas of critical thought and analysis. Parts of the "Education" field explore institutional and policy aspects of (primarily) the formal education world, in part because that field is a major institutional presence in modern societies. But the reason for exploring those institutional and policy issues is largely to see how they can better support the underlying goal of changing individual thought processes and conceptualizations.

> As a field of study, "Communication" focuses on social influence and persuasion. In this framing [!], communication looks at information exchange and the co-construction of meaning among participants in the communication process. Communication focuses on changing specific knowledge, attitudes, and behaviors, rather than the overall process and schemas of thought. As with the field of "Education," some aspects of the "Communication" research field examine institutional and policy issues. In some cases, these inquiries are part of research traditions seeking to better support communication processes; in many other cases, institutional and policy inquiries are part of research traditions less concerned with the effect on individuals and more concerned with issues of social structure and governance.

These attempts at defining the differences require, of course, over-generalizations. Some education scholars are motivated by concerns about democracy and its structures, rather than by concerns about individual learning. And some communication scholars focus on the effects of communication acts (including those in classrooms) on individuals. As noted earlier, the distinctions between the fields can also be traced to their practical origins: in schooling, in journalism, in public relations and marketing, in museum production.

But nonetheless these overall distinctions have implications for the moral position of researchers and practitioners in the fields. Teachers, for example (and by extension many education researchers) believe deeply in the ability of experts to identify necessary knowledge (in the broadest sense); the quest of teacher professionalization and education research is to find better ways to impart that knowledge. Marketing professionals care less about knowledge, and more about behavior, whether for commercial purposes or "pro-social" purposes such as health campaigns. And journalists are practically allergic to the claim that they serve a role in education; their goal, they say, is only to provide information. Longtime science journalist Charlie Petit summarized the position at the Knight Science Journalism Tracker, a media-criticism site run by MIT:

> Almost as long as I've been in journalism. . .I've watched colleagues bristle and snort when told how important news media are to educating the public. I've gone into full-dismissal mode myself on such occasions. We're not educators!, the line goes. Right, we cover what is new – news – and we use facts, quotes, stories, and narratives surrounding events to get some of their meaning and context over to the public. Sure, people learn from journalism but it's almost a side effect, a welcome result but not the immediate taskmaster – editor be thy name. We don't have time to think like a syllabus composer. We got news to cover, places to go, people to quote. Education is for schools: vitally important but not our job. (Petit, 2013)

Beyond the big issues of science literacy and the education/communication difference, a number of related themes recur in these articles. Similar to the question of disciplinary definition are smaller challenges produced when the same words are used in different ways. Among the most problematic terms is "engagement." To the education community, engagement focuses on the material: are learners engaged with the stuff that they are learning, in academic, behavioral, emotional, or cognitive ways (Appleton, Christenson, & Furlong, 2008)? But to the communication field, engagement is about public participation in the governance of science (Delgado, Lein Kjølberg, & Wickson, 2011; Rowe & Frewer, 2005; Kim, 2007). Besley et al. highlight this issue, noting that "[i]t is quite likely that, for example, those scientists who said they were willing to engage really meant that they were willing to perform education-focused outreach rather than engage in dialogue with their fellow citizens." On the other hand, Besley et al.'s data suggest that "understanding" (more closely tied to education) and "trustworthiness" (a product of dialogue)

are equally prevalent as motivators for scientists to participate in communication training. Feinstein is more optimistic about shared meaning, arguing that the two fields are converging "once again under the vast umbrella of 'public engagement with science.'"

The term "social construction" also means different things. For education researchers, social construction refers to the process by which individuals draw insight from social interactions to facilitate their individual learning (an approach that Feinstein attributes to Lippmann). But for science communication researchers (or at least those who use the social construction term), social construction is a much broader sociological process, by which knowledge is affirmed as reliable through the collective and institutionalized processes of science.

To put a more positive spin on the challenges posed by language: these articles do also show how drawing on multiple literatures can bring more nuance to a word that both sides are taking too much at face value. Davis & Russ show that drawing on literature of both science communication and science education lets them add nuance to the idea of "understanding" that is common in both fields. They add the issues of affect, interaction, and context as ones that need to be considered if we are to understand the experience of the learner. More work needs to be done to address the broader social meanings of the research or the ways that meaning might be altered through a further social process of interaction among multiple readers of the stories they examine, a step that might bounce the research back from science education towards science communication, adding richness to the science communication literature.

