Development and Assessment of a Model For Web-Based Safety and Health Education

Mark Hodges
Georgia Tech Research Institute
Georgia Institute of Technology
Atlanta, GA USA
mark.hodges@gtri.gatech.edu

Sandra Tillett
National Labor College
Silver Spring, MD USA
stillett@nationallaborcollege.edu

Terri Heidotting
Education and Information Division
National Institute of Occupational Safety and Health
Cincinnati, OH USA
toh8@cdc.gov

Abstract: This paper describes a three-year research study to develop and assess a model for web-based training in safety and health education. The study was a joint collaboration of the OSHA Training Institute Education Centers in Region III (the National Resource Center for OSHA Training at the National Labor College) and Region IV (the Georgia Institute of Technology), in cooperation with the National Institute of Occupational Safety and Health (NIOSH) Education and Information Division. The project involved the development of a web course in "Fundamentals of Confined Space Entry" and an extensive assessment of the course model by peer trainers and other worker-students. The end result of the study has been the development of a field-tested model for web-based safety and health education that relies heavily on animation.

Traditional classroom training may typically provide a richer learning experience than online coursework in safety and health education, but many workers find it difficult or impossible to leave their jobs and attend courses. For them, distance education appears to be the most viable alternative for learning principles of safety and health. Developers of web-based courses have often struggled to replicate the interactivity of the traditional classroom, in which participants can share knowledge and demonstrate safe job tasks. Advances in computer network capacity and animation software, however, are enhancing the ability of web courses to provide interaction and simulated depiction of work exercises. In addition, the availability of web courses: 1) allows workers to remain on the job, earning wages and maintaining productivity; 2) saves training costs in travel and time; 3) offers flexibility by giving busy learners continuous access to a course; and 4) provides a class that can be repeated to reinforce learning.

Some labor unions have been slow to embrace the use of information technology. Reasons for this delay in adoption can be attributed to a lack of financial resources or computer skills, as well as to the fear that new forms of technology-enhanced communications (i.e., Internet or Intranet) will replace the unions' role in protecting worker job interests (Fiorito, Jarley, & Delaney, 2000; Chaison, 2002). The growing popularity and advantages of information technology have led to advances in the development and use of e-learning courses and training tools. Such e-learning technologies have provided unions' educational organizations with an economical means of providing geographically disbursed and mobile members with an online training resource (Platner & Dong, 2002). The problem lies in ensuring that these e-learning courses meet the pedagogical requirements for high-quality

education and the distinctive needs of trade union students. Union educational organizations need to confirm that better models of online training are in use so as to make the most effective use of e-learning.

Several years ago, OSHA began to encourage its regional OSHA Training Institute (OTI) Education Centers to develop courses that students could take via the World Wide Web. Toward that end, the agency established distance learning as one of the criteria for continued support in a re-competition of those centers. The Region III center[1] and the Region IV center[2] established a partnership to develop a capability for web-based training. Both centers supported the efforts of a specialist in web-based training at the Georgia Tech Research Institute (GTRI) to develop a web-based OTI course and assess its effectiveness. The aim of this project was to develop a model that could be applied in future course development efforts.

Staff members from the Region III and IV OTI Ed Centers as well as the Center to Protect Workers' Rights (CPWR) also worked with the GTRI researcher to select a course topic for demonstration. This project team established the scope and design of the class, defined its topical content, continuously reviewed prototype versions of the course at various stages of development, and presented findings of the course at professional conferences and meetings.

The two centers were well positioned to support this assessment. The Region III Education Center provides courses to students throughout the mid-Atlantic region in Washington, DC, and the five surrounding states. This Ed Center also offers a labor field laboratory with access to three million construction union members and employer counterparts, along with 1,600 training facilities. Much of this work is facilitated through CPWR, an organization that conducts research in construction safety and health (in association with the Building and Construction Trades Department, AFL-CIO) through an ongoing cooperative agreement with NIOSH, and the National Labor College (NLC), which serves as the education arm of the AFL-CIO. The Region IV Ed Center provides courses to students throughout the 11-state Southeast region. Housed at Georgia Tech, this Ed Center offers state-of-the-art equipment, facilities and staff experienced in the areas of information technology, communications and education.

