Effective Design & Use of Web-Based Distance Learning Environments

By LON FERGUSON and KAY WIJEKUMAR

Distance learning environments are experiencing exponential growth. The effectiveness of these environments continues to be debated, especially in terms of student learning. This issue, as well as the needs of a diverse audience of safety professionals, were central concerns addressed in the development of distance education courses in Safety Sciences at Indiana University of Pennsylvania (IUP). This article describes the methods employed to develop these courses and reviews findings based on course delivery.

Safety sciences is a broad field concerned with the interaction between people and the physical, chemical, biological and psychological forces that affect their well being (ASSE 2000). Today's safety professional must be able to develop a systems perspective of the entire organization in order to adequately identify and evaluate hazards and develop cost-effective controls to eliminate or reduce these hazards and their adverse outcomes.

By its nature, safety is a broad field. It is also a dynamic field that is constantly affected by changes in the social, political, regulatory and environmental arenas. Developing skills to address these issues and maintaining currency are essential for both safety professionals and safety educators.

Unfortunately, time constraints and the lack of college-level safety courses makes it difficult for safety professionals to take such courses as a means to remain current in their field. However, as today's information dissemination process continues to evolve from a paper-based, time-and-place-constrained system to a fast, efficient Internet-based system, educational institutions and environmental, safety and health professionals are presented with new opportunities for training and learning (Castells). These new technologies offer tremendous flexibility and convenience; if designed properly, they can provide a quality learning experience for students (Educause; Jonassen and Reeves; Pea 167+).

To help safety professionals remain current while using these new technologies, IUP developed Internet-based courses that are available to a worldwide audience. Initially, these courses will be part of a four-course "certificate program" in safety sciences, which is currently in the approval process at IUP. The ultimate goal is to convert most of the university's M.S. in Safety Sciences courses so that a student can complete his/her master's coursework via the Internet.

DEVELOPMENT PROCESS

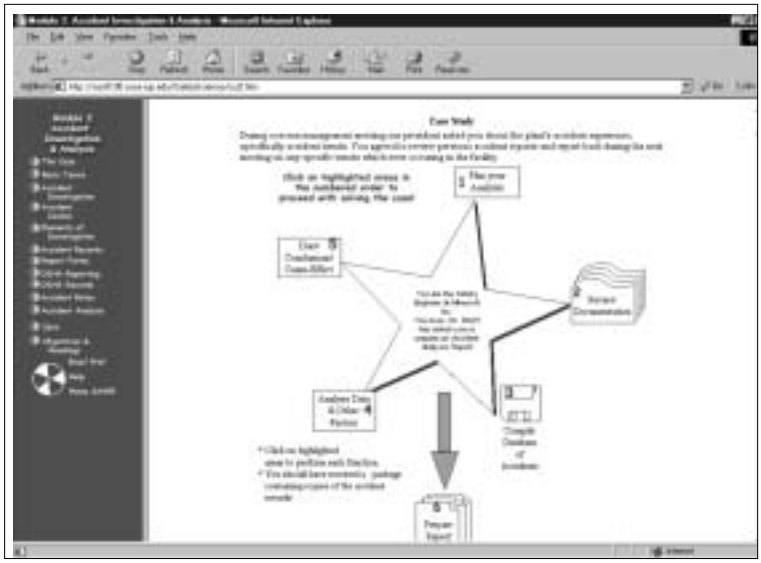
Course development involved three phases: outcome and content analysis, course design and pilot testing.

Outcome & Content Analysis

The first step was to analyze desired learning outcomes, course content and student profiles. To complete this step, IUP faculty:

1) **Conducted an online survey of student preferences and backgrounds.** A web-based survey instrument was developed and placed on the department website. Visitors to the site were encouraged to identify safety and health topics of interest; describe their educational and

FIGURE 1
Activity Theory Analysis Used to Teach the Process of Completing an Accident Analysis



professional backgrounds; and detail their experience with computers and the Internet. This information was used as one factor for developing course content, determining the level of content detail and use of instructional technologies within the courses.

