

## ARE EM'S COMMUNICATION TOOLS EFFECTIVE? EVALUATION RESEARCH OF TWO EM PUBLICATIONS

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### ABSTRACT

As a reflection of its growing culture of openness, and in response to the public's need for accurate information about its activities, the U.S. Department of Energy (DOE) Office of the Assistant Secretary for Environmental Restoration and Waste Management (EM) has increased the amount of information available to the public through communication tools such as brochures, fact sheets, and a travelling exhibit with an interactive computer display. Our involvement with this effort has been to design, develop, and critique booklets, brochures, fact sheets and other communication tools for EM. This paper presents an evaluation of the effectiveness of two communication tools we developed: the EM Booklet and the EM Fact Sheets. We measured effectiveness using non-parametric testing. This paper describes DOE's culture change, EM's communication tools and their context within DOE's new open culture, our research, test methods and results, the significance of our research, and our plans for future research.

### DOE'S CULTURE CHANGE

In 1989 Secretary of Energy James Watkins directed DOE to commit to cleaning up the environment and complying with the letter and spirit of environmental laws and regulations. To accomplish this, he mandated a new DOE culture of accountability and open communication with the public about past and present activities (1, 2).\*

DOE and its predecessor agencies, created in the 1940's and 1950's, produced nuclear materials for weapons used in national defense activities. Since this work was secret, DOE shared information on a strict "need-to-know" basis, and DOE was largely a self-regulating agency. DOE technical professionals were often ill-equipped to communicate clearly or completely with the nontechnical public (2). This isolation allowed DOE production concerns to overshadow environmental ones. In addition, DOE lacked understanding of the effects its activities had on the environment. DOE's challenge is to mold itself into an organization whose highest priorities are maintaining a clean, safe environment, sharing information with and involving the public in decision making, and complying with federal, state, and local environmental laws.

DOE reorganized in 1989 to create an office focusing on cleanup and compliance, the Assistant Secretary for Environmental Restoration and Waste Management, or EM. Secretary Watkins said this office, confirmed by Congress in November 1991, "emphasizes the importance of our (DOE's) efforts to clean up radioactive waste resulting from 45 years of nuclear weapons production. . . . To us at DOE, it is among our highest priorities" (3). DOE's new culture is being articulated at its sites across the country as well as at Headquarters. For example, the Richland Field Office describes itself as "a public agency, and members of the public have a right and need to access information" about it (1).

DOE is not completely successful at implementing this statement, as illustrated by a 1990 Office of Technology Assessment survey of 14 public interest groups. None of the groups felt they were getting the information they needed from DOE. However, this was before publications like the two we studied (the EM Booklet and EM Fact Sheets) were available. In order to meet its own and the public's needs without wasting taxpayer money, DOE must evaluate the effectiveness of its communication tools and public involvement programs (4).

### COMMUNICATION TOOLS

EM produces booklets, brochures, and fact sheets; hosts public meetings; and solicits public review of its plans and policies. EM has learned from experience at public meetings that communicating with the public includes being open to vigorous criticism. According to a recently published study of international nuclear waste politics, listening to public complaints may help improve public opinion. Responding to public complaints with information helps even more (5). Failure to educate and provide accurate and meaningful information will likely result in a negative outcome (6). An untrusting public with more access to information from interest groups than information from DOE may choose to side with the interest groups' agenda. This could work to prevent EM from accomplishing its goals, as demonstrated by delays in starting the test phase for the Waste Isolation Pilot Plant in New Mexico.

EM's annually updated Five-Year Plan outlines DOE's cleanup and compliance goals and policies and incorporates public comment. EM's other communication tools also embody DOE's commitment to a new culture of openness and responsive communication with the public, but they are intended to provide a simpler overview of EM activities than the

\* As stated in DOE-Richland's Draft Public Involvement Research and Planning Task Report, "the public" includes individuals and groups who might be affected by DOE's decisions, whether they know it or not. These groups are stakeholders such as Indian Nations, state and local governments, environmental organizations, and others. We add to this definition every citizen and member of the public whether they have a demonstrated interest in DOE activities or not (1).

