Development and Deployment of a Model for E-Learning in Safety and Health Education

Terri Heidotting
National Institute for Occupational Safety and Health

Mark Hodges
Georgia Tech Research Institute

Sandra Tillett
National Labor College
OSHA Region III Education Center

Abstract

In response to initiatives aimed at furthering the distance learning capabilities of OSHA Training Institute Education Centers (OTI's), a web-based OTI 2264 Permit-Required Confined Space Entry course was developed and evaluated. This prototype distance learning course would serve as a model for the development of future distance learning courses. While the availability of a web-based version of this course enabled learners to work at their own pace, repeatedly review materials, and access materials in a variety of formats, noted limitations are inherent to distance learning courses, such as the absence of hands-on learning experiences. Findings from this study need to be taken into account when designing occupational safety and health distance learning courses, where course content may be more or less well suited to instruction using a distance learning approach. Some courses may be best suited for a "blended" approach that combines both distance learning and classroom components.

Background and Rationale

Between 1997 and 2001, a total of 458 confined space workplace fatalities occurred (Meyer 2003). Industries with higher incidents of fatalities include construction, agriculture/forestry/fishing, and manufacturing. In construction, laborers reflect the group of workers that are at greatest risk (17% of the total number of fatalities for this period). The highest rates of fatalities occurred through exposure to toxic fumes and being caught in or crushed by collapsing materials. Fatalities among rescuers are significant. In their training material, OSHA reports that they are as high as 66% of all confined space fatalities (OSHA, 2004). Other researchers place this figure at somewhere between 5%-36% (NIOSH 1986, NIOSH 1994, Meyer 2003).

Confined space workplace environments present formidable challenges to employers responsible for securing worker safety. Hazards may be physical (crushing, engulfment) or atmospheric (lack of oxygen, exposure to toxic gases). They may emerge as a result of conditions in the external environment (weather/temperature, moisture-rain/humidity levels) and/or activities internal to the confined space (worker actions, presence of materials/equipment). Existing evidence suggests that not enough has been done in the area of safety training to provide workers with the knowledge and skills they need to prevent workplace injuries and fatalities. Based on a sample of 70 investigations from 585 confined space fatalities that occurred between 1983 and 1993 in the United States, only 67% (n=47) of the employers provided safety training to their workers (NIOSH 1994). It has been demonstrated that occupational safety and health (OSH) training can lead to improvements in worker knowledge and behaviors (Cohen and Colligan 1998). Evidence also shows that participation in OSH training has been associated with reduction of workers' compensation claims for construction laborers (Dong, et al 2004).

Nonetheless, the construction industry remains a field fraught with difficulties for employers trying to implement and evaluate safety and health training. Construction workers can be very mobile, both between multiple worksites and among different companies and contractors. The workforce is continually changing with an influx of new hires, many having limited English skills. While union construction workers may receive structured multi-year training, non-union shops represent 80% of the construction workforce (Goldenhar, et al 2001). Consequently, OSH training for construction must be able to meet the unique worker needs of this industry.

Role of Web-based Training. Web-based training shows considerable promise for overcoming some of the challenges that workers in the construction industry face in gaining the knowledge they need to work safely on the job. For example, web-based training can be completed at a time that is convenient for the learner. Because training can be completed where the workers are located, there is a reduction in travel costs and overall time devoted to the process (Gibbons and Fairweather 2000). Learners can proceed through the training at their own pace and repeat selected content as needed. Consequently, instructional methods inherent in web-based training address two important instructional goals that would be foundational to the development of the training program for this project : 1) the ability to effectively convey the information to all learners by creating an instructional environment that would be able to meet the wide range of audience learning needs (such as by providing a variety of communication formats, ability to proceed at the learner's own pace, and access to a range of resources), and 2) the ability to provide learners with the opportunity to monitor their own learning so that improvements in knowledge and skills can be made (through quizzes, learning checks, access to content experts or instructors) (Sugrue and Clark 2000).

