

EXPERIENCE IN PRESENTING SHORT COURSES IN WASTE MANAGEMENT TECHNOLOGIES FOR SECONDARY SCIENCE AND MATHEMATICS TEACHERS

W. J. Toth, T. H. Smith, M. M. Garcia and J. E. Ferguson
Idaho National Engineering Laboratory
EG&G Idaho, Inc., Idaho Falls, ID

ABSTRACT

The Department of Energy (DOE) and its Idaho National Engineering Laboratory (INEL) recognize the need for quality education in science and mathematics and are developing educational programs that will help nation avert projected shortages in scientific and engineering manpower. These programs have as their long-range goal encouraging more students to pursue technical careers. One approach to this end is to help teachers become better prepared to teach topics that are more relevant, and, thus, to enthruse more students. With assistance from other INEL contractors, EG&G Idaho, Inc., prime contractor at the INEL developed and offered a Short Course in Waste Management Technologies for Secondary Science and Mathematics Teachers. The 40-hour, one-week, intensive Short Course has two immediate purposes: (1) to provide secondary-level science and mathematics teachers with training and information that will be useful to them in the classroom, and (2) to provide information on a topic of widespread interest in today's society, i.e., the management of hazardous and radioactive wastes and the restoration and preservation of the environment.

The Short Course was offered for the first time in the summer of 1989. The enormous success of this program led to the development of an expanded program. Two sessions were offered during the summer of 1990, and additional sessions will be offered in future years.

This paper describes the development of the Short Course and summarizes some of the lessons learned in the preparation and presentation of such courses. By helping teachers enhance their knowledge in these areas, the INEL hopes that students will gain a better understanding of the environment and its management. Hopefully, many will also be encouraged to pursue careers in science and technology.

BACKGROUND

Recent projections by the National Science Foundation (NSF) (1) demonstrate a looming crisis in the future supply of technical manpower. The NSF estimates that by the year 2006 the nation will experience shortfalls of about 400,000 in the supply of scientists and about 275,000 in the supply of engineers. Such shortfalls in technical manpower will greatly affect the DOE's ability to meet its mission for the nation, as well as the nation's ability to compete globally in advanced technologies. In particular, the rapidly expanding manpower requirements for DOE's Waste Management and Environmental Restoration (ER/WM) activities will further increase the competition for qualified technical personnel, both in the near term and in the future.

These shortfalls have two primary causes. First, the number of college-aged students in the population is decreasing. The Baby Boom Bubble has passed through the educational system and the subsequent decrease in the numbers of students is now impacting the nation's colleges and universities. Second, the percentage of students pursuing careers in science and technology is dwindling as increasing numbers of students choose non-technical careers. Science, engineering, and mathematics are increasingly viewed by students as too difficult, boring, or "just for nerds."

They see other careers as more alluring and think they are easier to get into. As a nation we are simply failing to make science and math relevant and interesting to students who are being enticed by so many other options.

The combination of these two effects resulted in a drop of over 30% in the number of science and engineering majors graduating from college during the last two decades. Thus, our nation must resolve to make significant strides towards improving science and mathematics curricula and rendering them more interesting and relevant to today's students. Such measures will, we hope, prompt more students to desire to pursue technical careers, and the looming manpower crises may be somewhat abated.

Besides facing both immediate and future manpower shortages, DOE also faces a credibility deficit. Recent disclosures of environmental contaminations, continuing increases in waste inventories, and growing public concerns about the safety of DOE's weapons and nuclear technology facilities present the DOE with a public information and education challenge. The public is growing increasingly alarmed by inaccurate and emotional reporting. People are being told that what you cannot see, smell, hear, touch or taste, will definitely hurt you. Hysteria about perceived dangers persists, and the cost of correcting the problems

* This program was funded in 1989 by the U.S. Department of Energy, Environmental Restoration and Waste Management, and in 1990 by Nuclear Materials Production Programs at the INEL under DOE Contract No. DE-AC07-76ID01570.

and protecting ourselves rises to gargantuan proportions. The majority of the general public simply does not have enough information to sort out the information presented to them and to make intelligent choices. (This was readily apparent in the reaction of the teachers to the Short Course, as many of them expressed a reversal of very negative impressions to more positive ones as they realized that DOE was doing the best job possible.) As a result, so-called "experts" abound and easily arouse in their communities strong opposition to anything new. The challenge for DOE is to persuade the public that it does things in the safest possible manner. This is difficult indeed.