Five-Year Plan. They include the EM Exhibit; the EM Booklet, *Environmental Restoration and Waste Management (EM) Program, An Introduction*; numerous EM Fact Sheets; and other brochures.

The EM Booklet describes DOE's culture change, the Five-Year Plan, and EM's mission, functions, offices, and major activities including environmental restoration, waste management, and technology development. It also defines waste types, and treatment, storage, disposal, and transportation methods. The EM Fact Sheets describe waste types, environmental restoration and waste management activities at each of DOE's nine Field Offices, and environmental laws and regulations.

EM's publications accompany the EM Exhibit, a portable multipaneled exhibit and interactive computer display designed to inform the general public about EM's program to clean up the environment and manage waste. The EM Exhibit is presented throughout the United States at professional conferences such as the American Bar Association, the National League of Women Voters, the National Conference of State Legislators, and the National Science Teacher's Association, as well as DOE-related meetings. The Exhibit is staffed by technical and nontechnical DOE professionals who strive to provide citizens with information about DOE and offer a positive interaction with "the government."

#### Communication Tool Design

In many cases, EM communication tools and publications have been based on experience rather than systematic (but time-consuming) application of communication theory and technique. Many public affairs experts develop and conduct their programs based on intuitive guesses and experience. There is very little "hard" research defining what does or doesn't work (7). Although most of the studies that do exist focus on the commercial nuclear industry, research by the U.S. Council for Energy Awareness (USCEA) suggests that all nuclear-related activities are lumped together in the public mind. Thus, EM can learn from this research as well as its own.

Concern about the environment is high on the public agenda; but while nuclear waste is a national concern, it's far from the first thing on people's minds, according to public opinion polls. A 1990 USCEA study showed that although 12% of U.S. adults named waste as the most important environmental problem, only 1% named nuclear waste specifically (8). A series of 1990-1991 Gallop, Roper, and Opinion Research Corporation polls found air pollution listed most often as the greatest threat to the environment, with nuclear waste being mentioned significantly less (9). However, an August 1991 Roper Organization Survey found that 86% of adult Americans said they were somewhat or very concerned about nuclear or hazardous waste when choosing from a list of environmental problems (10).

Another USCEA study found that providing information about high-level waste disposal (in the form of a brochure) to an attentive public increased their confidence from 37% to 59% that nuclear waste can be disposed of safely. However, USCEA noted its research also showed that providing information to non-attentive audiences, or people who don't have some knowledge or context for nuclear issues already, may decrease their confidence by failing to address their concerns and bringing up any negative associations they already have (8).

EM's communication tools can benefit from amplifying the public's voice so EM can respond to public needs within a context that increases knowledge and improves perception. Cognitive learning theory suggests that the mind retains information categorically, or in context and reference to existing knowledge. Thus, new information can be easily memorized but not necessarily understood unless a context or knowledge base already exists (11). To take advantage of this theory EM could identify public contexts and present information within those contexts. Other improvements to increase cognition include grouping ideas, adding unique summaries, and clustering topics hierarchically from the general to the specific (12). EM's existing tools use some of these principles. For example, the EM Booklet presents a general overview with the EM Fact Sheets providing more detailed, specific data.

To produce effective communication tools it's useful to employ the formula: *Audience + Purpose = Design*. However, EM's public is made up of many audiences, and EM has had no time to survey and analyze them. EM's communication tools serve many different purposes, from illustrating DOE's new open culture to providing Congress and the public with technical and programmatic information about its activities. EM's audiences and purposes need to be better defined. For instance, how can EM assist the public in understanding highly technical and complex information? How much and what kind of information does EM want to provide? Whom does EM want to educate? What is the best kind of public involvement for DOE's activities?

A comprehensive study of EM's audiences and outreach methods would reveal which audiences are being exposed to information about EM and what they are actually learning from it. Eventually, we could provide a matrix describing which tools and what information would be effective for different audiences and purposes. Understanding the factors that affect communication tools will help EM describe its programs, policies, and goals to the public. It also will help reduce the costs of producing communication tools and the costs associated with responding to an irate, perhaps misinformed public.