Development of the Project. In response to initiatives aimed at furthering the distance learning capabilities of OSHA Training Institute Education Centers (OTI's), the confined space course was selected as the topic for a prototype distance learning course that would serve as a model for the development of future distance learning courses. The OTI 2264 Permit-Required Confined Space Entry course targets trainers, and its selection would provide the construction industry with a resource for delivering training to workers regarding a high risk confined space work settings. Availability of a web-based version would increase opportunities for trainers in the construction industry to receive this much-needed training and thus overcome some of the previously mentioned obstacles associated with classroom training, such as limited training periods/dates, increased training time, and associated travel costs. Because a hands-on component is not required to complete this course, it also provided a test bed for development and use of a course delivered entirely via distance learning. The course content would enable curriculum developers to apply a wide range of distance learning instructional techniques, and thus provide feedback on some of these methods. The purpose of this project was to develop and evaluate the web-based OTI 2264 Permit-Required Confined Space Entry course. The development and evaluation of this course was conducted through collaborations between OSHA Training Institute Education Centers from Regions III and IV, the Center to Protect Workers' Rights (CPWR), National Institute for Occupational Safety and Health (NIOSH), Georgia Tech Research Institute (GTRI), and national OSHA Training Institute.

Methods

To guide the course development and evaluation process, the project team used the Training Intervention Effectiveness Research (TIER) Model (NIOSH, 2000) developed by NIOSH's Training Research and Evaluation Branch (TREB). Using this model, the project team strategically guided research and evaluation efforts so that curriculum development and evaluation resources were used most effectively.

Overview of the TIER Model. Using the Training Intervention Effectiveness Research (TIER) Model (NIOSH, 2000) developed by NIOSH's Training Research and Evaluation Branch (TREB), the project team coordinated and integrated course development efforts with evaluative components from the beginning. The TIER model aims to effectively and strategically guide research and evaluation efforts so that curriculum development and evaluation resources may be efficiently applied. The model is designed to: 1) take into account the intrinsic challenges of identifying specific factors that make the training-learning-action continuum successful; 2) logically match research efforts with the nature of the question(s) at hand; 3) minimize training and curriculum development risks; and 4) concentrate research resources.

The TIER Model systematically structures training effectiveness research across four stages. Stages 1 and 2 are components of formative evaluation in which the objectives and processes of training are conceptualized, drafted and refined. In Stage 1, training goals and content were selected, reviewed and structured, while in Stage 2, draft training materials were tested in pilot training sites. During these stages, instructional alternatives are explored to determine which are most appropriate for study. Stages 3 and 4 of the TIER model reflect summative evaluation processes, where systematic examinations are conducted of the training to determine if the fully developed training intervention is meeting its objectives as desired. In Stage 3, a course evaluation is conducted to determine whether the training produced the desired outcomes and what critical elements helped to facilitate this, while Stage 4 reflects a longer term impact assessment of the training, of which only preliminary data was collected for Stage 3. Applications of the training through multiple offerings of a course would provide the information needed to monitor its longer term impact. To summarize across the four stages, the curriculum development process is an iterative one that cycles through the basic processes of curriculum design/development, data collection of learner feedback, and data analysis of learner feedback. The cycle begins again with subsequent redesigns, and additional data collection of learner feedback and additional data analyses, only to cycle again once more. Figure 1 provides an illustration of this process.

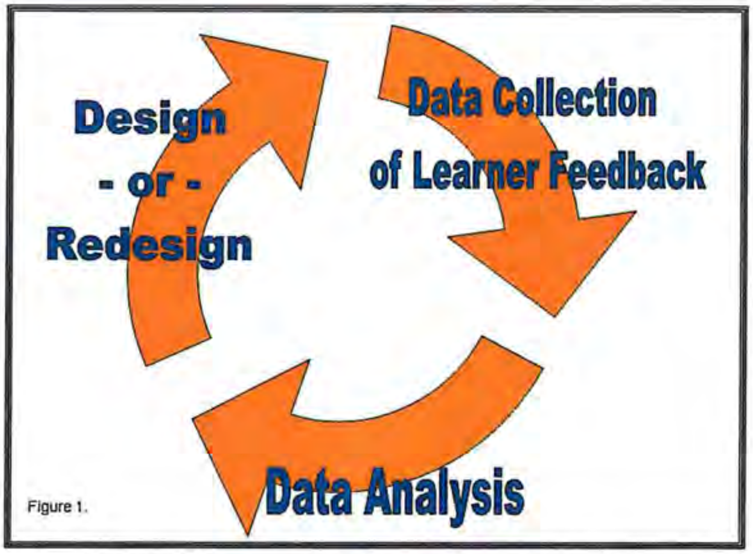

Figure 1. – Course Development and Evaluation Cycle Using the TIER Model

Project Methods - Stages 1 and 2: In the beginning stages of course development, curriculum developers of the team identified course content by participating in and reviewing curricula offered through other confined space courses and interviewed other confined space instructors. These efforts facilitated the identification and selection of the most important and necessary information that was found to be important across multiple instructional contexts.

