Learning to Pull the Thread: Application of Guided Discovery Principles to the Inquiry Process

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ABSTRACT

Investigation of direct causes is a fundamental component of inquiry and analysis tasks that require skilled observations, logical thinking, and a persistent search for a complete understanding of the events. The need to cultivate such skills and persistence is a major challenge for diverse disciplines from accident investigation to forensics to intelligence analysis. In this context, persistence means to keep pulling the threads of evidence until a sufficient understanding of cause-effect relationships has emerged. The training challenge is rooted in fundamental questions about performance measurement and instruction: Can we effectively instill the required skills and persistence by merely *informing* learners through traditional classroom instruction? Or would such cognitive skills and persistence be better developed and refined through carefully crafted experience-based training? In instructional systems design terminology, this question may be phrased as a choice between receptive/directive instructional architectures that focus on ASK and TELL approaches versus approaches that emphasize SHOW and DO. The latter, more interactive instructional approaches emphasize active learning and performance assessment. We suggest that active, performance-based paradigms such as scenario-based and guided-discovery learning approaches may provide more effective solutions. By immersing the learner in appropriate interactive scenarios, we can ascertain through actual performance the extent to which the learner demonstrates the objective knowledge or skills. We have previously reported on an application of guided-discovery principles to develop web-based awareness training for security inquiry officials. The purpose of this paper is to report on subsequent research that employs guided-discovery scenarios to enhance the learner's evidential reasoning process through practice in following threads to identify direct causes. Implications for inquiry/analysis and cognitive skills training are discussed**.**

ABOUT THE AUTHORS

Frank L. Greitzer has thirty years of R&D experience in areas of cognitive psychology, user-centered design, expert systems, and advanced performance support and training. After receiving a BS in mathematics in 1968 from Harvey Mudd College and a PhD in mathematical psychology in 1975 from the University of California, Los Angeles, Dr. Greitzer held university teaching positions and R&D positions in the federal government and the aerospace industry prior to joining the Pacific Northwest National Laboratory (PNNL) in 1992. Dr. Greitzer leads the Cognitive Informatics R&D thrust at PNNL and has managed a variety of R&D programs including advanced distributed learning and training applications.

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INTRODUCTION

In his first Sherlock Holmes novel, *A Study in Scarlet*, Sir Arthur Conan Doyle (1887) praised the powers of evidence gathering and deduction (in an article written by his famous character, Sherlock Holmes):

> From a drop of water … a logician could infer the possibility of an Atlantic or a Niagara without having seen or heard of one or the other. So all life is a great chain, the nature of which is known whenever we are shown a single link of it. (p. 15)

In the same work, Holmes says to Dr. Watson:

> … the grand thing is to be able to reason backward. That is a very useful accomplishment, and a very easy one, but people do not practise it much. In the everyday affairs of life it is more useful to reason forward, and so the other comes to be neglected. (p. 119)

Doyle's inscrutable detective Holmes was the expert crime-solver with infallible attention to detail and logical/deductive powers that served to connect the chains of evidence and reveal causes, precursors, or implications of observations. These traits are critical for inquiry and analysis. Investigation of direct causes and linking chains of evidence represent a fundamental component of inquiry and analysis tasks requiring skilled observations, logical thinking, and a persistent search for a complete understanding of the events. The need to cultivate such skills and persistence is a major challenge for diverse disciplines from accident investigation to forensics to intelligence analysis.

In this context, persistence means to keep pulling the threads of evidence until a sufficient understanding of cause-effect relationships has emerged. Most adults lose this inquisitiveness—a development enjoyed by beleaguered parents, but one that does not necessarily aid the inquiry process. The question of how to train such inquiry skills is tied to fundamental instructional systems design (ISD) issues with philosophical and theoretical roots to theorists such as Jean Piaget, John Dewey, and Lev Vygotsky (Doolittle & Camp, 1999): namely, the view that learning contexts should be coupled with multiple opportunities for the learner to "construct" or discover meaning in the material (the constructivist or student-centered instructional philosophy) as contrasted with the behaviorist or instructor-centered approach that is associated with traditional expository instruction.

The constructivist approach, also embodied in inquiry-based, problem-based, or discovery-based training, has been practiced with successful results in a variety of educational domains, including teaching of science, scientific processes, critical thinking skills, and agricultural education (e.g., Haury, 1993/2002; Parr & Edwards, 2004), and it has been endorsed by the National Research Council in its *National Science Education Standards* (National Research Council, 1996). This approach has by no means been universally accepted or adopted in classroom education, and it is at best an emerging approach in computer-based and web-based training.

Our interest is in the application of experiential approaches to computer-based training. We have previously reported on an application of guided-discovery principles to develop web-based awareness training for security inquiry officials (Greitzer, Pond, and Jannotta, 2004; Greitzer, Merrill, Rice, and Curtis, 2004). The purpose of this paper is to report on subsequent research that employs guided-discovery scenarios to enhance the learner's evidential reasoning process through practice in following threads to identify direct causes. Implications for inquiry/analysis and cognitive skills training are discussed.

