Leveraging Expertise: A Web-Based Authoring Tool for Scenario Generation

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ABSTRACT

Seasoned officers have important experiences to share with younger leaders. However, converting that knowledge into effective training can be challenging. Today's instructors and training developers are increasingly in search of easy-to-implement training solutions that can help them address and improve tactical assessment and decision-making skills. The use of scenario-based training methods is one solution. High-quality scenarios are built by subject-matter experts who have a thorough understanding of the domain and the kinds of decisions and assessments operators in those environments face. Narrated as if they are unfolding in real time, scenarios pose realistic situations that culminate in a dilemma which forces students to practice complex reasoning skills such as decision making, problem solving, and sensemaking. Scenario-based training also enables students to focus on specific learning objectives and provides reflective learning experiences to help build a student's experience base. Together, these elements form the "cognitive building blocks" for effective classroom training. This paper describes the research and development of a scenario-authoring assistant that helps instructors create scenarios for classroom and distance learning environments. The research objective was to succinctly define the best practices in scenario development from experts who create and employ scenarios on a regular basis. A component of the system under development will utilize a streamlined content development process that ensures that the training scenario will incorporate cognitive tasks, challenges, perceptual cues, environmental factors, and strategies that will develop junior leaders' assessment and decision skills. The system is intended to facilitate the development of a community of practice in scenario authoring. This will be accomplished by each user community continually contributing to a repository of scenarios, maps, graphics, icons, instructional tools, and lessons learned for future scenario developers to use.

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TURNING STORIES INTO TRAINING

In work settings characterized by time pressure, uncertainty, and high stakes, scenarios are widely accepted as valuable tools for preparing trainees for the job (Klein, 1998; 2004). One of the best uses of scenarios is as a means to practice and improve decision making and other cognitive skills (Pliske, McCloskey, & Klein, 2001). Narrated as if they are unfolding in real time, scenarios pose realistic situations that culminate in a dilemma which forces students to practice complex reasoning skills. Scenario-based training also enables students to focus on specific learning objectives and provides reflective learning experiences to help build a student's experience base. However, the benefits of scenario-based training are largely contingent on the quality of the scenarios, and the effectiveness of the execution of the exercises.

To exercise judgment, decision making and other cognitive activities, the scenarios must have “cognitive authenticity” (Ross, Halterman, Pierce & Ross, 1998). Cognitive authenticity is achieved when the training accurately captures the elements that exist in the naturalistic environment: background setting, perceptual cues, cultural factors, likely dilemmas, multiple players, conflicting or ambiguous information, and competing goals. In addition, the instruction accompanying the training exercise must challenge and expand students’ thinking around those elements. Thus, a cognitively authentic exercise requires that both the scenario and the instruction focus on the decision environment the student will face in an operational setting. If one of these elements is missing, the effectiveness of the training experience is significantly reduced.

How do we ensure that our training scenarios capture these elements of cognitive authenticity? Traditionally, researchers have employed Cognitive Task Analysis (CTA) studies in order to uncover the appropriate cognitive content that should be built into scenarios (Ross, Lussier, & Klein, 2003). For example, incident-based methods (Flanagan, 1954; Hoffman, Crandall, & Shadbolt, 1998) help elicit powerful stories that can serve as the basis for scenario or simulation story lines. While CTA is an effective means of building comprehensive sets of training and instruction, most seasoned officers, instructors, and training designers do not have the time, resources, or experience to execute an analysis of this magnitude and then convert that knowledge into effective training.

Recognizing this dilemma, Klein Associates, Studio 361, the Joint Advanced Distributed Co-Laboratory, and the U.S. Army Engineer School are collaborating on the research and development of a Web-based authoring tool to create scenario-based training on demand. The authoring tool will help trainers create text and graphics-based instruction for classroom and distance learning settings more rapidly and efficiently than before. Furthermore, the tool is intended to facilitate the development of a community of practice in scenario authoring. This will be accomplished by various user communities continually contributing to a repository of scenarios, maps, graphics, icons, instructional tools and methods, and lessons learned for other authors to use.

The overall research objective of this study was to capture the best practices from those who routinely develop scenario-based training and couple that with an understanding of how to streamline CTA techniques to help the author create a cognitively authentic scenario. This paper describes the effort underway to leverage expertise in scenario authoring, in order to develop a streamlined authoring tool that allows developers to create, store, and reuse high-quality scenarios. The paper will summarize the method, findings, approach to building the authoring assistant, and a general discussion of limitations and next steps.