One goal of the training was to effectively convey the information to all learners by creating an instructional environment that would be able to meet the wide range of audience learning needs. To meet this goal, the course incorporated a variety of instructional techniques (Sugrue and Clark 2000). Graphics and streaming videos were used to help illustrate the concepts and equipment used in a confined space setting. Textual information was narrated in software animations for learners who may have preferred to hear, instead of read, the content. These techniques would enhance the learning experience for those who may have had learning or language difficulties, as well as reach learners with different learning styles and needs. Learners had the opportunity to select from a range of peripheral instructional components (regulation documentation, interactive animations) that were capable of meeting their individual learning needs. Navigation structure (i.e. page numbering, menus bars) enabled the learner to review previously learned material, access a glossary of terms, a library of readings, and obtain a copy of the regulatory standards. Another goal of the training was to provide learners with the opportunity to monitor their own learning. Here, the training incorporated interactive animated simulations in order to provide learners with the opportunity to practice and apply the information. Pre-course assessments and learning checks were incorporated throughout the course so that learners would be able to monitor their understanding and progress.

Reflecting Stage 1 and the formative evaluative components of the TIER model, a prototype of the course was developed and a pilot study was conducted with safety and health trainers (n=6) at the International Brotherhood of Electrical Workers (IBEW) union computer learning laboratory in Washington, D.C. and again evaluated by confined space entry instructors from GTRI and CPWR. Evaluation of the data collected from individual think-aloud protocols and focus group discussions with respect to this prototype module were used to enhance the course. After extensive course reviews and format modifications based on data obtained in Stage 1, a working version of the complete course was used on the web with learners (n=38). In Stage 2, course evaluations were collected after learner completion of the working version of this course. As a result of the above, additional improvements were again made to the course.

Project Methods - Stages 3 and 4: Reflecting summative evaluative processes of the TIER model in stages 3 and 4, comparative evaluations were made of the impact of the course on peer trainers participating in the web-based training relative to peer trainers participating in conventional classroom training. All participants were peer trainers (n=21) enrolled in the OTI 2264 course sponsored by the Center to Protect Workers' Rights (CPWR). The project team collected learner feedback via course evaluations and focus groups. Approximately half (n=12) of the peer trainers in the course volunteered to receive a module of the training via the web. Consequently, these volunteer peer trainers received one web-based module while the same content was being covered in the classroom. After completing the modules, peer trainers from both classroom and web-based groups filled out a course evaluation and participated in a focus group. The course evaluations were used to gain feedback regarding whether the training module was effective in producing the desired outcomes (effective learning of the content) and what instructional elements helped to facilitate this (Stage 3-TIER). Focus groups collected information regarding how relevant the peer trainers felt the module would be to their own workplaces, as well as the effectiveness of the module as an instructional tool (Stage 4-TIER). Focus groups were comprised of peer trainers depending upon the type of training (classroom-based for all modules vs. recipients of one web-based module) and the module topic (rescue, instrument, and hazard) for a total of six focus groups. Table 1 summarizes the processes involved in each of the four TIER stages along with the evaluation objectives/activities, and the target population that provided feedback.

Table 1. – **Project Applications of the TIER Model**

Stages / Timeline		Objectives and Activities	Targeted Population
Stage 1	FORMATIVE STAGES	*Formative research with trainers/trainees* • Pedagogic review/comment. • Materials development (partial). • Training materials delivery (pilot). • Focus groups/Interviews.	Peer trainers (n=6) IBEW union members review prototype course. Feedback provided via think-aloud protocols and focus groups.
Stage 2	FORMATIVE STAGES	*Process research - Pilot test & refine course* • Deliver pilot training program. • Focus groups/interviews. • Feedback for revision. • New Course development.	Learners completing and evaluating online OTI 2264 Permit-required Confined Space Course (n=38) through Atlanta web training and hosting firm. Feedback provided via course evaluations.
Stage 3	SUMMATIVE STAGES	*Outcome research - Assess Learning Outcomes* • Observe random trainers. • Course evaluations regarding learning effectiveness. • Collect and analyze data regarding outcomes. • Synthesize feedback for future revisions.	Peer trainers completing modules of online or classroom versions of the course (n=21) at Center to Protect Workers' Rights course. Feedback provided via course evaluations.
Stage 4	SUMMATIVE STAGES	*Impact Assessment - Measuring Impact of Training* • Post-training focus groups – relevance and applications to workplace. • Collect and analyze data regarding impacts. • Compile final report. • Ongoing collection learner feedback from future course offerings.	Peer trainers completing modules of online or classroom versions of the course (n=21) at Center to Protect Workers Rights course. Feedback provided via focus groups.