BACKGROUND

Training of security investigators or intelligence analysts is often performed "on the job" and might be characterized as "trial by fire." Providing effective practice with realistic problems is not always an option. For this reason, we are interested in the application of computer-based training to these training challenges. Our conjecture is that, by immersing the learner in appropriate interactive scenarios, we can ascertain through actual performance the extent to which the learner demonstrates the objective knowledge or skills.

Training Needs and Focus of This Research

For purposes of our research, we have operationally defined the desired or target behavior as persistence in seeking out all pertinent data to support a decision. While this attribute can be studied and taught in the context of either expert or non-expert decision makers, we deemed it most appropriate to apply after important concepts have been mastered.

One might expect that the amount of information used in making decisions would distinguish experts from non-experts. However, experts do not tend to use all relevant information (Shanteau, 1992) and they often rely on heuristics that lead to systematic biases (Tversky & Kahneman, 1971; Kahneman, Slovic, & Tversky, 1982). For example, Posner's (2003) assessment of the September 11, 2001, terrorist attacks identifies perseveration of hypotheses in the face of contradictory evidence and confirmation bias in the use and interpretation of information. This is consistent with cognitive biases that Heuer (1999) describes in *Psychology of Intelligence Analysis*. Cognitive errors and biases limit human performance, and what we know about such limitations can be used to motivate education and training programs.

Thus, there is a need for training R&D that seeks to overcome misconceptions and biases that prevent analysts from thoroughly pursuing all threads of evidence. While the research findings described above are relevant to many fields, we shall limit the discussion of our training approach to the application that we have developed for training of U.S. Department of Energy (DOE) security inquiry officials on contributing factors that underlie security incidents.

Security Incident Inquiry Training

Typically, most security incident reports address only direct causes—e.g., equipment/material failure, external phenomena such as energy blackouts, personnel decisions/action, non-malevolent breach of proper action, and acts that are willfully malevolent. The Enhanced Security Through Human Error Reduction (ESTHER) program, created and led by Dan Pond at Los Alamos National Laboratory (LANL), aims to identify more specific, underlying factors that contribute to human errors in security incidents. Drawing from research on safety errors, the ESTHER program analyzed security incidents in a manner similar to accidents by identifying sequences or patterns of contributory causes, or human error contributors (Pond and Leifheit, 2003). This process identified an overarching set of direct causes that reflect the surface-level reasons for human error (i.e., the most obvious causes and those usually initially reported by respondents during the inquiry process). A set of 28 contributors was identified and divided into four categories:

- Data Flow (e.g., information, procedures)
- Work Setting (e.g., distractions, environment, management systems)
- Work Planning/Control (e.g., job pressure, task difficulty, task aversion)
- Employee Readiness (e.g., preoccupation, fatigue, illness, misperception, memory).

This research led to the implementation of a training program for security inquiry officials on human error contributors underlying security incidents within the DOE complex (Pond, Greitzer, & Mace, 2005; Greitzer, Pond, & Jannotta, 2004). While LANL's initial training efforts focused on classroom instruction, a collaborative effort between LANL and Pacific Northwest National Laboratory (PNNL) has developed an interactive computer-based training program to complement classroom-based workshops. The initial ESTHER e-Learning application was briefly described by Greitzer, Pond, & Jannotta (2004).

APPROACH

Instructional Design Philosophy

Expertise is acquired through stages of development, much like the mental development of children. Fitts and Posner (1967) describe three such stages: the "cognitive stage" in which specific facts are memorized to perform the task; the "associative stage," where connections between successful elements are strengthened; and the "autonomous stage" in which skills become practiced and rapid. In the context of educational objectives, Bloom and Krathwohl (1956) cite six stages (popularly referred to as "Bloom's Taxonomy"; see Figure 1) that increase from learning of specific facts at the lowest level (knowledge) through successive levels of comprehension, application, analysis, synthesis, and evaluation in which the highest levels of synthesis and evaluation demonstrate the learner's ability to solve new problems and evaluate solutions provided by others. While the lower stages of learning are characterized by procedural knowledge and rote memorization, the higher stages require the development and application of cognitive skills.

For cognitive skills learning, it has been argued that the most effective learning environments are problem-based (Greitzer, 2002; Merrill, 2001; Merrill, 2002). Learning and memory are facilitated when the learner is able to relate the new knowledge or skills to existing knowledge (Merrill refers to this as activation of prior experience). Greitzer (2002) builds upon this notion in describing an instructional framework that exploits human associative and organizational processes to stimulate semantic memory and to build understanding of new, more complex concepts from more basic ones.