#### Publication Production

In order to produce the best possible documents in the least amount of time, we gathered information by interviewing high-level DOE managers, talking with DOE'ers who have public relations experience, and conducting multiple content reviews with DOE nuclear experts, managers, and editors. EM managers at DOE Headquarters and Field Offices often modified content to accommodate national and local political or legal concerns.

We designed the 100-page EM Booklet to describe EM with minimal text and many illustrations. We translated highly technical and bureaucratic information into understandable terms and eliminated as much time-dependent information (like milestones) and jargon (including acronyms) as possible. We used many photos and figures with detailed captions to describe technical processes and boost an image of openness.

As an overview for such a large and complex organization, the EM Booklet left a lot of questions unanswered. So we designed fact sheets to provide more detail about EM activities and sites. Our goal was to answer as many questions as possible and include as much information as we could on a one-page fact sheet. Each fact sheet includes at least one



picture or illustration with an accompanying caption, and in many cases, a map to geographically locate the facility or site for the reader. We gathered information and conducted reviews in the same way as for the EM Booklet. In both cases, the Five-Year Plan served as an information source.

Despite efforts to simplify the text, the politics and jargon associated with EM nuclear-related information made it difficult to simplify these publications. Both the EM Booklet and EM Fact Sheets are written at about a 15th grade (junior in college) reading level according to the Flesch-Kincaid Readability Formula (13). This formula measures how easy a document is to read and comprehend based on sentence length and number of syllables per word (word complexity). The reading level often used by the news media for the general public is 8th grade (14). Although both the EM Booklet and EM Fact Sheets are very difficult to read according to the above formula, word complexity (e.g. Environmental Restoration and Waste Management, Hanford Waste Vitrification Plant) was identified as a bigger problem than writing style or sentence length.

### TESTING EFFECTIVENESS

In spite of its constraints--time, organizational inertia, negative public opinion--EM is actively pursuing the public trust. EM hypothesizes that educating the public by providing unbiased information about its program will improve public perception and encourage the interested public to learn more on its own about technical issues (15).

How much is the public learning from the communication tools EM provides? Is the public getting the information it needs? How does public opinion affect EM's effectiveness? What does the public think about radiation? About DOE activities? Does the information EM provides affect the public's perception, and if so, negatively or positively? EM needs answers to these and other questions.

In order to find these answers it's necessary to conduct tests. Test design impacts test results. It's as important to ask a relevant question as it is to design a test that answers that question. Otherwise, test results give false indications. It's also necessary to use applicable measurement tools. While it's difficult to assess how people feel about EM, it's relatively easy to test what facts they know about EM. Since EM's effort is to communicate with and educate the public, we need to measure how effective tools are for different audiences rather than comparing tools. For example, although EM and public response to the two communication tools we designed was very positive, we decided to explore their effectiveness by measuring how much different audiences learned from them. We wanted to find out whether these publications are good teaching tools--that is, whether after reading them, an audience remembered more *correct information* about EM than before. We used non-parametric testing to explore this question.

#### EM Booklet Test Method

Our first test group was 17 DOE interns participating in a training program. These were future DOE employees--college-educated professionals with a vested interest in learn-

ing the material presented to them. The training program introduced each office within DOE, including a session on EM. We tested the EM Booklet as text material for this session. All the students were given a pre-test to determine their knowledge before the EM session began. Some students received a pre-test on information unrelated to EM but included in previous lectures; the others received a pre-test exclusively on EM-related information. The instructor presented a three-hour lecture on EM that included information not covered in the EM Booklet. The instructor did not know an evaluation test was being conducted. The interns received the EM Booklet during the session on EM and were told to read it.

We conducted a post-test one week after the interns received the EM Booklet and attended the lecture. The EM pre- and post-tests were designed to ask the same questions worded differently and in a random order. The test questions included specific material readers should learn from the EM Booklet. At least 25% of the test questions were on material from the session that wasn't covered in the EM Booklet. This allowed us to determine the effect of previous knowledge about DOE activities. Of the 17 interns, 14 turned in both pre- and post-tests.

