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Basic Science and Risk Communication: A Dialogue-Based Study*

Char J. Word, Anna K. Harding, Gordon R. Bilyard & James R. Weber**

Introduction

The public is considered one of the primary stakeholders in agency and corporate decisions involving risk, and its participation has become central to environmental policy formation and regulatory compliance.[1] The efforts to create a dialogue between scientists and non-experts focus on empowering citizens by allowing them to be heard, providing them with perspectives on risk, and allowing them to make informed judgments about how various risks and scientific activities may affect their communities.[2]

Communicating risks often proves difficult, partly because the information transfer tends to be asymmetric (expert to non-expert). As such, the expert may focus on the best way to transmit, rather than better ways to listen.[3] In light of this, in 1989 the National Research

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1 *See* Robert L. Heath, *Corporate Environmental Risk Communication: Cases and Practices along the Texas Gulf Coast*, in 18 Communication Yearbook 255-277 (B.R. Burleson ed., 1995); Judith A. Bradbury, *Risk Communication in Environmental Restoration Programs*, 14 Risk Anal. 357 (1994).

2 *See* Naploleon Juanillo & Clifford Scherer, *Attaining a State of Informed Judgements: Toward a Dialectical Discourse on Risk, in* 18 Communication Yearbook 278-299 (B.R. Burleson ed., 1995); Richard Rich, et al., *Citizen Participation and Empowerment: The Case of Local Environmental Hazards*, 23 Am. J. of Community Psych. 656 (1995); Aiden Davison, et al., *Problematic Publics: A Critical Review of Surveys of Public Attitudes to Biotechnology*, 22 Sci. Tech. & Hum. Values 317 (1997).

3 *See* Juanillo, *supra* note 2; R. Keeney & D. Von Winterfeldt, *Improving Risk Communication*, 6 Risk Anal. 417 (1986); Krimsky Sheldon and Alonzo Plough, Environmental Hazards: Communicating Risk as a Social Process (1988); National

Council proposed a definition of risk communication that emphasized two-way "democratic dialogue," rather than one-way persuasion.[4]

With greater focus on public participation, scientists and regulators seem encouraged to talk to the public about scientific technologies, characterizations and standards.[5] Although dialogue appears as the desired goal, science and risk communication is not straightforward.[6] Dialogue is often dynamic and difficult to control because public ideas and attitudes are not fully formed before, during or after discussion. Thus, experts often seem to be required to respond to ideas that may seem uninformed, unscheduled digressions, frequent topic changes, and not necessarily predictable reactions to science and risk information. Needless to say, this is not the expert-to-nonexpert dialogue reminiscent of classrooms.

This paper contains two noteworthy sections of dialogue from a focus group discussing a topic still in the stage of basic science. That topic was the potential for bioremediation to decontaminate soil and groundwater. The following discussion analyzes the process by which scientific information is conveyed and the various dynamics of communication at work.

Discussion

The focus group consisted of two biologists who are engaged in bioremediation research at the Hanford Site in southeastern Washington State and five community members. The five public participants included a retiree, farmer, public works director, business owner, and a construction engineer. The participants were chosen without prior knowledge regarding their views on scientific issues. All of the non-experts shared an interest in local issues, had active financial stakes in the community, had raised or were raising families, and displayed an interest in cleaning up the Hanford Site.

Research Council, Improving Risk Communication (1989); Rob Weterings & Josee Van Eihndhoven, *Informing the Public about Uncertain Risks,* 9 Risk Anal. 473 (1989).

4 *See* National Research Council, *supra* note 3.

5 *See* Ward Edwards & Detlof von Winterfeldt, *Public Values in Risk Debates*, 7 Risk Anal. 141 (1987).

6 *See* D.E. White & R. Wehlage, *Community Collaboration: If it is Such a Good Idea, Why is it So Hard to Do?* 17 Educ. Eval. & Pol'y. Anal. 23 (1995).

The researchers analyzed data from the focus groups by using both ethnographic summary and systematic coding via analytic induction approaches.[7] The units of analysis were the words transcribed from audio and video tapes of focus sessions.[8] In analyzing the data, four message components were particularly noted:[9]

Terms used by various participants;
Topics;
Frequency and the manner in which participants returned to topics; and
Grouping of topics.

The analysis of taped interactions also revealed certain communication-process issues that the participants or facilitators may not have noticed.

Neither of the following interactions can be considered a breakthrough in understanding by either the experts or the non-experts. Dialogue Unit A illustrates the transactional nature of the dialogue, while Dialogue Unit B illustrates the parallel, but not coincidental use of language to discuss similar issues.