Demonstration of skills is another instructional method described by Merrill (2001) as comprising a TELL component (presenting general information, such as definitions, procedural steps, etc., to the student) and a SHOW component (presenting or demonstrating specific information, such as an instance of a concept or a demonstration of a procedure). This level of learning corresponds to Bloom's knowledge and comprehension stages and represents a relatively passive role of the learner. Clark (1998) refers to this as a *receptive/directive* instructional architecture.

A higher level of the educational taxonomy, application of skills, generally requires practice. Merrill (2001) describes two components of the application/practice phase, ASK and DO. ASK refers to requiring the learner to recall information that was

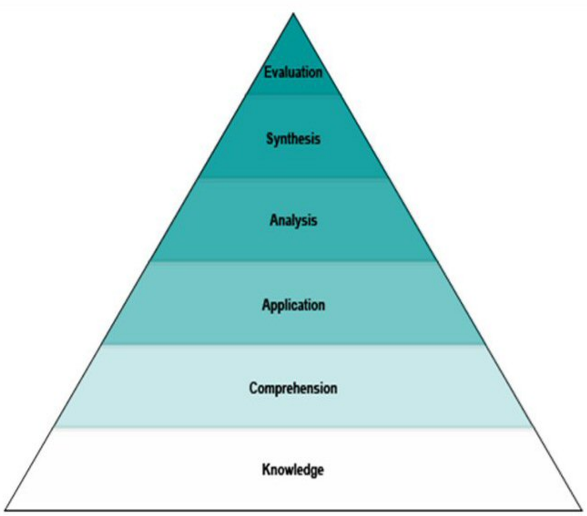

Figure 1. Six stages in Bloom's Taxonomy of Educational Objectives.

presented; DO refers to requiring the learner to *apply* the newly gained knowledge. It is not sufficient simply to ask the learner to recall a concept or a definition. Learning is facilitated when learners are required to use their new knowledge or skill to solve problems. An active, experiential form of training using these concepts has been referred to as *guided-discovery* or *exploratory learning* (Clark, 1998). Such problem-based or scenario-based learning approaches, while still relatively rare, offer exciting alternatives to traditional forms of instruction (e.g., Van Merriënboer, 1997; Jonassen, 1999; Schank, Berman & MacPerson, 1999; Greitzer, Pond, & Jannotta, 2004; Greitzer, Merrill, Rice, and Curtis, 2004).

It is evident that as the architecture progresses from *receptive* to *exploratory*, the prescribed role of the learner changes from passive/constrained to active/unconstrained. Many traditional courses adopt the receptive or directive architectures: information is presented in a series of lessons, each of which is followed by some multiple-choice or objective questions to test the learner's understanding. In the *guided discovery* architecture, the goal is to construct a more experiential approach that presents realistic problems (also called scenarios) and to provide coaching to facilitate learning. As the learner gains knowledge and skill, the level of coaching diminishes (the "scaffolding" is gradually withdrawn) and more responsibility is left to the learner. This is best accomplished by giving learners tasks that they know how to perform initially, gradually adding difficulty until they are unable to perform the tasks flawlessly, and provide help via demonstrations or coaching/hints.

In ISD terms, our research seeks to design and develop a computer-based training system for teaching cognitive skills and strategies for "pulling the threads of evidence" in inquiry/analysis tasks. The objective is to use an active learning paradigm that exploits scenario-based guided discovery problem-solving. Our approach was to build upon the existing guided-discovery learning application for security incident inquiry training by incorporating scenarios that increase the learner's skills and motivation to persist in inquiry/analysis information collection. This goal requires a multidisciplinary effort with contributions from cognitive scientists, instructional designers, graphics/multimedia artists, computer scientists, and subject matter experts to create scenarios that exercise critical skills. These scenarios are implemented using multimedia technology within a virtual, experiential learning framework and a computer-based architecture for developing, delivering, and managing the discovery-based training content.

A flexible guided-discovery learning process forms the structure of the e-Learning system that we designed in order to implement the learning application. Figure 2 depicts the process flow for the learner. One may start at any component (module), and each module follows the general strategy of beginning with simple tasks, using part-task scenarios (breaking problem into smaller parts) to reduce the cognitive load on the learner, and providing multiple levels of coaching and hints to compel the learner to actively work toward a solution. The basic discovery learning module makes few assumptions about the learner's prior knowledge; the advanced discovery learning module requires the learner to perform based on the objective concepts to be learned, but not necessarily to present complete solutions; the mastery module requires the learner to investigate further by prompting the learner to continue the analysis toward a more complete solution and to provide explanations. The next section describes the results achieved to date in this endeavor.

RESULTS

The ESTHER e-Learning application originally included three main modules: **Discover Contributors**, **Use Contributors**, and **Resources**. The **Discover** and **Use Contributors** modules are aimed at a basic level of training on error-contributor concepts. The **Resources** module provides access to course material, links, and other useful reference material, and is not described further here.