#### EM Booklet Test Results

We answered three questions: (1) Did we bias the interns' post-test scores by giving them a pre-test?; (2) Did the lecture and the EM Booklet teach the interns material they did not already know?; and (3) Did the lecture affect how much the interns learned from the EM Booklet?

The pre-tests did not affect the scores on the post-test. Taking the pre-test did not clue the interns in on what to study in the lecture and the book. The average post-test score was 75%. This was significantly higher than the pre-test scores. We concluded that the lecture and the EM Booklet taught the interns materials they did not already know. The sample average improvement in their test scores was 20%. Finally, test results showed that the lecture did not affect test scores and was not an effective tool for reinforcing the EM Booklet. The 20% improvement in test scores was 100% attributable to the EM Booklet.\*

#### EM Fact Sheets Test Method

Our objective in testing the EM Fact Sheets was to explore their effectiveness as teaching tools, evaluate whether exposure time affected learning, and test whether attitude affected knowledge acquisition. We used a group of 15 undergraduate college students who had completed one or more semesters of college and did not have a vested interest in learning about EM. We tested four of the 35 existing EM Fact Sheets: *Resource Conservation and Recovery Act*, *Environmental Restoration Activities at Feed Materials Production Center*, *Waste Management Activities at Idaho Field Office*, and *Radioactive Waste*. We measured the student's baseline knowledge about EM with a pre-test. The test questions reflected specific material readers should learn from the four EM Fact Sheets. The post-test asked the same questions differently and in

\* For question one, we applied the Smirnov two-sample test (16, Table 17) to the data with  $\alpha > 0.2$ , ( $T = 0.4545 < 0.5917$ ). For the second two questions, we applied the Wilcoxon Signed Ranks test (16, Table 7). Question two,  $\alpha < 0.005$ , ( $T = 0 < 6$ ); question three,  $\alpha > 0.2$  (and  $\alpha$  close to 0.4,  $18 < T = 22 < 23$ ).

random order. We also included opinion questions about radioactive waste and nuclear power.

The test was set up in a randomized complete block design with each block receiving one of two treatments. Group One was given five minutes to read each fact sheet in a mock-exhibit environment (people talking, exhibit materials on the walls, TV, displays, etc.). They received a post-test four or five days later. Group Two took the four EM Fact Sheets home and were instructed to read them twice for 10 minutes each a few days apart. They received a post-test four or five days later.

### EM Fact Sheets Test Results

We answered five questions with this test. (1) Did the two groups have different post-test scores (in other words did time exposure affect test scores)? There was no difference in test scores based on length of exposure time for this test with this audience. (2) Did the EM Fact Sheets teach the students information they did not already know? Test scores increased by 24% from the pre- to the post-tests for both groups. The average pre-test score was about 19% (11%-34% range) and the average post-test score was about 43% (11%-65% range). (3) Did attitude affect test scores? There was no difference in test scores based on attitude for this test with this audience. However, it appears that access to the information did not negatively impact this audiences' opinions about radioactivity or nuclear power. (4) Were test scores higher for different topic fact sheets? No. Based on this test, none of the four fact sheets was more effective than the others. (5) Were more questions answered correctly when based on information at the beginning and end of a fact sheet than the middle? We found no discernible pattern showing more information was remembered from the beginning and end of the fact sheets than the middle.\*

### DISCUSSION

EM is on the right track. Based on our test results and existing literature on public involvement, we can infer that EM is somewhat effective in meeting its goal of providing correct information to a select public.

The test groups in these experiments are comparable to the audiences for the EM Exhibit--mostly college-educated professionals, some of whom have never heard of DOE. Based on our test results, we can conclude that the EM Booklet and EM Fact Sheets are effective in communicating information to college-educated groups. We also can infer that EM Exhibit attendees learn from their experience. For the EM Booklet a 75% average grade and 20% improvement is acceptable. However, for the EM Fact Sheets, while a 24% increase in test scores is significant statistically, the average post-test score was 43%. Thus, about 57% of the information was not communicated to these groups.