Participating personnel from NIOSH enhanced the project by providing expertise and a framework for evaluation through their Training Intervention Effectiveness Research (TIER) model. TIER is a research guide for evaluation 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. During these stages, researchers explore instructional alternatives to determine which are most appropriate for study. Stages 3 and 4 are components of summative evaluation—a systematic attempt to determine if the fully developed training intervention is meeting its objectives as planned or desired (NIOSH 1999).

Year One Activities

Selecting the Course and Gathering Content

The first activity in the study was to select a course topic appropriate for the assessment. The project team chose OTI 2264, Permit-Required Confined Space Entry, (Georgia Tech 2005) because OSHA does not require this course to be taught with a hands-on segment, although class offerings often have one. The three-day course also provides extensive content that is amenable to the software animations that GTRI wanted to incorporate in the web class. After selection of the topic, the researcher from GTRI gathered content for the web course through a variety of means, including: 1) attending classroom offerings of OTI 2264 conducted by CPWR in Huntington, West Virginia,

---

[1] The Region III Education Center is operated as a consortium of the National Labor College; the Center to Protect Workers' Rights on behalf of the Building and Construction Trades Department, AFL-CIO; and the University of West Virginia Safety and Health Extension. Information about the Region III OTI Education Center is available at http://www.georgemeany.org/html/nrc_for_osha_training.html.

[2] The Georgia Tech Research Institute of the Georgia Institute of Technology operates Region IV Education Center. Information about the Region IV OTI Education Center is available at http://www.oshainfo.gatech.edu.

and by Georgia Tech in Smyrna, Georgia; 2) utilizing course notebooks handed out to students in these classes; 3) reviewing PowerPoint presentation slides on the course topic that the U.S. OSHA Training Institute had compiled; 4) and having conversations with OTI 2264 trainers at GTRI and CPWR. The OSHA PowerPoint slides reflected OTI course content requirements and became the framework for the web course's lesson modules. They were enriched with additional textual information and visual images.

Developing the Course Model and Graphical User Interface

Under GTRI leadership, the project team gathered textual and visual content and began to adapt the model for the conventional classroom version of the course to the web. Team members determined that the online version of OTI 2264 would contain the following basic elements:

- A pre-course assessment that allowed students to answer a series of questions and determine their basic knowledge about the topic; and
- A series of lesson modules that the project team decided would focus on nine topics: 1) scope and definitions; 2) hazards; 3) general requirements; 4) instrumentation; 5) ventilation; 6) entry permits; 7) training; 8) rescue; and 9) permit-required confined space systems. Each module would contain a statement of learning objectives, learning material on the confined space entry standard, and multiple-choice quizzes with five to seven questions. The modules would present course content in a series of lecture-style "overhead" screens incorporating text, photographs, and illustrations, as well as software animations (authored in Macromedia Flash) and streamable video clips as needed.

During the same time period, GTRI also prepared a prototype graphical user interface for the course. The course frame included a window in which each lesson could be viewed, screen by screen (see Figure 1). The frame itself contained hot links for the lessons as well as supplemental material: a statement of the course's objectives, a guide for using the course, a copy of the confined space entry regulatory standard, a library of readings, a glossary of terms, and a page on which students could compose and send e-mail questions to the course instructor. GTRI also designed a standard format for the lesson pages (see Figure 2). While the intent of the designers was to create a simple "look" for each page, the process of reaching the final design required a number of iterations. The final design included the following elements:

- A page numbering scheme near the top left edge of the screen that allowed students to know which page they were at in relation to the entire lesson (e.g., Page 10 of 16);
- A subhead beneath the page numbering information that defined the name of the lesson;
- A main heading beneath the subhead describing the topic to be covered; and
- The content of the page itself, including text, image, animation and/or video clip.