Discover Contributors Module

The **Discover Contributors** module employs the guided-discovery learning approach. This is aimed at students who are not familiar with the ESTHER concepts or are unsure about them. To implement the guided discovery notion, we provide scenarios that allow the learner to explore various types of information such as a "scene re-enactment" or a testimony from a co-worker or some documents. The scenarios are displayed in various tabs that the learner can select: the Incident tab describes the incident as reported; the Listen tab includes testimonies from witnesses that can be read or played via audio playback; the Read tab shows documents that may be read; and the Examine tab presents interactive representations of relevant scenes (an example is shown in Figure 3; other examples are shown in Figures 4-7).

Based on information gathered during this exploration of material, the learner identifies *observations* that correspond to contributors that apply to the given scenario. Their observations are in everyday language without the more precise terms required by ESTHER. This guided step with observational cues helps the learner transition to the terminal objective of correctly

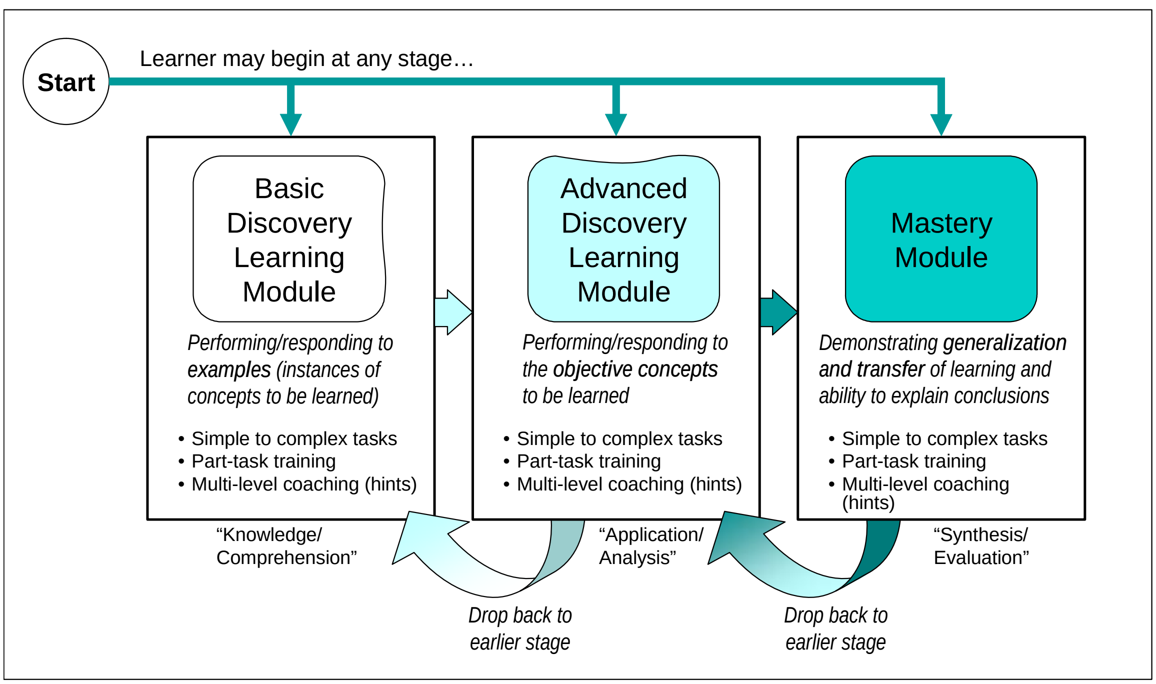

Figure 2. Process Flow for Guided Discovery Learning Application.

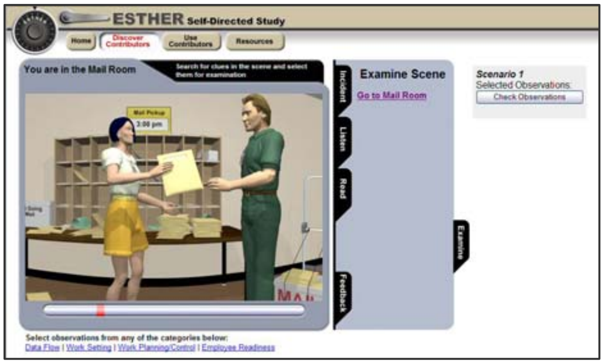

Figure 3. "Examine Tab" of original version of ESTHER e-Learning application.

discerning among lists of causes and error-contributors that are needed for subsequent analysis by ESTHER specialists. While progressing through the scenario, the learner is exposed to the relationships between the observations and the human error contributors, which represent the concepts that are being trained (learning objectives).

Use Contributors Module

The **Use Contributors** module is designed for learners who are more familiar with the ESTHER concepts and who can benefit from more practice applying the concepts. This module works much the same way as the **Discover Contributors** module, except that it provides less coaching (guidance). The list of observations (which act as cues or prompts for the learner) in the guided-discovery module is absent in this module. The scenarios allow the learner to explore the multimedia material in the same way as before (scene re-enactment, testimony from a co-worker, email or other documents). However, the learner must respond directly using the appropriate ESTHER contributors. This module also exposes the learner to appropriate text "comments" or descriptions of what was observed as evidence for the selected error contributor. This reinforces how the observations in the **Discover Contributors** module map to the ESTHER contributors.