Tomorrow's adults, as well as today's, must be increasingly well informed about technical matters in order to make good, rational decisions about public policy and about everyday choices regarding lifestyle options and their effects on the environment. One way to create a better informed and more technically literate public today is to provide accurate and objective information through the nation's media; however, in order to ensure that tomorrow's public is more technically literate and informed, we must start turn to the educational system. By improving science and mathematics curricula, we will better prepare students to understand the technical issues they are certain to face as adults. By making science and mathematics more interesting and relevant to today's world, we will keep students interested longer, and students are more likely to consider technical careers. The nation as a whole must make this a priority, and the DOE must do its part.

With the goals of educating the public and encouraging students to pursue careers in science and engineering clearly in mind, DOE has taken a leading role addressing improvements in science and mathematics education. For years DOE's national laboratories have aggressively pursued this mission by developing programs to achieve these goals. The current Secretary of Energy, James D. Watkins, has reinforced this mission by making science and mathematics education a priority for DOE.

INEL PROGRAMS

Like other national laboratories, the INEL has developed and implemented a number of programs aimed at science and mathematics education. The challenges for the INEL, however, are magnified by the fact that it is located in a region where small rural schools are the rule. Programs that are highly effective for sister laboratories located in more populated areas are not as effective in the rural Intermountain region surrounding the INEL. The causes of this reduced impact lie in 1) the longer distances students and teachers must travel to take advantage of laboratory-based programs, and 2) the lack of resources available to the schools to do this travelling.

Therefore, the INEL developed and implemented programs that can be taken to the schools. While many of these programs challenge and stimulate students directly, special emphasis has been given to developing programs that assist teachers. This targeting of teachers for special emphasis in developing programs is intentional.

Teachers are the backbone of our educational system, and we recognize that this system can only be as good as the teachers in it. Teachers have a huge impact not only on what we know, but on how we think. Teacher attitudes carry over to their students and influence student attitudes for the rest of their lives. In the course of a lifetime of teaching, one single teacher can have a dramatic impact on literally thousands of students directly and several times that number indirectly. Thus, by training teachers about today's technology and its problems and issues, and by helping them develop methods to apply this knowledge in the classroom, we can contribute tremendously towards the creation of tomorrow's informed public, at the minimum, and towards increasing the ranks of tomorrow's scientists and engineers, at the optimum.

To improve curricula and inspire students to pursue technical careers, INEL's teacher programs have the following goals: 1) to increase teacher understanding and knowledge of science and mathematics associated with energy-related technologies, especially those technologies under development at the INEL, 2) to provide teachers with in-depth knowledge and first-hand experience with programs and activities at the INEL, especially in ER/WM areas, 3) to help teachers develop methods and skills to apply this knowledge and experience in the classroom, and 4) to increase the resources (materials, information, and personnel) available to teachers in the classroom. One type of program that allows for all of these goals is the development of short courses for secondary science and mathematics teachers.

The goal of short courses is to provide teachers with timely and accurate information about energy cycles, the wastes that they produce, the impacts these have on the environment, and the ways in which these impacts can be reduced. In addition, short courses can help teachers understand the activities at the INEL, as well as the challenges faced by DOE in the management of the nation's nuclear and hazardous wastes. To this end, the "Short Course in Waste Management Technologies" was developed in 1989 and was offered to secondary school educators for the past two summers. The offerings to date have met with great acceptance and enthusiasm on the part of the teachers and have done much to impact the education in Idaho with respect to waste and environmental issues.

WASTE MANAGEMENT SHORT COURSE

The purpose of the Short Course is to provide teachers with a "real world" science and mathematics experience to help them understand how science comes into play in current research DOE areas. The Short Course also provides useful information on a topic of current interest and high visibility in Idaho, i.e., waste management and its impact on the state's environment. Teachers are then able to carry this information back to their students and create more positive and knowledgeable attitudes about science and mathematics.

The Short Course was first held on pilot scale in the summer of 1989. It was made possible through the joint effort of the DOE, INEL contractors, the State of Idaho Department of Education, Idaho State University, and an advisory group of teachers. This partnership resulted in a successful Short Course.

Each participating organization made a unique contribution to the development of the Short Course. DOE sponsored the program by underwriting most of the costs and by providing access to its considerable facilities. INEL contractors participated by organizing the Short Course and providing experienced personnel to act as instructors. The State Department of Education announced the program throughout the State's schools and provided a small stipend to participating teachers.