GTRI inserted part of a sample lesson into this graphical interface and asked team members and advisors from NIOSH and the two participating Education Centers to comment on the course model and prototype graphical user interface. The early involvement of evaluation was deliberate and in keeping with the TIER model adopted for the project. The TIER model integrates evaluation into all stages of training development.

Building the Full Course Prototype

The next phase of work involved modifications to the graphical interface and course model based on comments received. Once these changes were made, GTRI began the labor-intensive process of building a full course prototype, using all of the textual and visual content resources gathered. They adopted the organizational framework for the course lessons already developed by the national office of the OSHA Training Institute. These course slides were essentially PowerPoint-style talking points and did not contain enough information to serve as a stand-alone class without the explanatory information that a lecturer would ordinarily provide. GTRI filled in these gaps, using conversational-style language designed to help students grasp the concepts under consideration.

The most innovative part of this work involved the creation of a series of 22 animations depicting relevant processes or required students to provide answers to problem scenarios. The authoring tool used to create these animations was Macromedia Flash. The GTRI project leader developed the concepts for the animations in collaboration with the Region III OTI Ed Center director, and a research associate at GTRI with a master's degree in information design technology implemented the designs in Flash. In one of these animations (see Figure 3), the student determines whether the oxygen level in a confined space is safe for entry. The student is presented with three oxygen levels—one that will lead to human suffocation, another that will cause an explosion, and the other resulting in a safe entry. The student must choose between entry and ventilation, and is given feedback on these choices.

Figure 1: Original graphical interface course frame (in tan)

Figure 2: Original graphic interface lesson design

Evaluation of the Full Course Prototype

The full course prototype received extensive evaluation from three different sources: 1) continued reviews by confined space entry instructors from GTRI and CPWR as well as by other trainers associated with these two organizations; 2) reviews by several staff members at the OSHA Training Institute in DesPlaines, IL; and 3) a user study involving six safety and health trainers at the International Brotherhood of Electrical Workers (IBEW) union computer laboratory in Washington, D.C.

The IBEW user study was facilitated by the Region III OTI Ed Center director (then at CPWR) and directed by education/evaluation specialists from NIOSH in keeping with dictates of the TIER model. For approximately an hour, the six peer trainers worked through several lessons most representative of the full range of features offered by the course. As the peer trainers cycled through these modules, they spoke aloud their reactions, pro and con, and a project team interviewer assigned to each trainer recorded their comments. Following these one-on-one sessions, all of the peer trainers and interviewers met jointly in a focus group led by the NIOSH education/evaluation specialists.

Strengths identified by the IBEW peer trainers included the animations, general graphic appeal, pre-test, ability of students to go at their own pace, appendices, conciseness of explanations, quizzes at the end of each lesson, and the range of topics selected. Areas of improvement identified by the group included the need for more examples to illustrate general points, better illustrations of confined space applications, enhanced audio and photographic images, instructions for drag-and-drop style animations, and installation of a print-page option.

Figure 3: Interactive course animation on determining safe oxygen levels

Year Two Activities

The project team decided to contract with an Atlanta online web training firm to host the course. The company's proposal combined professional hosting of the site with an established marketing capability while accommodating a flexible graphic design. The main purpose of this activity was to: 1) gain access to a variety of student evaluations of the course; 2) get a better sense of the potential market for web-based safety and health courses; 3) determine some of the advantages and difficulties of this approach to safety and health training; and 4) realize revenues to use in building other OTI courses.

The two participating OTI Education Centers and the firm reached a one-year agreement to have four public offerings of the course, each available for three-week periods to groups of students. The reason for compartmentalizing the course in this way was OSHA's rule that a course chair (instructor) must be available to answer students' questions while a class is underway. It was not economically and logistically feasible for an instructor to be continuously available, so the project team created three-week course "windows," during which students could take the class.