Both the **Discover** and the **Use Contributors** modules provide feedback in the Feedback tab. Multi-level feedback is provided (see Figure 4):

- First-level feedback indicates that some information was missed and/or that some was identified incorrectly (but specific correct/incorrect feedback is not provided).
- Second-level feedback identifies the incorrect items and provides hints about missed items (e.g., directs the learner to a particular scene). This is illustrated in Figure 4a.
- Third-level feedback identifies the incorrect items and provides more specific hints about missed items (e.g., directs the learner to a specific location or item within a scene). Figure 4b is an example of an excerpt from this level feedback.
- If the learner still fails to provide all the correct answers, the final feedback differs depending upon

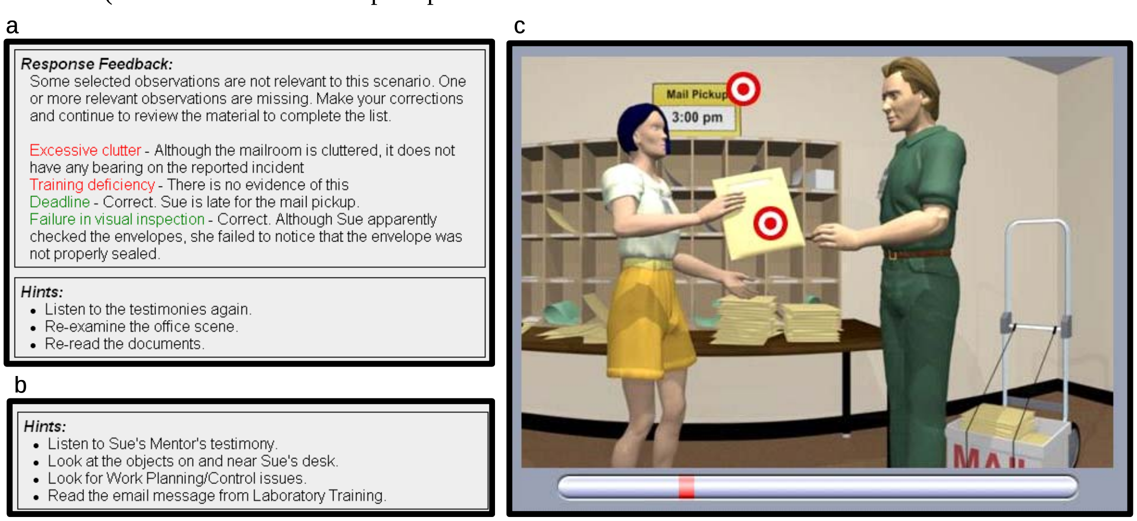

Figure 4. Examples of multilevel feedback. (a) The first level only provides general feedback (first paragraph only); the second level includes the general feedback, color-coded right-wrong feedback, and general hints. (b) The third level of feedback provides more specific hints in addition to the right-wrong feedback. (c) Feedback at the conclusion of the scenario points out and describes specific relevant observations (shown with red target symbols).

the learning module in use. In the **Discover** module, we display the correct answers in a review mode that points out relevant observations with explanatory feedback (an excerpt is shown in Figure 4c, where red "target" symbols indicate relevant observations, which are described when the target symbols are clicked). In the more advanced **Use** module, we send the learner back to the guided-discovery mode and present the same scenario with the guided-discovery format.

- If the learner completes the exercise successfully, the e-Learning system allows the learner to peruse all of the learning content for the scenario in a review mode (same as in Figure 4c) that points out relevant observations with explanatory feedback.

By mastering the **Use** module, the learner demonstrates an understanding of the ESTHER error-contributors and how to apply them. However, this does not imply an ability to "pull the threads" sufficiently to reveal underlying causes of errors.

New Learning Module: Master Contributors

The purpose of the follow-on research and development was to design and implement a **Master Contributors** module that would compel the learner to continue to press on in search of a more complete description and assessment of the problem. For the particular application of interest, we further require that the learner describe the basis for his or her determinations using plain, understandable language that is easily and consistently interpretable. This requirement is derived from the need for consistent reporting from the field to enable effective aggregation and interpretation of the data to reveal trends and underlying factors, which the organization should ultimately address through appropriate mitigation strategies.