2) **Interviewed subject-matter experts.** The course designer met on a weekly basis with the course instructor. Course description and overall course objectives were the focus of these initial meetings.

Once objectives were clearly defined, module topics related to those objectives were developed. These topics formed course modules, and specific objectives were then developed for each module. The instructor addressed how faculty would approach the course, with a focus on teaching strategies and technical aspects of the content. The designer interpreted and synthesized this information and developed prototypes within an instructional technology framework. A typical exchange: Instructor: "Here is what I teach and how I teach, as well as some examples of activities and cases I have used." Designer: "Here are some ways to use technology to present the information on the Internet, as well as activities that will foster the outcomes you have identified."

3) **Interviewed current and former students of the program.** Students were asked about experiences in similar courses as well as what types of activities fostered their learning. Many students suggested that case studies and other real-life examples that allow application of material were most-helpful.

4) **Reviewed existing course materials**.

•*Class notes.* Based on module objectives, content for course notes was developed; this typically included PowerPoint slides and printed documents (outlines) in Word format. In most cases, notes were reorganized with content added to explain the slides and outlines prior to converting to HTML format. By far, this was the most time-consuming process. Unlike a lecture where the instructor can discuss his/her notes included on the overhead, notes for modules had to be both comprehensive and easy-to-follow. In other words, much of the material discussed in class regarding overheads now had to be included in the module notes, text readings or module activities.

•*Activities.* Module activities often used links to other Internet sites to cover select material or supplement notes. Most activities presented specific assignments to be completed at these sites, which showed students how such sites could be a valuable reference for practicing safety and health professionals.

•*Quizzes.* Quizzes were converted to a WebCT format (the tool IUP uses as a resource for distance education). Quizzes featured true/false or multiple-choice questions, and were intended only as a review; as such, they accounted for only 15 percent of the course grade.

•*Case studies.* To allow students to apply concepts, case studies were included at the beginning of each module. These scenarios were based on actual cases the instructor had encountered as a practitioner. To provide the learner with the information needed to solve these cases and learn from the experience, supporting information—Internet resources, textbooks, course readings and notes—were available.

5) **Performed activity theory analysis of the functions of safety professionals.** When creating a learning environment, one must identify how professionals may react in particular situations. For example, if a safety professional is conducting an accident investigation, s/he must complete specific tasks and collect certain information. These tasks must become second nature to the professional because at an accident scene, s/he will not have time to review a text on accident causation or reread a policy about what types of accident reports must be filed.

Activity theory analysis documents the steps that must be taken to solve problems (investigate an accident); tools available (internal accident reports, a database and spreadsheet to store and analyze information); and types of information that must be collected to solve the problem (identify accident causes and develop control measures). Figure 1 shows how activity theory analysis was used to walk students through the process of completing an accident analysis.

Design Phase

After analyzing the audience and content, and evaluating methods of delivery, courses were designed using a modified cognitive flexibility theory approach.

Cognitive Flexibility Theory

In response to growing evidence that students were concentrating on the surface features of subjects, thereby reducing complex knowledge into compartmentalized objects, and not understanding the inter-relatedness of concepts, Spiro, et al developed cognitive flexibility theory. This approach calls on instructors to use a large number of small cases that allow students to apply their knowledge to real-life cases; understand the complexity of these cases; see the inter-relatedness of issues; understand that each case has multiple perspectives; and present domain-related (e.g., safety sciences) concepts and principles in the context of the cases (Spiro, et al 24+).

For example, one learning module in the IUP course presents a case where the student plays the role of a safety manager of a facility where an employee has had a finger amputated while operating a mechanical press. Unfortunately, this accident was not reported to OSHA, and an OSHA inspector has just arrived.