The two participating OTI Education Centers agreed to share the duties of course chair, with Region III handling this task in November 2002 and May 2003 and Region IV taking on the job for the March 2003 and September 2003 offerings.

Figure 4: Typical course lesson screen

Course Launch and Management

The Atlanta web training firm adapted the web course to its proprietary authoring software, using materials provided by the project team, and then built an online registration site. The course was marketed through several means, including an e-mail flyer to former safety and health course registrants in the Region III and IV programs, a flyer distributed by the web hosting firm to its clients, and announcements on the Region III and IV Ed Center web sites.

The course was first offered as a prototype version in November 2002. Subsequent offerings were made on the original schedule of March, May and September 2003 with minimal technical problems. The class continued in 2004 with offerings in March and September. To date, 40 students have taken the course. The size of the classes has been large enough to provide course developers with valuable feedback from the students. A typical lesson screen is shown is Figure 4.

Student Evaluations

Students were required to first complete the preliminary knowledge assessment and then complete the lessons in a sequential progression. Every OTI student was required to fill out an evaluation before receiving a course certificate of completion. Students gave ratings of excellent (5), very good (4), good (3), adequate (2), deficient (1), or not applicable (NA) in 10 rating categories. A section following these 10 rating categories allowed students to make written comments explaining their reactions to the course in greater detail. The cumulative ratings (on a five-point scale) from 38 students doing evaluations in the first six course offering periods are listed in Table 1.

Table 1. Year 2 Course Evaluations – Web-based Confined Space Training

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

The evaluation category, "effectiveness of audio/visuals," provoked the most wide-ranging responses. Almost two thirds of the evaluations rated audio/visuals (the photographs, diagrams, illustrations, animations, tables and video clips) as "very good" or "excellent," but three evaluations rated these resources as "deficient." One respondent complained that the visuals should be larger, and another said that the technical quality of the images was poor, while the other student was not specific in her criticism. The project team has found no evidence of poor technical quality in evaluations using its computers; however, the team will continue to monitor this element of the course and seek to enhance it, especially by increasing the sizes of images where possible.

One student expressed the need for a course notebook, and the project team implemented this good idea by preparing an electronic version (in PDF format) of a 178-page downloadable notebook. The notebook contained the text of the confined space standard, appendices to the standard, a document on how to apply the standard, a series of frequently asked questions about the standard, a library of supplemental resources, a glossary of terms, and renderings of the slides in all lessons. Other enhancements made to the program in response to student evaluations consisted of several changes in misleading text in the lesson narratives and quiz questions.

Year Three Activities

Description of Activities / Methodology

In July 2004, the project team conducted a peer trainer review of the completed web course in conjunction with a classroom-style confined space entry course. The classroom offering was led by Master trainers from the Center to Protect Workers' Rights at an International Brotherhood of Electrical Workers (IBEW) facility in Knoxville, Tennessee. The project team used the IBEW computer laboratory for this review. Team members from the National Labor College, NIOSH, and Georgia Tech designed the peer trainer review so that 12 of the 21 total enrollees voluntarily took selected web course modules in the computer lab in lieu of classroom participation. These peer trainers reviewed one computer-based module at the same time as the same content was covered in the classroom. The three modules of the training selected for the peer review were lessons on confined space hazards, instrumentation, or rescue. For each of these modules, four separate peer trainers used the computer-based version of the training. In this way, the 12 review participants were able to receive most of their training in the classroom and have an effective means of comparison between the web and classroom learning experiences.