The **Master** module begins where the **Use** module ends: at the point where the case has apparently been correctly "solved" with all contributors identified. However, the learner is prompted to reinvestigate the evidence to discover more about the incident and uncover the deeper "root causes." Additional information may be found by re-examining the evidence and by asking questions of the witnesses who provided testimonies. This interaction is illustrated in Figure 5. For example, the learner may ask a question as a follow-up to testimony, or to inquire about other evidence that was available in the "Read" or "Examine" tabs. In this way, the learner is able to pull the threads of evidence to discover the root causes of an incident and reach a more complete solution. As the learner progresses through this additional inquiry process, feedback and hints are provided as in the **Use Contributors** module. Finally, when all contributors

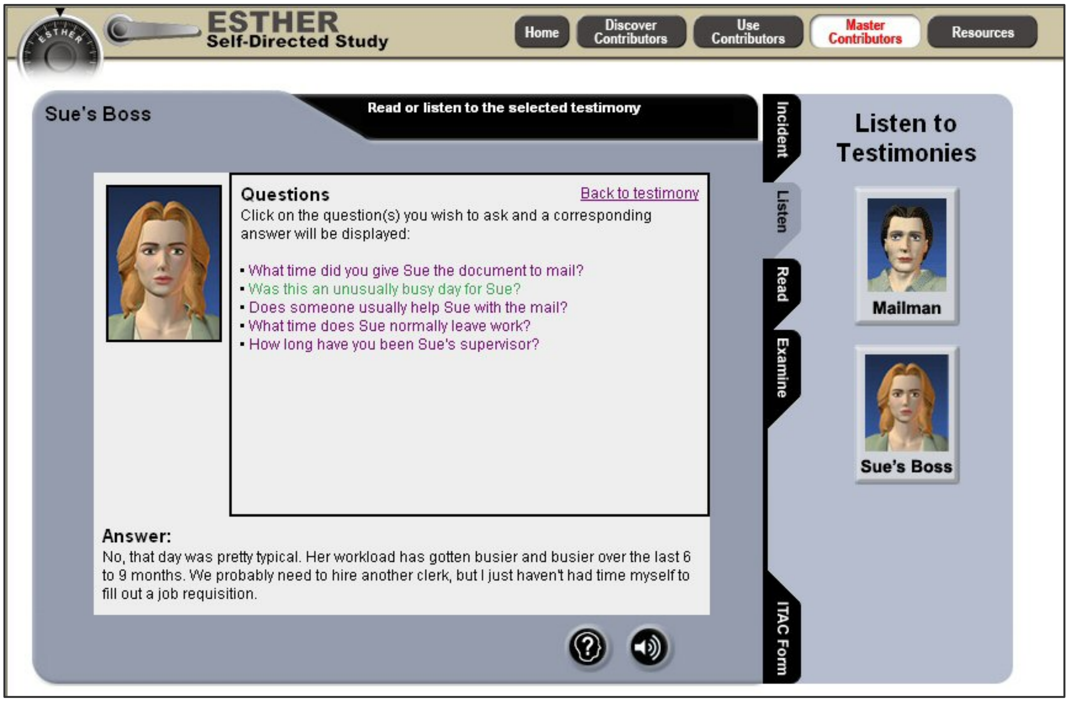

Figure 5. Learners have the opportunity to ask follow-up questions and gain deeper knowledge of the incident.

have been identified and reported on the report form, the learner is asked to provide descriptions/explanations of each contributor that was identified. While natural language text entry would have been an ideal mechanism, budget and time constraints led us to implement a simpler and more direct series of choices to construct a sentence by stringing together subject-verb-object phrases, as shown in Figure 6. Once this task is completed, the learning scenario is concluded by displaying for the learner a flowchart that visually depicts the relationships among contributors (See Figure 7).

Implementation of e-Learning Application

One requirement of the ESTHER e-Learning application was that it could be run from a CD as a standalone training application, without the need for internet connectivity. However, we wanted to design a system flexible enough to support future web-based delivery and tracking, if needed. The design we chose makes extensive use of standard web languages and mechanisms.

Software Design and Implementation

Specifically, we have incorporated Dynamic Hypertext Markup Language (DHTML) to dynamically manipulate HTML content and Cascading Style Sheets (CSS) through JavaScript. The result is a highly interactive interface that can be viewed within web browsers without requiring constant page refreshing. This approach also eliminates the need for duplicate content and data shared among the **Discover**, **Use**, and **Master Contributors** modules.

Solutions to each learning scenario (correct observations, responses, hints, and feedback) are stored within scenario data files that are read, processed, and used to dynamically build application interface components. For each learning scenario there is also an associated HTML content file containing specific scenario content (e.g., testimony text and links to associated audio clips, email and other documents, and links to all media files for each scene reenactment). The scenario data files and the HTML content files are stored separately. Thus, the user interface can be completely redesigned without requiring modifications to the data. Because the page elements for each scenario are identical, we chose to create HTML templates into which scenario-specific content is entered. Similarly, the actual placement and formatting of the HTML content within the interface is determined by a CSS. As the learner navigates through the scenario, selects objects, and makes responses, the DHTML modifies the visibility, placement, and formatting of the scenario content.