To complete this assignment, the student must react to this situation. This requires him/her to learn the inspection process; understand the safety manager's rights and responsibilities during the inspection; comprehend applicable regulations; and consider a variety of perspectives, including those of plant management, employees and the inspector. The student must then apply this knowledge to the problem at hand

TABLE 1
Learning Strategies & Web-Based Tools

CASE STUDY	Cognitive flexibility theory states that multiple short cases allow students to learn complex knowledge. Each module started with a real-life case with all the supporting materials available to solve it. In many cases, these situations have no single correct answer; instead, justification for the suggested answer was more important.
EMBEDDED ACTIVITIES	For students to practice real-life problem solving, they must proceduralize activities. For example, in Module 2, students analyze trends in accidents for planning purposes. A database tool was available for data storing and spreadsheets were used for analysis. It was critical for the instructor to provide timely feedback to the students while completing the activities.
INFORMATION-SEARCHING ACTIVITIES	Module activities often use links to other Internet sites to cover selected material. Most of these activities had specific assignments at the sites, which allowed the student to learn how the site could be a valuable reference for the practicing safety and health professional.
CHAT ROOMS	Structured chat rooms were conducted by the professor to provide group discussion on module concepts and activities. Questions were designed to assess whether students had learned the theoretical basis, facts and concepts surrounding each module.
BULLETIN BOARD	Collaborating, sharing thoughts, perspectives and resources are other learning techniques well-suited to the Internet. In this course, the bulletin board was used primarily to post good examples of student work and as a means for students to share information.
QUIZZES	Multiple-choice questions that focused on major theoretical constructs within each module.
PROJECTS	Projects fostered group work and reflected the challenges professionals face when working with others. Students were not able to physically meet, so much of the communication between group members occurred via e-mail and the bulletin board.
NOTES	Notes were linked directly to the case study and followed a logical sequence to solving the case.
COURSE REFERENCE PACKET	Additional assignments and articles to supplement the text and notes were provided in a course reference packet. For example, the accident analysis included 40 accident reports to be reviewed by the student in order to complete the analysis.

A variety of learning strategies and web-based tools were used to teach students about OSHA inspection procedures and employer rights and responsibilities.

(OSHA inspection). Figure 2 shows the presentation of this case in the course.

Cognitive flexibility theory adapts well to hypertext environments because of the nature of hypertext (Jonassen and Reeves). Hypertext is an approach to managing information (text, graphics, video, sound) where data are stored in a network of interconnected nodes that allows links to different perspectives and allows the student to respond to the situation interactively (Smith and Weiss). In a learning environment, hypertext is said to mimic the human mind in allowing multiple connections and allowing the learner to see the complex interactions of situations (Jonassen).

In the case of the finger amputation and OSHA inspection, the student clicks on the image shown in Figure 1 and receives pop-up windows that allow him/her to review the perspectives of the safety manager and OSHA inspector. The student may also click on questions and notes pertaining to this module, and use "Safety Pays" from the OSHA website to calculate an estimated cost for this injury. The student must then answer questions regarding rights and responsibilities. This case will ultimately lead the student through the process of handling an OSHA inspection. Table 1 summarizes the learning strategies and web-based tools used to implement this theory in these safety courses.

Student learning was assessed in several ways. The first course featured a combination of case studies, quizzes, homework activities, group projects and chat room participation. This range of evaluation tools helped faculty better gauge student learning and evaluate what techniques and strategies worked best. The bulk of a student's grade was based on case studies because it was believed the student's ability to apply knowledge and solve the case was the primary objective of the learning experience.

Pilot Test

A pilot test of the course was then conducted over a three-week period. Four graduate-level students participated; they were given access to the course on the Internet and received a guide that included written instructions for accessing and navigating the course. They were asked to document time spent on each module as well as any problems encountered while completing a module. After completing each module, the students were asked the following questions:

1) Were instructions in the student guide helpful?

2) What did you believe were the objectives of the module?

3) Did you have any problems understanding directions within the module?

4) Did all the links and activities work as described?

5) Can you identify features that helped you learn the content?

6) Did you have the necessary information/resources to complete case studies within the module?

7) How long did it take you to complete the module?

Based on this feedback, the course was revised. All four participants suggested that the case studies in each module were the most-helpful element in terms of organizing content and helping them apply the concepts.

It quickly became clear that students were receiving a good educational experience—comparable to that of a live-lecture-based course.

COURSE DELIVERY

The first course was delivered via the Internet; supplemental materials included a CD-ROM, selected readings, accident reports and an orientation guidebook.