EM publications need to be written at a level that is understandable by the public. DOE's written communication should be written at the simplest reading level possible, even for college-educated groups, because reading levels are so low in the U.S. (17)\*\* (The average reading level for college-educated people is said to be about 10th grade high school.) In addition, scientific literacy in the U.S. is low, and the public lacks basic scientific knowledge (18). These gaps make it even more difficult for DOE to communicate and for the public to understand highly technical and complex information. This is especially true with the topic of radiation, which is emotionally charged and misunderstood by the majority of the public (19).

In general, people remember only 10% of what they read, 30% of what they see, and 50% of what they read and see (20). Thus, pictures are invaluable aids in communicating and should be an integral part of the text to help people of all reading levels comprehend complex information. Our test result of about 20% improvement in test scores may be related to the plentiful photographs and illustrations used. However, this result also could be attributed to the reading level difficulty. For example, since our fact sheet test showed no difference in test scores based on time exposure, it's possible that the material is so hard to read that a saturation point is reached and test scores wouldn't improve no matter how much time the reader had. Further research is needed to determine which attributes should be changed to improve EM publications. For example, we could reduce the number of facts per page, add more illustrations, reduce information and word complexity, and add summaries.

Perhaps more important than reading level and even publication design is the distinction between credible information and authentic communication. Research in risk communication has found that credibility "depends less on the packaging of information than on the quality of the relationship" between the communicators. Information communicated by those in a relationship that nurtures mutual trust and respect is more likely to be believed no matter how it's packaged (21). Thus, EM's publications must work in concert with a public involvement program to create an authentic relationship with the public. EM also must consider that educating the public may improve public perception of DOE, but it does not guarantee public support of DOE's activities or the activities of the commercial nuclear industry (21).

### CONCLUSION AND FUTURE RESEARCH

EM needs more research answers to improve its public outreach effort (15). Literature on learning and public participation supports EM's idea that educating the public is the best way to improve public perception and facilitate public involvement. By educating the public, EM is creating an initiated audience that can begin to understand the programmatic and technical aspects as well as the constraints of its program.

\* For question one, we applied the Smirnov two-sample test (16, Table 17) to the data with  $\alpha > 0.2$ , ( $T = 0.214 < 0.482$ ). For question two, we applied the Wilcoxon Signed Ranks test (16, Table 7) with  $\alpha < 0.005$ , ( $T = 1 < 16$ ). For question three, histograms of the conditional probabilities were compared. For question four, we applied the Friedman test (16, pp. 264-7) which is approximately chi-squared with  $\alpha > 0.25$  and three degrees of freedom (chi square =  $2.8 < 4.108$  (16, Table 2)). For question five, histograms of the conditional probabilities were compared.

\*\* According to the 1990 Digest of Education Statistics, a little less than half of college educated young adults (and only about 10% of high-school graduates) are highly literate as measured by ability to comprehend prose, understand documents (such as maps, schedules, etc.), and calculate quantitative information (such as tips) (17). Ability to learn facts is related to reading level as well as education, interest, attitude, social factors, etc.



EM communication tools can be evaluated to assess and improve their effectiveness. Some specific topics to investigate include: improving information portrayal, determining the best number of facts per fact sheet, and conducting an audience analysis to form a matrix of tools and audiences that will work well together. Another topic is whether and how proximity to a DOE site affects interest, understanding, and interpretation of EM-related information. Effective communication may differ significantly for this population compared to the general public. Another area that needs further investigation is whether and how attitude affects learning rate. Additionally, EM's communication tools could be revised to reflect recent research findings that show the public responds better to scientific facts and information about safety than attempts to "naturalize" radioactivity or compare it to familiar or common things (19, 21).

EM needs to expand its outreach to the general public. The EM Exhibit is currently aimed at college-educated audiences. EM needs to inform the public at all levels, especially those who live near DOE sites. In addition to testing EM Exhibit audiences, a sample of the general public should be tested. These tests could be used to evaluate which audiences learn best from the EM Exhibit, and what kind of dialogue has a positive impact. These tests could also be used to determine how the information needs of the general public differ from those of EM Exhibit audiences. Research results would help EM evaluate what its audiences and purposes are, whether it is using the best communication tools, and how to improve its public outreach effort.

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