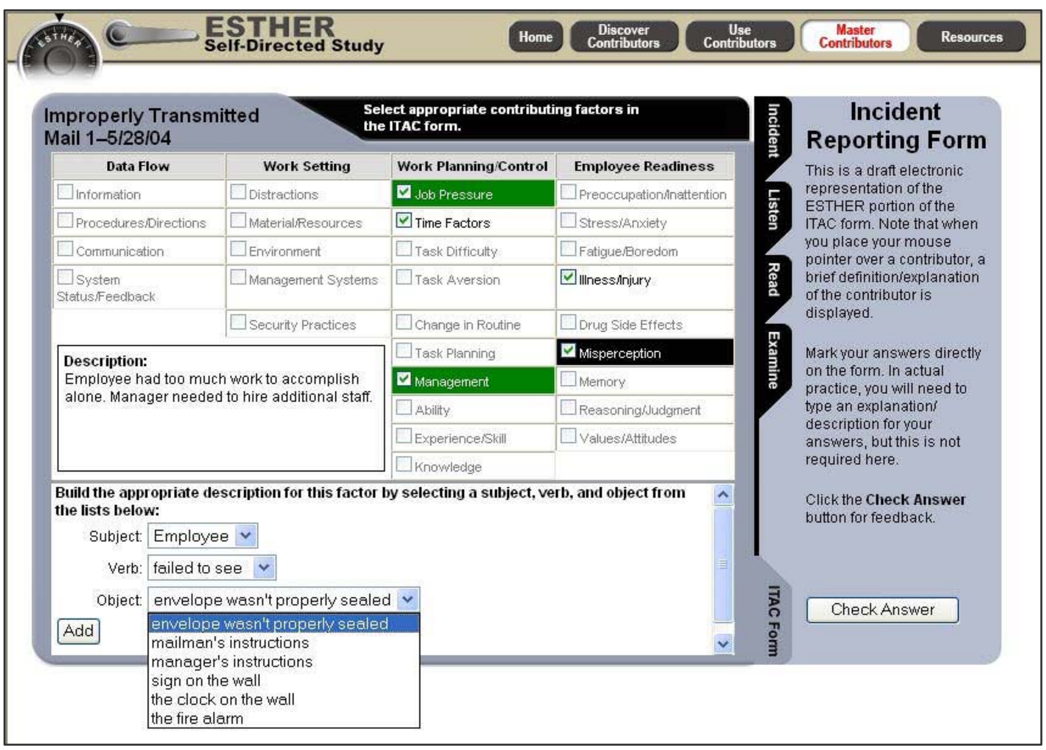

Figure 6. The learner constructs sentences describing the identified contributors by stringing together subject-verb-object phrases.

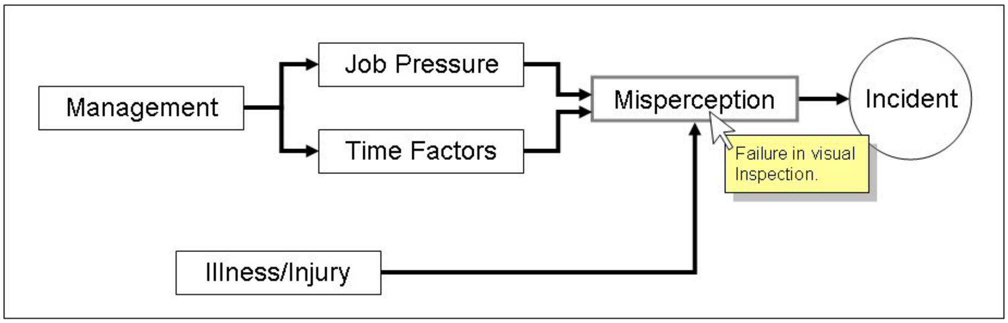

Figure 7. A diagram such as this is displayed at the conclusion of a training scenario to depict the evidential reasoning process—showing the factors contributing to an incident, tracing back to original or root causes.

This combination of DHTML, centralized data, and the separation of the content from its presentation eliminates unnecessary duplication, provides more flexibility in the application interface design, and increases the speed of the content delivery. While JavaScript has limitations in terms of computing power, relative to other programming languages, it provides a perfect fit for dynamically creating and manipulating the web page elements used in our training application.

Interactive Multimedia Implementation

Because the approach stresses experiential learning, we made extensive use of interactive graphics and multimedia to enhance its realism and engage the learner. Several types of multimedia interactions have been employed. For the scene re-enactment interactions, we used 3-D modeling software (Alias Maya) to render office environments and objects. Human characters were built using e frontier's Poser and then imported into Maya. Implementation of the interactive multimedia objects within the re-enactment scenes was accomplished using Macromedia Director and then exporting to Shockwave. This provides a realistic rendition of objects that enables the learner to interact even more with details in the scene; for example, the learner can inspect a notepad more closely, see details of a calendar on the wall, or read the label of a prescription bottle. It also allows the learner to control a panoramic view of a modeled environment, such as look around an office by moving from one end to the other. Shockwave also enabled us to provide feedback (following completion of a scenario) with notes and overlays placed in relevant locations within the scene to call out critical features that the learner may have missed. With our DHTML implementation, the appropriate Shockwave files can be swapped in at appropriate times, based on the learner's current status within the training.