That question of which literature has more to gain from the other hangs over these articles. To a large extent, these papers are about what the science education literature can learn from the science communication literature. Feinstein practically scolds science education researchers for failing to look outside their narrow specialty: "Far too often, we unquestioningly accept that school science can prepare people for. . .debates. Other thinkers have arrived at very different conclusions, and it is important for us to learn from those outside our immediate field who have grappled with" these questions. (Feinstein does demur that he is sufficiently new to science communication that he doesn't feel qualified to critique it; but no other papers in this set do, either. My own interest in social context may be blinding me to the ways that the interest in individual learning highlighted in the science education literature could inform the science communication field's focus on social collectives.)

Neither field is entirely coherent within itself, of course. Most notably, science communication includes both scholars of science journalism and of learning science in informal environments for whom the value of science is unquestioned (the only important question is how to improve public uptake and use of science); and also researchers from the science studies world who take a more critical approach to science, seeking to understand how social processes both create reliable knowledge and, especially in public contexts, generate conflict and controversy over what knowledge gets to be counted as reliable, what experts acquire the authority to declare what will be counted. Science education, too, is complex, especially insofar as some schools of thought continue to focus on a conception of knowledge narrowly focused on content, rather than a broader conception which includes the social practices of science as well. And while most science education researchers do focus on the individual learner, a few (as noted above) do highlight the way that learning can be collective, whether in the family or the community (Borun et al., 1996; Roth & Calabrese Barton, 2004; Roth & Lee, 2004).

Tying all these issues together – science literacy, the difference between education and communication, the meanings of engagement and understanding – is the question of goal. Davis & Russ suggest, for example, that we should avoid characterizing particular activities as education or communication because "such a division may obscure continuities between theoretical perspectives and ultimately lead to these two fields systematically failing to study those whole

phenomena. . . in ways that could contribute to a *complete picture of how people come to know science*" (emphasis added). But is that the goal? Feinstein says that Lippmann and Dewey considered the question of science literacy closed: "Individual citizens simply could not know enough *to take part in policy discussions across a wide range of topics*" (emphasis added). For Lippmann and Dewey, the real question (says Feinstein) is the possibility of productive public debate given individual ignorance. Even this goal, however, remains instrumental. Much of the existing literature, whether focused on individual learners or on broader social processes, seeks explicitly to find the tools for immediate action to make the world a better place.

The origin of the deficit model in Freire's attention to oppression, however, points to a much deeper goal: The role of social power in the dynamic relationship among sciences, publics, and learning. Many science communication scholars prefer to look at social patterns, using examination of public communication of science and technology as a lens for understanding distribution of social power (Irwin and Wynne, 1996; Jasanoff, 2003 2014; Wynne, 2006 2008). In that way, science communication researchers are closer than science education researchers to the position that Feinstein attributes to Dewey: "Lippmann did not consider the possibility that groups could accomplish what individuals could not; it was in this possibility that Dewey found hope for the public sphere. . . . Dewey believed that groups of citizens reflecting and acting together could transcend the stark limitations of the individual."

Dewey and Lippmann are often read today for their philosophical positions rather than their particular suggestions. Perhaps we should take that step back, too. The challenge for us, on reading this set of articles, is to articulate *our* goals. Do we seek individual empowerment and better civic operation within an existing system in which scientists hold substantial social power? Or do we seek to understand – and perhaps to disrupt – the power dynamics inherent in the existing system? If so, how might we do that? Bringing the literatures of science education and science communication together makes the need to choose between philosophical positions more evident. More conversation will continue to shed light on – and, one hopes, move forward – discussion on the implications of the choice.

Endnotes

[1]Practitioners sometimes crossed the fields, as well. These movements of teachers to museums to journalism to world's fairs happened across the 20th century, including such people in the United States as E. E. Slosson (a chemistry teacher who wrote one of the most popular chemistry books for general readers and who later became founding editor of a wire service for science news), Waldemar Kaempffert (an attorney who edited a popular science magazine before becoming the New York Times's science reporter, though with an interlude as the founding director of the Chicago Museum of Science & Industry), Gerald Wendt (a chemist and popular lecturer, then director of science and education for the 1939 World's Fair in New York, followed by years as science editor at *Time* and other publications), and most recently Paul Hoffmann (a journalist and book author who is currently CEO of the Liberty Science Center in Jersey City, NJ) (Anon., 1929, 1956, 1973, 2014).

[2]Excluding the current issue, of course!

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