Project Findings

In Stage 1, analyses of think-aloud and focus group data obtained in Stage 1 from IBEW trainers (n=6) provided both the strengths and areas for improvement in the prototype version of the course. One frequently mentioned area of difficulty involved computer "glitches" that were not a part of the design of the course, but the result of a problem with the technology or a result of limited technology experience of the learner. For example, instances where drop-down menus did not work, audio did not work, and slow loading of graphics were technology-related problems, while instances where learners did not know how to work some of the drop-down menus, learning check exercises, navigate effectively through the content to different areas, or get rid of pop-up boxes may have reflected the inexperience of the learner. Other suggestions focused on the need to improve graphics and the visual appeal of the environment (for example, the need for additional pictures, improvements in some pictures, changes in color of hot buttons and vocabulary words, and eliminating large areas of blank space on a page). Where possible, the project team made improvements in the program based on these comments. One suggestion noted that learners should be able to email an instructor with their questions. Use of email was not made available to the IBEW trainers but was incorporated into the actual fielded course. Some learners still stated a preference for a hands-on component for this kind of course, especially if the learner needed to receive certification level training; however, the web course can be delivered in a blended format, with classroom demonstrations included. Learners noted that the strengths of the course included the animations, graphics, presentation of the content, availability of additional information, and concise explanations. Learners also greatly appreciated the pre-tests, quizzes and learning checks, and the interactive animations/simulations that all provided a means for them to monitor their own learning. Highly praised was the ability for learners to proceed both through the training at their own pace and to review the content as often as desired.

Stage 2 provided the opportunity for the team to monitor feedback from actual learners (n=38 respondents) taking the course and to see what additional modifications needed to be made and whether changes made based on Stage 1 were sufficient. Table 2 provides a summary of the cumulative ratings for the evaluation criteria. One criteria rated lower, though it still received a "good" rating (n=3 responses), was regarding the effectiveness of the audio/visuals, where write-in responses said that some of the images were of poor technical quality and some of the pictures should be larger. Because the project team could not find evidence of technical difficulties in the web course, the problem may have been due to a limitation of the computer that the learner was using. All of the remaining criteria were rated as adequate through excellent, with most criteria being rated in the very good and excellent categories.

One suggestion received was the need for a course notebook that provided a written document with the course information. Consequently, a notebook was created that contained the text of the confined space standard, appendices, frequently asked questions regarding the standard, glossary of terms, library of supplemental materials, and slides used in the course lessons. This document was made available with subsequent course modifications as a printable PDF file that learners could access while they took the course.

Table 2. – Stage 2 Course Evaluation Feedback

Evaluation Criteria	Cumulative Rating
Communication of learning objectives	4.1 (Very Good)
Accomplishment of learning objectives	4.1 (Very Good)
Course content	4.1 (Very Good)
Training environment was conducive to learning	3.8 (Good)
Relevance of course topics to your job needs	4.4 (Very Good)
Effectiveness of exercises/workshops	4.0 (Very Good)
Effectiveness of labs/field trips (32 "NA" answers)	3.7 (Good)
Effectiveness of audio/visuals	3.8 (Good)
Usefulness of course materials and handouts (12 "NA" answers)	4.0 (Very Good)
Overall rating of this course	4.1 (Very Good)

Rating Criteria: 1=Deficient, 2=Adequate, 3=Good, 4=Very Good, 5=Excellent

In Stage 3, course evaluations were collected in order to obtain feedback regarding the effectiveness of the module (i.e., content, instructional approaches, web-based versus classroom formats) and what critical elements helped facilitate their learning of the materials. In comparisons of learners who received the web-based module with learners who received the classroom-based module, learners from the classroom rated the modules slightly higher on selected criteria (web-based mean of 2.5 versus classroom-based mean of 3.5). A summary of the course evaluation criteria and the mean response scores for both web-based and classroom-based responses are provided in Table 3.