Two weeks before the first class, a voluntary student orientation session was held on campus. The objective was to introduce students to the new technologies, discuss course format and answer questions. Faculty members felt this session was critical since this was IUP's first Internet-based course and because some students were unfamiliar with the technology involved. Six of the 10 registrants attended this session.

The student guide (received during orientation) detailed how to access the class and navigate through the modules. Basic information on use of e-mail, chat rooms and bulletin boards was also provided, as were some common Internet navigational tools. The guide also outlined learning strategies employed to develop the class and offered suggestions designed to facilitate student learning.

Each student also received a CD-ROM of the course. This resource provided flexibility because students could review materials even when traveling (provided they had a computer equipped with a CD-ROM drive). However, in this mode, it was not possible to interact with the professor or other students.

For the first course, the instructor allotted two weeks for each module. All student work for each module was due during that two-week period, with the module quiz available online Friday and Saturday of the second week. Students were also required to participate in one online chat session each week. To better meet student needs, one session was offered during the day, one at night.

Chat sessions were highly structured and featured three basic elements:

•**Open-ended questions.** Each chat started with open-ended questions students had regarding the case study, module activities, notes or text readings.

•**Directed questions.** The second part of the session, which typically took about 45 minutes, involved directed questions from the instructor to each student. Students received hints in the module notes about important topics that would be discussed. To facilitate discussion, the instructor posted the questions into the chat room before the session, then randomly selected students to answer each question; after his/her response, remaining members of the group could respond.

•**Session wrapup.** The wrapup portion of the session was dictated by student questions on material covered during the session.

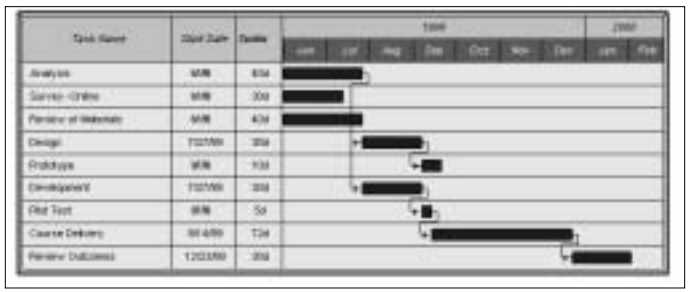
Chat room discussions remained posted for one week, after which they were copied and placed on the course bulletin board for all to review.

Students were encouraged to communicate with each other via e-mail and to post questions and comments on the bulletin board. For the first class, students used e-mail extensively, especially when working on the required group project.

Most course assignments were completed by students using a word processing program; completed documents were attached to an e-mail and forwarded to the instructor. The instructor then printed a hard copy of the assignment, wrote any relevant comments on it and mailed it back to the student.

FIGURE 2
OSHA Inspection Presentation

FIGURE 3
Online Course Timeline



The instructor allotted two weeks for each module. All student work for each module was due during that two-week period, with the module quiz available online Friday and Saturday of the second week.

Other grading alternatives were not used due to the length of assignments and the need for detailed feedback. After grading student work, the instructor posted two good examples on the bulletin board for other students to review. The goal was to provide students with a benchmark against which to judge their own work.

FINDINGS FROM DISTANCE LEARNING COURSES

Lessons learned from the development and delivery of this course can be best classified in three major categories: student learning, instructor learning and long-term goals.

Student Learning

This was the instructor's first opportunity to teach a distance education course, so it was essential to critically evaluate course delivery. On a weekly basis, chat sessions were initiated by asking a general question regarding module content as well as any technology problems encountered.

At both the mid-term and conclusion of the class, evaluation instruments used by IUP for distance education courses were administered. Responses were received from nine of the 10 students. These evaluations assessed course instruction, content and technology. Specific questions related to instruction and content received very favorable ratings, with 75 percent very sat-

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isfied. In fact, 87.5 percent strongly agreed they learned something valuable from the course, and 75 percent indicated they would recommend the course to another student. Overall, 90 percent rated the technology as satisfactory. Written comments were also positive, with many students calling this a good learning experience and noting the convenience of a distance education course for working professionals.