Dialogue Unit A

The following verbatim dialogue resulted when a non-expert asked how bioremediation for soil would differ from its use in the petroleum industry. One biologist replied that his research dealt with unique types of contamination such as radionuclides and heavy metals in a complex mixture: arsenic, chromium, mercury, lead and radioactive materials such as technetium, americium, uranium and plutonium.

> *Scientist 1:* Usually those things aren't by themselves in the soil and the groundwater, but they're usually in there with some kinds of organic compounds. A lot of times you'll find them, not surprisingly, co-mingled with different kinds of organic compounds that were used as cleaning agents, like carbon tetrachloride or trichloroethylene. And, uh, they'll also be co-mingled with different kinds of organic compounds called chelaters that were used because they helped make chemistry go better but, unfortunately, they also dumped these in the soil.... Where bioremediation might

7 *See* P. Johnson, *Analytic Induction, in* Qualitative Methods and Analysis in Organizational Research: A Practical Guide 28-50 (G. Symon & C. Cassel eds., 1998); B.G. Glaser & A. Strauss, The Discovery of Grounded Theory (1967).

8 This is the standard data collection unit used in the Organizational Cultural Communication (OCC) method of ethnographic analysis.

9 The OCC method uses these message components to develop inductive coding schema; *see* C.R. Bantz, *Organizing and the Social Psychology of Organizing* 40 Comm. Stud. 231 (1967).

> ultimately offer some opportunity for, on the one hand, at least understanding what the fate of these materials will be over time and distance. On the other hand, it may also suggest ways in which you can manipulate natural processes to, you know, modify the behavior of these things in the environment, like stop them from moving or something.

One of the non-experts deals with this information by translating it into a common metaphor:

> *Non-Expert 1:* So, is the mechanism for the cleaning up? I mean, you're not, you're not actually taking in a base element and gobbling it up.
> *Scientist 1:* No, the incident. The thing is that, that there are micro-organisms a number of different places....
> *Non-Expert 1:* Microbes, is that what you're...?
> *Scientist 1:* No. That is one things microbes can do. They can fight. They can take them out....
> *Non-Expert 1:* Huh.
> *Scientist 1:* But, generally, what they do. The, the particular mechanisms we're interested in are seeing whether or not in nature you could actually take advantage of some phenomena that have been described whereby microbes act as catalysts for changing the, the oxidation.
> *Non-Expert 1:* Oxidation.
> *Scientist 1:* Oxidation of the things. It turns out, at least in the lab, you can do, there's a lot of microbes that will reduce uranium, cobalt, all sorts of different things in order to gain energy. They can take and change iron3 to iron2 and get energy out of it that's useful for them to grow. They can do the same thing in uranium and cobalt and technetium and things like that. In the lab.
> *Non-Expert 1:* Okay.
> *Scientist 1:* And so the idea is that in most cases chromium anduranium are the two prime examples, when they are in theoxidized state, most of the aquifers out here at Hanford and Savannah and places like that are oxidized. That is they have a sufficiency of oxygen for metabolism. That maintains these things in an oxidized state and they move with the groundwater. It turns out that those two elements at least, uranium and chromium, if they're in the reduced state they precipitate and stop. And so, the whole idea is ultimately being able to see whether it's feasible to manipulate natural communities so that you could change the oxidation state of metals.
> *Non-Expert 1:* Are you changing the oxidation?
> *Scientist 1:* Changing the oxidation.

Non-Expert 2: Or change the amount of movement so that entrapment would be easier or something?
Scientist 1: That's a possibility as well. Microbes and plants and other things will accumulate metals. It will accumulate metals but in most subsurface environments that have been explored to date the total amount of the microbes that are actually down there is pretty small. And because they're limited in the amount of food they have at any given time, they're also not very active.

The inadequacy of the negotiated metaphor becomes apparent a few minutes later when a community member asks whether "gobbling up" would fit in another circumstance, such as bioremediation in the petroleum industry. The negotiation over metaphors resulted in something mutually understandable but clearly not adequate:

Non-Expert 2: Are these things going to gobble up the metals and this type of thing? Now, as I understand it, very basic, that in the petroleum situation, isn't there an actual gobbling up...?
Non-Expert 3: But what about the metals and radionuclides?
Scientist 1: They're able to gain energy by changing the oxidation state of a number of different metals.
Facilitator: Turn into rust.
Scientist 1: And by doing that, they change the behavior of that thing in the environment. Chromium and uranium.
N*on-Expert 3:* Accelerate the decay process or something?
Scientist 1: No. They won't do anything with the radioactivity but what they will do is. You can, theoretically, you can by changing the oxidation state of uranium or chromium. When it's oxidized, it's moving with the groundwater, once it's reduced it drops out of solution and stays there.
Non-Expert 1: Oh, cool. Okay. I forgot. Or my definition of behavior, it changed the behavior.
Scientist 1: Yeah, yeah. It's not scientifically correct but for us....
Non-Expert 2: That is. Behavior is the word. Yeah.
Scientist 2: But you could do the other process, too, if it was precipitated in a place that you didn't want it. You could mobilize it and then suck it out.
Scientist 1: Suck it out. Yeah, in the other direction.
Scientist 2: Then you capsulate it and.
Non-Expert 3: Let's talk theoretically.
Non-Expert 2: Yes.
Scientist 1: Do it in the lab.
Non-Expert 4: If I understood your previous conversation, is that it says they're looking for oxygen. They are moving with the groundwater to gain new oxygen?
Scientist 1: Okay.

Non-Expert 2: The contaminants, metals.
Scientist 1: No, they're oxidized because....
Non-Expert 4: Why, why are they moving with the groundwater?
Scientist 1: Because the chemistry is different. They won't, when they're oxidized they won't combine with other things like OH-, for example. Or, they won't co-precipitate with some other inorganic compound to form a salt that doesn't move.
Non-Expert 4: There's no identity or energy levels.
Scientist 1: It's not soluble, for example. So when they're in an environment where there is sufficient oxygen such as most of these groundwaters. That the chemistry is such that they do not combine with other things and precipitate. They stay soluble.
Non-Expert 4: Even though they stay in the groundwater, or in the water table. You're saying they won't move.
Scientist 1: They do move until you reduce them.
Non-Expert 4: That's what I'm saying.
Scientist 1: Right, right and then they.
Non-Expert 4: How do you know for sure that they won't move then after you reduce them?
Scientist 1: Well, we're not certain that that would be the case in all different kinds of subsurface settings because they're complex. That's the whole purpose of the program is to fill in these gaps in our understanding. How the geology and the mineralogy and the water movement and the bugs all interact, naturally.

The final lines of this section show one non-scientist taking at least three false starts (one might think of them as cul-de-sacs) in his attempt to understand the physical dynamics of microbes interacting with contaminants under ground. His false starts involve at least two questions and one paraphrase: "They are moving with the groundwater to gain new oxygen?," "Why, why are they moving with the groundwater?," and "There's no identity or energy levels." Some understanding is apparently reached when both the scientist and community member found a common visual or conceptual frame, marked by the community member's saying, "That's what I'm saying."

Although it may seem obvious that non-experts need to understand new ideas, Unit A demonstrates that information is not simply conveyed, as in a linear model, but transacted. The way non-experts interpret information depends heavily on existing knowledge.

This dialogue confirms what Judith Bradbury previously observed in proposing a "convergence" model of stakeholder engagement.[10]

10 *See* Bradbury, *supra* note 1.

Bradbury noted that the traditional linear communication model was inadequate because it failed to consider the cultural frames of reference that participants bring to community dialogue. Rather than using a model in which experts solely provide information to non-experts, Bradbury's model accounts for the creation and sharing of information by everyone in a public engagement process. Thus, despite the clear need to explain the science behind a situation involving risk, experts will appear to fail to communicate when they do not consider the social and cultural contexts of the act of communication [11]

Dialogue Unit B

At the end of Dialogue Unit A, the facilitator changed direction of to allow one scientist to explain more about the programmatic background of the bioremediation initiative. The following thus began several minutes after, with an abrupt change of topic by one of the community members.

Non-Expert 4: Why not use what we already have? Why not use technologies that exist already? That have already been developed. The money's already been spent on them.
Scientist 2: Go to the next question.
[laughter]
Non-Expert 2: Whatever. Well, I understood and accept that you had one target in the lab and you're going after that one particular target, chromium. Chromium or whatever you call it. What concerned me was your comment about they're all mixed up down there. So there might be ten different things that are all products or targets. And, how do you control going after 'em? I mean, you can't create every situation in the laboratory.
Scientist 1: You can't.
Non-Expert 2: So, you're going to be actually moving the laboratory into the ground. How do you know what's going to happen?
Non-Expert 1: Perfect characterization is very easy to do.
[laughs]
Non-Expert 2: Then, the answer is?
Scientist 1: That conceptually, at some point you should be able to understand in sufficient detail the important mechanisms and processes that control the complexity. To the point where you

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11 *See* Dominic Goulding et al., *Evaluating Risk Communication: Narrative Versus Technical Presentations of Information about Radon*, 12 Risk Anal. 27 (1992); Harry Otway, *Experts Risk Communication and Democracy*, 7 Risk Anal. 125 (1987).