Idaho State University offered education credits for Short Course participants and approved an INEL senior staff member to serve as the Instructor of Record. Credit consisted of two hours at the undergraduate or graduate level. Participants obtained undergraduate credit by attending the Short Course and successfully completing the final examination. Participants earned graduate credit, which is applicable towards recertification, by completing a take-home assignment. This assignment involved preparing a sample lesson plan or curriculum to demonstrate how the information in the Short Course could actually be applied in the classroom.

The advisory group of teachers participated initially by helping us structure the workshop to address topics of greatest interest to the participants, and then by reviewing and critiquing individual presenters. This latter function is invaluable in the development of such courses by non-university organizations. In this instance, it ensured that the INEL technical experts presented information at a level useful for teachers and commensurate with their training and education. Through the involvement of teachers in defining the needs, structuring the activities intended to address those needs, and implementing those activities, we found that the credibility of the program with enrolling teachers was greatly enhanced, and appropriateness of topics and materials was ensured.

In the pilot offering, 23 Idaho teachers participated and gained knowledge in the handling, transportation, treatment, and storage of hazardous and radioactive waste (2). In the two sessions offered during the summer of 1990, over 60 teachers from around the State of Idaho, and including one from Montana, participated in the Short Course. The format of the course was a one-week, 40-hour, intensive course. Table I summarizes the topics and activities of the week-long course.

As the table shows, participants heard some introductory information about the INEL and presentations on radioactivity. Other subject areas included biological effects of chemical and radioactive contaminants; energy cycles, including the nuclear fuel cycle and the fossil fuel cycle; definitions of the types of waste, the sources of these wastes, their characteristics, and the hazards they present to the public and to the environment; and treatment and handling technologies. A brief history of government regulations was also included.

Teachers were shown examples of protective equipment and clothing provided to workers as well as a demonstration of a worker donning these protective devices. Transportation and handling techniques were discussed, technology demonstrations were given to illustrate treatment technologies such as In-Situ Vitrification, Vacuum Vapor Extraction, and other advanced treatment technologies. Laboratory tours afforded a firsthand experience of the types of monitoring systems used to maintain a vigilant watch over the environment at the INEL. Facility tours included a waste volume reduction facility, a reprocessing facility, a storage facility, and a disposal site.

In order to assess the effectiveness of the Short Course, a pre-test was given to all participants. In the 1989 pilot offering and the first session of 1990, the pre-test was mailed to the teachers several weeks before they arrived at the INEL. In the second session of 1990, it was offered at the beginning of the course. This provided a baseline from which the level of educational benefit could be measured. A final examination measured the level of understanding at the conclusion of the course. Table II summarizes the pre-test and final examination scores for the three sessions. As can be seen, the course was very effective in increasing the teachers' overall knowledge of waste management topics.

At the conclusion of the Short Course, teachers were asked to provide a written evaluation of the workshop and were asked to participate in a discussion period that followed. The evaluations were overwhelmingly positive and have convinced the INEL's management to continue to offer the Short Course in the future. One common comment was that the teachers appreciated receiving instruction by actual practitioners in the area of waste management. Comments received are being used to improve aspects of the course. Additional positive evaluations have come from two

TABLE I

**List of Activities for the INEL's One-Week Short Course in Waste Management Technologies
for Secondary Science and Mathematics Teachers**

Registration, Welcome and Introduction

INEL Overview

Review of the Nuclear and Fossil Fuel Cycles

Effects of Exposure to Chemical and Radiological Hazards

Definition, Source, Characteristics, Hazards, and Management Methods for Various Classifications of Wastes, including

- Hazardous Chemical Wastes
- High-Level Radioactive Wastes
- Low Level Wastes
- Transuranic Wastes
- Mill Tailings
- Mixed Wastes
- Solid, Non-Hazardous, Non-Radioactive Wastes

Transportation Methods and Containers for Wastes

Historical Perspective: Case Histories and Regulatory Evolution

Personnel Protection Practices and Equipment

Migration of Contaminants in the Environment with Emphasis on INEL

Examples of Basic Chemistry, Biology and Physics Applications

INEL Research Overview

"High-Tech" Waste Management Activities at the INEL

Laboratory Demonstrations

- Biotechnology Research
- Vapor Vacuum Extraction
- In-Situ Vitrification
- Plasma Applications

Laboratory Sampling, Monitoring and Analysis Instrumentation

Tour of Waste Experimental Reduction Facility

Presentation on Buried and Stored Waste Management

Tour of Radioactive Waste Management Complex Facilities

Presentation on Spent Fuel Handling Technologies

Tour of Process Experimental Pilot Plant and Spent Fuel Facilities

Presentation on Nuclear Fuel Reprocessing

Tour of the INEL Chemical Processing Plant Facilities

Review and Discussion of Course Materials

Final Exam

Graduate Credit Take-Home Assignment: Educational Module Development

Course Critique (Written and Discussion)

Graduation and Reception with INEL Managers

other DOE laboratories that have expressed interest in using the INEL materials to offering similar courses in waste management technologies in their regions.