Peer trainers who completed both classroom-based and computer-based versions of the lessons filled out a course evaluation and participated in a focus group. A staff member from the National Labor College was present to guide the study participants through a written evaluation and focus group after they completed their web learning modules. Team members from Georgia Tech and NIOSH participated in the focus group through a conference call connection and were able to ask questions and hear student responses. Through this course evaluation, valuable feedback was collected on the effectiveness of the module in enhancing learning. Course evaluations captured viewpoints regarding the training that might not have surfaced through the subsequent focus group discussions. Feedback from the course evaluations and focus group at the CPWR course included the following key points:

Advantages of Web Course

- Material was concise and flowed well, without overly technical content.
- The supplemental resources were useful.
- Animations conveyed some concepts that cannot be easily presented in video.
- The course design was user-friendly and easy to navigate, with students able to navigate at their own pace.
- A web-based class did not have interruptions or digressions to irrelevant topics.

Enhancements Needed

- Some of the quiz questions should be shorter and easier to understand.
- Some explanations were too wordy; smaller blurbs of information would have been more desirable.
- Some topics required hands-on demonstration and personal interaction for students to really "get it."
- Some animations needed "click here" instructions.
- More quizzes were needed that are sprinkled more frequently through lessons.
- More video clips would be helpful.
- Web-based course information needs to be more integrated into classroom teaching.

Relevance to Trainers' Teaching

- Web course can reinforce what is presented in the classroom.
- The web material is ideally suited for homework and other "on your own" learning.
- More feedback is needed as found in classroom discussions.
- A balance of hands-on learning and web learning is needed.

Conclusions And Lessons Learned

The course assessment has confirmed the utility of the basic course model developed and refined in this project. The cumulative evaluations received from students taking the web course and peer trainers reviewing selected lesson modules have been very positive, with the overall student rating in OTI classes averaging "very good" (4.1 on a

scale of 5.0). Peer trainers also responded favorably and suggested only minor adjustments in the program. Based on evaluations of these audiences, the project team offers the following conclusions and general observations:

• A definite niche exists for web training in safety and health education. Conventional classroom learning is widely viewed as ideal, but workers are not always able to attend scheduled classes. A web alternative is often the only option. In addition, some students prefer web training for reasons that include the ability to: a) complete a course faster than in a conventional classroom, or b) review the course material repeatedly after completing it the first time.

• Many students reported that they would like having more illustrations, photographs, video clips and animations, but a course heavily based on advanced audio-visual elements isn't feasible because some students can't view these resources and others need support gaining access to them. The best approach, at least over the short term, appears to be to: a) build two versions of the web course, one primarily textual with still photographs and another that is heavily audio-visual; or b) build a single version that provides some supplemental audio-visual elements but doesn't require students to use them to receive the necessary course information. As technology enhancements are made and students become more comfortable with multimedia learning methods, training organizations will be able to maintain only a single graphically sophisticated version of the course.

• Because students have different learning styles, it is prudent to provide these alternatives in the course so that the learner can either read text on a screen or listen to an audio clip. Content-rich visualizations can be particularly effective, especially if they are interactive (i.e., animations). These interactive technology resources can assist students in practicing what they know.

• In many cases, courses that use both the web and the classroom settings to best advantage may be the ideal pedagogical choice. With the "blended" approach, the instructor can ask students to learn information that is purely academic by reviewing it on the web site (repetitively, if necessary) while spending class time on interactive exercises and hands-on demonstrations. This approach can often make the best use of limited teaching resources.

References

Chaison, G. (2002). Information technology: The threat to unions. *Journal of Labor Research*, 13, 249-259.

Fiorito, J., Jarley, P., and Delaney, J. (2000). The adoption of information technology by U.S. national unions. *Relations Industrielles/Industrial Relations*, 55, 451-468.

Georgia Tech. OSHA 2264 permit-required confined space entry course description. Retrieved April 27, 2005 from: http://www.pe.gatech.edu/conted/servlet/edu.gatech.conted.course.ViewCourseDetails?COURSE_ID=164

NIOSH (1999). A model for research on training effectiveness (TIER). Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH). Publication No. 99-142.

Platner, J. and Dong, X. (2002). Impacts of digital information networks on construction contractors and unions. *Journal of Labor Research*, 13, 575-589.

Acknowledgments

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).