could pose a hypothesis that you could test with a field experiment somehow.
Scientist 2: And there is a discussion inside the program of having one or more sites as eventual test beds. Hanford is a candidate. Oak Ridge is a likely candidate and there are several others. But that has not, nothing has been decided. But there's been discussions of substance.
Non-Expert 2: Well, when you go into the ground. It's never going to be a sure thing. Never going to be as clean, know what's going to happen. So there's a degree of risk. And some people say it's only a percentage. You're talking one degree. Various.
Scientist 1: As I said earlier, on the one hand, there's insufficient understanding of the complexity of the environment now, even with any degree of certainty. I don't know it could pose a future scenario even if you didn't do anything — it's what's going to happen in 10 years, 50 years, 100 years over special scales that we're interested in.... because we don't understand the underlying mechanisms and processes controlling behavior of these....
Non-Expert 4: Well, back kind of again to the question about using existing technologies. Why couldn't you go out there, how far you're going down for your research. Let's say you build a coffer dam around a 100x100 site or whatever and take the technology we know about organisms now and instead of spending millions more in the lab, just go do it.
Scientist 1: Well, there's a couple of things. First of all, I'm not sure that the technology exists to go down or even if you could afford to do it if you could. To go down, you know, 200+ feet to groundwater and coffer offset a square mile which is one of the problems that's there. But even....
Non-Expert 4: But your research isn't gonna do so much for tomorrow.
Scientist 1: It might and it's only costing $18 million a year. I wouldn't want to look at a bill for putting a wall in deep around the... area.
Non-Expert 3: Yeah, but I think....
Non-Expert 4:.... I'm talking about like a 100x100 area square foot area.
Non-Expert 1: Oh, oh, oh. That's cool.
Non-Expert 4: That's a test property land and make that your lab.
Scientist 1: At some point in time that is a possibility.
Non-Expert 4: Then why wait?
Scientist 1: Because I wouldn't know what to hypothesize and try to do because, again, we don't, I don't, we don't think.... We don't we think we sufficiently understand the important processes and mechanisms that control this complexity... to manipulate them

with some predictable end point.
Non-Expert 2: You know, I have a feeling that the science is very little from a technical point of view. I don't know a damn thing about bugs.
Scientist 1: Um, umm.
Non-Expert 2: Uh, my biggest fear on a project like this that it will never be commercialized.... It scares me as far as taking science from the lab — which a lot of scientists don't give a damn [about]. And, I'm not picking on you... but what I'm saying is they, they really want to do "science for science's sake."
Non-Expert 4: Well, of course, part of this focus group is, again going back to communication to the public which is going to give you a thumbs down. And you say if they're going to study for 30 years.... I don't know, try 10 at Hanford. Maybe by that time it's already in the river.
Scientist 1: We were told when DOE pulled a few of us together to draw up a program plan, they said that what we'd like is a program plan that, umm, someone proposes science that's needed in a, in a — do it in a 10-year time-frame and at $20-50-million-a-year level. This is its third year of funding and it's at about $18 million. But it was originally conceived of as a 10-year program in basic science....
Non-Expert 3: But this particular area, work has been so secretive for so long that it's, that aspect hasn't even been a wet dream in any of these scientist's minds or political minds and whatever. And it's something you'd better start doing because we're getting tired of paying for nothing to happen.
Non-Expert 1: Metals remediation. My God, metals has been in processes for years.... And that has lots of use in several countries.
Scientist 1: Sure.
Non-Expert 1: So, it has the universal application. So again, again, unless you can prove to the people that you really know how to "put in on the shelf" — you know what I'm saying?
Scientist 1: Yes, yes.
Non-Expert 1: Package it, sell it.
Scientist 1: Right.
Non-Expert 3: Then we become pretty friendly....
Non-Expert 1: When can [John] go down to Ranch & Home and buy a box of Bug-x? Right. [All talk at once/laughter]

The preceding demonstrates different approaches to the concept of scientific research. The scientists discuss research positively whereas the community members seem to discuss it negatively. Although at no time is the term "research" mentioned, it is placed in a framework of related ideas. More specifically, research is discussed in the context of "complexity," as used in scientific terminology, and "utility," as used by the community members.[12]

Whereas Unit A suggests that the participants' frames of reference can change (via metaphor and negotiated meaning), Unit B seems to illustrate the opposite possibility; there are certain concepts that may remain non-negotiable in dialogue. "Complexity" may be such a concept, as it becomes a central and recurring player in a tug-of-war between the scientists and community members over the time-scale of cleaning up the contaminated soil. Whereas the community members seem to advocate a shortened path from laboratory to field application, the scientists repeatedly return to the complexity of the chemical, biological, and geological processes at work in the contaminated areas.