The overall final grade distribution for this course was similar to the instructor's lecture-based graduate courses, with 70 percent of students receiving an "A" and the remaining 30 percent receiving a "B."

Instructor Learning

As with any new learning tool, the decision to develop this class was not an easy one. As the course proceeded, however, those concerns were allayed, and it became clear that students were receiving a good educational experience—comparable to that of a live-lecture-based course. Specific lessons learned:

1) The amount of time needed to transfer notes from lecture notes to an appropriate web-based environment was drastically underestimated. On average, it took about 25 hours to transfer each module to an acceptable distance education format. Each module was a typical six-hour lecture.

2) Distance education is not for everyone. Therefore, it is critical to have an orientation before the class starts, as well as a student guide, so that students fully understand the process. The time commitment must also be addressed because some believe that a distance education course requires less work. In this case, 37.5 percent of the students indicated that the course was *more work* than a lecture-based course, while 50 percent indicated it was about the same amount of work.

3) The directed/focused chat rooms were critical to evaluating student learning. As the saying goes, "What gets measured gets done." Students knew they would be questioned and came to these sessions prepared to participate.

4) Rather than allow students to submit assignments at any time, assignments had to be submitted each week. This helped avoid "overload" that would likely occur if students could wait until the last day to turn in all assignments.

5) For future classes, the amount of e-mail to the professor should be limited and the use of chat rooms expanded to evaluate student learning. This will also allow students to learn from one another.

6) Before an institution considers offering a distance education course, it must ensure that it has quality technology support to address unavoidable glitches. For example, some problems were encountered with "submit" buttons within the modules because of the various ways browsers handle these requests. Quality technical support also helps bridge any gaps in users' computer skills.

7) Where possible, it is best to provide students with virus protection updates through the university license, as well as links to sites that offer Real Player, Adobe Acrobat Reader, Unzip and other frequently used utilities.

Long-Term Distance Education Plans

Based on instructor and student feedback, as well as the overall experience, IUP has identified several elements that must be considered when developing distance learning courses.

1) Know the audience, their knowledge level, perceptions and goals.

2) Clearly identify course objectives.

3) Organize and base the content on the objectives and the audience.

4) Identify what technologies are most appropriate for presenting the material.

5) Evaluate student learning continually, and be open to introducing new objectives, content, technologies and activities to enhance student learning.

CONCLUSION

These courses were developed to provide safety professionals with both a convenient and quality learning experience. Based on this experience, that goal has been accomplished. In addition, through this experience, students gained more than just an ability to recall and recite information. They learned how to seek, analyze, synthesize and apply knowledge to real-life safety issues—and that is the true value of learning. ■

REFERENCES

American Society of Safety Engineers (ASSE). "Careers in Safety." Des Plaines, IL: ASSE, 2000.

ASSE Foundation and Board of Certified Safety Professionals. "Career Guide to the Safety Profession." Des Plaines, IL: ASSE, 1997.

Castells, M. *The Information Age: Economy, Society and Culture.* Vol. I. Malden, MA: Blackwell Publishers, 1996.

"Educause Survey on Computer Importance." Washington, DC: Educause, 2000. <http://educause.com>.

Jonassen, D.H. and T.C. Reeves. "Learning With Technology: Using Computers as Cognitive Tools." In *Handbook of Research for Educational Communications and Technology,* D.H. Jonassen, ed. New York: Macmillan Library Reference, 1996.

Jonassen, D.H. "Hypertext Principles for Text and Courseware Design." *Educational Psychologist.* 21(1986): 269-292.

Pea, R.D. "Beyond Amplification: Using the Computer to Reorganize Mental Functioning." *Educational Psychologist.* 20(1985): 167-182.

Smith, J.B. and S.F. Weiss. "Hypertext." *Communications of ACM.* 31(1988): 816-819.

Spiro, R.J., et al. "Cognitive Flexibility, Constructivism and Hypertext: Random Access Instruction for Advanced Knowledge Acquisition in Ill-Structured Domains." *Educational Technology.* May 1991: 24-33.

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