Table 3. – Stage 3 Course Evaluation Feedback (Mean Values)

	Participants received:	
Evaluation Criteria	**Web-based Module**	**Classroom-based Module**
Effectively presented information.	3.1	3.3
Accomplishment of learning objectives.	3.0	3.4
Provided examples (case studies, stories, demonstrations).	2.4	3.3
Provided pictures/graphics that were helpful.	2.8	3.6
Presented information so that it was interesting.	2.7	3.7
Provided feedback that helped with learning.	1.8	3.8
Able to apply what learned (i.e. via exercises)	1.7	3.6
Training prepared me to be able to effectively convey safety information to others.	2.5	3.7
Overall rating of this course	2.5	3.5

Rating Criteria: 1=Deficient, 2=Adequate, 3=Good, 4=Very Good, 5=Excellent

Write-in comments from both groups of learners provided a more complete picture of the advantages and limitations of each instructional approach. Advantages of the web-based module echoed some of the previous themes from data collected in stages 1 and 2, and reflected the same advantages that are often used to describe web-based instruction in general. For example, learners noted the advantages of the web-based module as the ability to proceed through the material at one's own pace, flexibility to take training according to one's own schedule, the ability to repeatedly review content, access to additional resources, no distractions that are often present in the classroom, and entertaining interactive animations provided feedback on their own learning progress. Limitations that were noted also reflected some of the previously mentioned themes and included, for example, lack of discussion with instructors/co-learners, inability to ask questions of an instructor and receive immediate feedback, and no hands-on learning experiences. More detailed examination of learner feedback revealed that some modules were regarded more favorably than others. Modules that contained more interactive animations and video (i.e. instrumentation module) were praised more highly than modules that contained less of these components (i.e. hazards module). This was an unintentional outcome of the course design in that some content, such as where instrumentation may be used, might have provided more opportunities for these types of techniques. However, it may be worth further investigation as to whether selected content in web-based training may be overlooked should it be presented in a less interesting manner than other modules.

No major differences were found in the types of responses provided by learners with and without previous web-based learning experiences. Though much more data would be needed, there was a slight tendency for learners with previous web-based learning experience to rate the course slightly lower overall than learners without these previous web-based experiences. It's possible that experienced learners may have more exposure to other web or computer-based programs that could be more sophisticated and entertaining (i.e. Playstation games). Learners without these prior experiences may have been more "dazzled" by this novel learning experience. This may have long term implications for whether selected animations may remain to be effective with subsequent generations of progressively more sophisticated computer users.

In Stage 4, focus group discussions were used to collect information regarding how relevant the peer trainers felt the module (i.e. content, instructional approach) would be to their own workplaces. While all of the web-based learners responded that they would readily use the training with their co-workers, they also felt that the training could not replace a hands-on classroom component, especially if the co-worker would need to perform some of the skills that were addressed in the training (i.e. use of instrumentation). They noted that the web-based instruction could be used as "homework" or to provide background instruction prior to engaging in hands-on demonstrations. They all noted that they would like to use the interactive animations and videos when conducting their own courses. Some of the respondents noted that there was limited access to the technology, so the web-based form of instruction would still not be a viable option.

Conclusions

Feedback from learners in all stages of this project highlights the important advantages of web-based training. Enabling learners to work at their own pace, savings in travel costs and time, opportunity to repeatedly review the materials, and the presentation of the information in multiple formats are just a few of those that were mentioned. However, the web-based training environment is not without problems. Advanced graphics, animations, and videos will not be useful to learners with limited technological capabilities. In addition, as noted by the learners who participated in this project, the web-based version does not include a hands-on component that is critical to the development of some workplace safety skills. Providing learners with multiple versions of a web-based course may be one way to address limited technological capabilities, where a "low-tech" version with less graphics/animations could be made available. Courses that combine both web-based and classroom-based instruction, often referred to as "blended learning" classrooms, may overcome web-based instruction's lack of hands-on training. This approach may also enable instructors to make the most efficient use of classroom time if learners receive background content via the web-based component beforehand. This approach would enable instructors to use valuable classroom time for the hands-on training and demonstrations.

Next Steps

It is anticipated that the online version of the 2264 Permit-Required Confined Space Entry web-based course that was developed and evaluated in this project will continue to be available depending on the demand. This project serves as a model for other courses that are also under development. Regions III and IV aim to continue offering web-based courses in dual formats, both a "low" and "high tech" versions, in order to meet the technological capabilities of a wider range of audiences. Discussions are ongoing about creating "blended learning" courses that combine the advantages of both web and classroom-based formats.