TABLE II

Average Scores of Pre-test and Final Examination for Each of Three Sessions

Session Average	Pre-Test Average	Final Exam Average
1. Summer 1989	68%	92%
2. Summer 1990, #1	61%	81%
3. Summer 1990, #2	50%	81%

Teachers taking the Short Course for graduate credit were given a take-home assignment which was due three weeks after the conclusion of the course. For 1989 these were published and distributed to each of the participants and to other interested teachers. A similar effort is being considered for the 1990 participants. A follow-up evaluation for 1989 participants is recommended in order to determine the actual effectiveness of the Short Course in influencing the teacher's classroom presentation of materials related to environmental management. A similar survey is recommended for 1990 participants after one full year of teaching in order to see how much they used the Short Course information in the classroom. Follow-up surveys in later years can provide assessment of the long term influence of the Short Course.

The workshop provided a number of benefits to teachers. Besides extensive instructional materials which included a textbook, copies of all lecture materials, and a notebook full of reference articles and materials, teachers were provided with other materials and information on waste management. The INEL paid the fees for Idaho State University credit. Travel and local living expenses were provided to teachers traveling more than 75 miles one way. In 1989 the State of Idaho paid a stipend to each teacher to help defray any incidental costs. One of the best benefits for the teachers will be the continued availability of INEL personnel to answer questions and provide assistance in the delivery of information in the classroom.

LESSONS LEARNED

A number of valuable lessons learned as we developed and executed this program are summarized below.

1. Meticulous preparation is necessary. Attention to detail ensures that small problems with administrative or logistical details do not mar the content of the program and generate confusion among the participants.

2. An advisory group of local teachers is essential for scoping such a course to the technical level and subject areas that will most benefit teachers enrolled in the course.
3. Dry runs of all presentations should be done before the course begins. The advisory group of teachers should critique these presentations with the presenters immediately afterwards.
4. Hard copies of all presentation materials should be provided to participants so that notetaking is kept to a minimum. The hard copies must be in the exact order used by presenters. Teachers should be invited to duplicate these materials and use them in the classroom when appropriate.
5. Supplementary and reference materials for each presentation helps teachers do further reading on particular topics.
6. Presenters should be practitioners in the area. Managers tend to have much less credibility than workers. Presenter resumes should be provided so that participants can get to know the presenters. Work phone numbers should be provided so that teachers can use the presenters as resources during the school year.
7. Care should be taken to ensure objectivity. Tell it like it is. Honesty is the best policy. Answer all questions fully, except, of course, when security prevents this. Allow no propaganda--teachers are quick to pick it up and to discount the presenter.
8. Cooperation between the laboratory, the state Department of Education and the sponsoring university is essential. Making this cooperation evident to teachers increases credibility.

CONCLUSIONS

The INEL has successfully developed and delivered a Short Course in Waste Management Technologies. The Short Course is an effective way to educate teachers regarding DOE's ER/WM activities, problems, and solutions. Teachers are receptive to this type of continuing education, especially when it is accompanied by college credit. Teachers use the information gained in the classroom to help students understand the "real world" of ER/WM and, hopefully, to excite some to pursue careers that will enable them to participate in DOE programs in the future.

DOE, the entire federal government, and the nation as a whole also received benefits from the Short Course. First, enlightened teachers have a better understanding of the real issues and situations in areas important to ER/WM. Second, through the teachers, students will be educated more thoroughly on aspects of waste management and associated issues. Finally, many students will, hopefully, identify interesting career opportunities for themselves in science and mathematics as it applies to waste management in particular and to energy-related research in general. DOE hopes that

many of these students will eventually comprise part of the future work force of the Department and its laboratories.

REFERENCES

1. C. HOLDEN, "Wanted: 675,000 Future Scientists and Engineers," *Science* (June 30, 1989).
2. W. TOTH and L. NOVELANKO, "A Short Course in Waste Management Technologies for Secondary Science and Mathematics Teachers," *American Chemical Society Corporation Associates Annual Symposium* (April 23-24, 1990).