Scientists stress carefully controlled research because they do not completely understand the interplay and complexity of the processes. One such example can be seen in Scientist 1's use of the term complexity.[13] For Scientist 1, the term points to a tangled skein of physical and biological relationships in contaminated soil that can, it is presumed, eventually be expressed as a relationship of "mechanisms and processes." It, thus, stands for abstract principles yet to be determined and for the risks inherent in not understanding physical processes.

The transcripts, however, show that at least some of the non-expert group recognizes the risks of bringing research out of the laboratory too soon. Non-Expert 2 raises the issue of complexity by paraphrasing the concept and its scientific significance (i.e., the danger in uncertainty) by stating:

> What concerned me was your comment that they're all [the soil contaminants] mixed up down there. So, there might be ten different things that are all products or targets. And how do you control goin' after 'em?

Non-Expert 2 continues by stating that the scientists should not proceed year-by-year to reproduce field conditions in vitro since they could not possibly simulate all the field conditions in a laboratory or

[12] "Utility" is discussed by the community members in terms of several interlocking sub-concepts: test plots for bioremediation, use of existing technologies, commercialization of findings, and time-scale of clean-up for using bioremediation.

[13] Scientist 1 uses the term "complexity" during three separate occasions: "mechanisms and processes that control the complexity," "insufficient understanding of the complexity of the environment," and "important processes and mechanisms that control this complexity."

control the outcomes precisely. Rather, Non-Expert 2 urges the scientists to use the field plots as their laboratory. Despite his desire for the scientists to begin field testing, Non-Expert 2 also acknowledges the risks:

> Well, when you go into the ground, it's never going to be a sure thing, never going to be as clean [as outcomes from a laboratory setting], know what's going to happen. So there's a degree of risk.

Not only do uncertainties associated with premature testing exist, the non-experts posit another risk — the risk of delay, which seems to be inherent in research itself.

Throughout, non-experts intertwine four topics that closely relate to risk: the time-scale for clean-up of contaminated soil, the importance of prompt field testing, consideration of the use of existing technologies (as opposed to slow development of new technologies from research), and commercialization of technologies.

Conclusion

Our research thus far emphasizes the importance of capturing and analyzing the talk itself to reveal when frames of reference seem to be converging. Real-time dialogue on basic science and related public issues, such as risk, is not trivial. These dialogues appear to be as complex as the natural processes being discussed.

One could evaluate the interactions reproduced here as a failure because the scientists and the participants did not finally see eye-to-eye. One could easily miss the similarities between the parties' concerns because of the different terminologies used by the scientists and the non-experts. It is also possible to confuse their real differences in opinion as the failure of the groups to understand one another. Nonetheless, members of both groups show that they grasp the concepts of complexity and of risk trade-offs. These differences in language and background point out that dialogue illustrates an arena for negotiating meanings, rather than for conveying points of view or soliciting support.

Allowing questions be asked and voices be heard seems vital in democratic processes. Perhaps one of the marks of a fair democratic process is that few will be entirely satisfied with the outcomes, but particularly those who hope for specific outcomes (say, political support or complete understanding). An open dialogue approach, as revealed in our focus group interactions, does seem to allow all participants to have a voice, for questions to be asked, and opinions to be shared. In this sense, dialogue poses a symmetrical interchange rather than an asymmetrical flow of information.

Certainly, a single series of focus groups, from which these segments were drawn, does not provide a sufficient answer to the questions that these segments raise.[14] Our research continues to examine how dialogue provides process information that can aid facilitators, and participants in forging mutual contexts in discussing risk and other issues. Our research also continues by exploring the features of the dialogue method and the role of facilitators that may permit a fruitful dialogue among multiple parties concerning issues of risk, basic science, and public interests.

14 Among them are the following:
a) What are the outcomes to be expected from a dialogue process such as this? Would a follow-up meeting or subsequent activities be reasonable expectations?
b) Could dialogue be hybridized with other forms of scientist/public interactions, say, games?
c) How much and in what ways can dialogue approaches really be expected to contribute to educating the public about particular initiatives?
d) Would the outcomes be acceptable to constituencies that normally are involved in scrutiny of public science?
e) Would a greater degree of structure, for instance, that provided by a skilled facilitator, aid in achieving observable convergence in participants' frames of reference?
f) Do dialogue-based events make a unique contribution to public engagement process?
g) What are the strengths and weaknesses of a dialogue approach to public engagement?