Acknowledgements

This project was partially sponsored through a grant from the Center to Protect Workers' Rights in association with its Cooperative Agreement with CDC/NIOSH (No. U60/CCU317202) and with internal funding from the Georgia Tech Research Institute. The findings and conclusions in this report are those of the author(s) and do not necessarily represent the views of the National Institute for Occupational Safety and Health (NIOSH).

REFERENCES

Cohen, A., and Colligan, M. (1998). *Assessing occupational safety and health training: A literature review*. DHHS (NIOSH) Publication Number 98-145.

Dong, X., Entzel, P., Men, Y., Chowdhury, R., and Schneider, S. (2004). Effects of safety and health training on work-related injury among construction laborers. *Journal of Occupational and Environmental Medicine*, 46, 1222-1228.

Gibbons, A. and Fairweather, P. (2000). Computer-based instruction. In Tobias, S., and Fletcher, J. (Eds.) *Training and retraining: A handbook for business, industry, government, and the military*, p. 410-442. American Psychological Association. MacMillian Reference USA: New York, NY.

Goldenhar, L., Moran, S., and Colligan, M. (2001). Health and safety training in a sample of open-shop construction companies. *Journal of Safety Research*, 32, 237-252.

Meyer, S. (2003). Fatal occupational injuries involving confined spaces, 1997-2001. *Occupational Health & Safety*, 72, 58-64.

National Institute for Occupational Safety and Health (NIOSH). (1986). *Preventing Occupational Fatalities in Confined Spaces*. DHHS (NIOSH) Number 86-110. Cincinnati, OH: National Institute for Occupational Safety and Health.

National Institute for Occupational Safety and Health (NIOSH) (1994). *Worker deaths in confined spaces: A summary of NIOSH surveillance and investigative findings*. DHHS (NIOSH) Number 94-103.

Occupational Safety and Health Administration (OSHA). (2004). "*Understanding OSHA's Permit-Required Confined Space Standard: Course 7300*" in Rescue pg. 1, August 2004. Washington, D.C.: U.S. Department of Labor, Occupational Safety and Health Administration.

Sugrue, B., and Clark, R. (2000). Media selection for training. In Tobias, S., and Fletcher, J. (Eds.) *Training and retraining: A handbook for business, industry, government, and the military*, p. 208-234. American Psychological Association. MacMillian Reference USA: New York, NY.

About the Authors

Terri Heidotting
Dr. Heidotting has been a researcher with the National Institute for Occupational Safety and Health (NIOSH) for five years in the Training Research and Evaluation Branch (TREB) and is involved in multiple research projects that include assessing the effectiveness of toolbox training talks for construction workers, development and assessment of tailored safety training materials for small businesses, assessment of bilingual training materials for non-Spanish speaking supervisors of Hispanic roadway workers, and an evaluation of the effectiveness of computer-based training on the calculation and use of the revised NIOSH lifting equation. Dr. Heidotting has also collaborated with the Meany Center for Labor Studies and Georgia Technology Research Institute on the development and evaluation of a confined space web-based training program. National Institute for Occupational Safety and Health (NIOSH), 4676 Columbia Parkway, MS C-10, Cincinnati, Ohio, 45230. Business Phone: 513-533-8325 Email: toh8@cdc.gov

Mark Hodges
Mark Hodges is a Senior Research Associate at the Georgia Tech Research Institute's (GTRI) Information Technology and Telecommunications Laboratory. His work primarily involves web-based training and dissemination of targeted technical information for occupational safety & health and hazardous substance management. At GTRI, Hodges has served as project director in a Center to Protect Workers Rights funded study to establish and implement a model for web-based learning in safety and health education. For his extensive experience in environmental hazard information dissemination, he was named chair of the Technology Transfer and Outreach Review Committee of the EPA-sponsored Great Lakes Environmental and Molecular Science Center. He holds an M.S. degree in Technology and Science Policy from Georgia Tech. (Telephone: 404/894-6987; e-mail: mark.hodges@gtri.gatech.edu)

Sandra Tillett
Sandra Tillett is the Director of the National Resource Center for OSHA Training, an OSHA Region III Education Center, at the National Labor College in Silver Spring MD. Her previous experience includes having served as the Executive Director of the Occupational Health Foundation, Director of Safety and Health for the Building and Construction Trades Department, AFL-CIO, and Senior Scientist with the Workplace Health Fund. Ms. Tillett was also previously engaged in research at the University of Cincinnati and has published extensively in the field of public health. She has a B.A. in Labor Safety and Health from the National Labor College (Telephone: 301-628-4852; e-mail: stillett@nationallaborcollege.edu).