While most of the scene elements are static, future versions will include more animation of objects, scene fly-through, and character action. We may also exploit more advanced features that enable the learner to interact with 3-D objects within Shockwave multimedia. We are also exploring the possibility of dynamically altering, or even constructing, portions of the media files by providing communication between Shockwave and JavaScript.

Enhancements for Automated Content Development Support

Developing multimedia and textual content, as well as planning out the path for each training scenario, can be an extremely time-consuming process. With the ESTHER application, the time required to complete that process manually is multiplied three times because each scenario may be delivered in any of three possible modules. To reduce the time required to implement scenarios within a training application, we have begun developing a tool to automate the process. The Scenario Builder provides content developers with a web-based environment in which to enter the content for each scenario component and provide the necessary data (correct answers, feedback, etc.). All media and textual elements associated with each specific scenario are entered into the Scenario Builder directly or via copy/paste from an existing document (e.g., Microsoft Word, PowerPoint, etc.). When submitted, all necessary scenario support files are generated. These include the HTML file content file and the JavaScript data file. Future versions of the tool will provide more advanced editing features and the ability to modify or duplicate existing scenarios.

Impact/Effectiveness of the Approach

An earlier paper (Greitzer, Pond & Jannotta, 2004) described possible levels of evaluation based upon Kirkpatrick's (1998) four-level evaluation model. This unique opportunity to assess the impact of the training even at the highest level (organizational impact) still applies, but no data are available that can be applied to this assessment because the new approach embodied in the current e-Learning application has not yet been offered formally in the field. We continue to be interested in assessing if engaging and compelling learners to discover effective inquiry strategies is a more effective training strategy than merely telling them about such strategies (e.g., imploring them to keep pulling the threads of evidence). To answer this question convincingly, we would need to compare the traditional instruction (e.g., workshop or standard e-Learning without guided-discovery scenarios) with the guided-discovery training approach. We have not had the opportunity to incorporate such experiments into the workshops conducted to date.

Indeed, as Clark and Mayer observe: "Although a number of problem-solving [e-Learning] courses… have been produced, few have been systematically evaluated." (Clark & Mayer, 2003; p. 255). Nevertheless, at least one controlled experiment suggests that guided-discovery training using effective application of multimedia and simulation may effectively compress experience and build skills that would otherwise take many months in an actual work setting. Clark and Mayer cite an experiment that was performed (Lesgold, Eggan, Katz, and Rao, 1993) to assess the effectiveness of an intelligent multimedia course that employs guided-discovery, scenario-based training application to train Air Force technicians on troubleshooting skills. A group of 16 technicians that received 25 hours of e-Learning was compared with a control group that did not receive training and with another group of 16 expert technicians. The pre-test scores of the e-Learning group and the control group were equivalent on the pretest, but the e-Learning group performed significantly better than the control group; they also performed at the same average skill level of expert technicians with an average of 4 years on the job. We hope to conduct our own experiment to evaluate the effectiveness of the guided-discovery approach by either comparing it with a classroom-based workshop or with a computer-based version of the training implemented using a more traditional instructional architecture.

DISCUSSION

This paper has described a guided-discovery approach to online training and a specific implementation of the approach to meet a DOE training need. The ESTHER e-Learning application, available on the internet at http://www.pnl.gov/esther, was originally developed with a basic, guided-discovery learning module and a practical learning module to strengthen skills. This paper described the rationale, design, and development of a new, mastery module that aims to enhance the learner's ability to "pull the threads of evidence" during inquiry and analysis. While this work is still in progress, we offer the following preliminary conclusions and expectations:

- Although developed to complement the classroom-based workshops on human errors underlying security incidents, this web-based training application could ultimately replace the classroom instruction and reap benefits that typically result from reduced training hours and travel costs associated with distributed learning.
- While this application was aimed at training professional security inquiry officials, we believe that the training approach and the content can and should be adapted to provide education/training to general personnel on human error contributors to security incidents. Such training can be developed for DOE, military, and even industrial workers as new employee and annual refresher training.
- More broadly, we hope to apply this new training approach to other inquiry/analysis domains such as intelligence analysis, information assurance, and forensics—all of which share a common investigative process requiring the collection, synthesis, and analysis of evidence or "clues" to yield an understanding of past events or the ability to more reliably predict future events.

The word *clues* in the Chinese language is *shien-suou*, which literally means "threads." The e-Learning application discussed in this paper focuses on cognitive skills involved in acquiring, manipulating, and analyzing such threads. This guided-discovery approach to e-Learning, specifically tailored to inform and exercise skills in pulling the threads of evidence, offers a promising means of training inquiry/analysis professionals in methods and strategies that they otherwise would be left to acquire haphazardly through on-the-job training and experience.

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