METHOD

The primary research objective was to use CTA to elicit effective development processes that instructional designers and subject-matter experts (SMEs) employ when creating scenario-based training. A secondary objective was to design and evaluate streamlined CTA techniques that, when built into the system's instructional modules, could help users inject the flavor of CTA into the training product. That is, streamlined CTA techniques embedded into the tool should assist in the recall of personal experiences as the basis for a scenario. By rooting the training exercise in lived experiences or artifacts from those experiences (decisions, typical dilemmas, perceptual cues), the developer can build cognitively authentic scenarios without themselves having to employ a lengthy CTA study.

In order to satisfy both research objectives, the team first employed CTA to capture SME scenario development processes and then tested streamlined CTA techniques for the authoring tool.

Eliciting Expert Scenario Development Processes

To accomplish the first objective, the team recruited and interviewed experienced scenario developers from the Navy, Marines, and Army. Each officer had utilized scenarios in different ways, from capturing real operational events in near-time fashion, which were then sent back to the schoolhouse to train the next group of replacements, to developing scenarios for field exercises and web-hosted tactical decision games.

Two experienced CTA practitioners interviewed each expert scenario developer for 2-4 hours. The goal was to capture the actual creative processes employed during authoring. The interviewers did not focus on collecting general tips or advice; rather, each interviewee was asked to describe his or her processes in the context of developing a specific training exercise.

The interview protocol included questions on a range of topics, from the timeline and sequencing of constructing a scenario to the use and importance of visual elements to support the scenario. The team was especially interested in whether and how the developers used authoring strategies that could be linked to components of the Instructional Systems Design (ISD) process. Sample questions from the interview protocol are as follows:

- *Analyze:* How do you integrate learning objectives into the scenario authoring process? Did you inherit those objectives or create them yourself?
- *Design:* What development requirements did you have? Where did the idea for the scenario come from?
- *Develop:* Describe the process you used to develop a scenario. How did you utilize your own expertise or that of others?
- *Implement:* What did a "finished" scenario training package include? How did you consider the execution of the scenario in the classroom?
- *Evaluate:* How do you evaluate what you do? When in the development process do you do this? How do you know you have created something worthwhile?

One hypothesis was that the development of the training content and the training support package (e.g., the execution plan for the classroom) would be inherently linked and difficult to delineate. Therefore, each author was asked to describe his or her plans for executing the training. The implication for verifying this hypothesis was that the authoring tool must also support the instructional plan for the scenario, as stopping short of this activity would not ensure a strong scenario.

Testing Streamlined CTA Techniques

The SMEs utilized for this portion of the research effort were all small group instructors (SGIs) and instructional designers for the Engineer Captains Career Course (ECCC) at the U.S. Army Engineer School, Ft. Leonard Wood, MO. This subset of interviewees was selected for this data collection because of their likelihood of being the primary user group for the eventual authoring tool.

To determine the appropriateness of streamlining specific CTA methods for assisting in the creation of cognitively authentic scenarios, the team devised an interview protocol that, if successful during live interviews, would be built into the authoring tool. The interview protocol consisted of three CTA methods: the *Task Diagram* (Militello & Hutton, 1998), the *Decision Requirements Exercise* (Klinger & Hahn, 2003), and the *Knowledge Audit* (Militello & Hutton, 1998). All three methods were administered to each participant in a sequential fashion. The intent was to determine which methods helped the SME select a focus and capture contextualized information to build an authentic scenario. An overview of the combined CTA method is as follows:

Step 1.
SGIs were first asked to consider the courses that they taught in the ECCC and then select one course for the purposes of developing a scenario. Interviewers then walked them through the *Task Diagram* to develop an overview of the engineer course of interest and to identify cognitively complex elements students taking the course would have to master. Sometimes the team had to perform the *Task Diagram* repeatedly, in order to get to the cognitively challenging tasks deeper than high-level stated course objectives.

Step 2.
The SGIs were asked to select one cognitively complex task or element (such as a decision, judgment, or assessment) from the *Task Diagram* they had just completed. This served as the focus for the *Decision Requirements Exercise* (see Figure 1 below) in which SGIs examined that complex task or element by considering:

- Difficulties associated with the cognitive task or decision,
- Situational factors that contribute to increased understanding or ability to solve the problem,
- Meaning of perceptual and environmental cues when perceived in the context of the problem,
- Typical novice errors that are often made, and
- Strategies that could be employed to overcome difficulties and avoid errors.

Decision: ___________________________				
Why is this difficult?	Important situational factors?	Perceptual or environmental cues?	Typical novice errors?	Strategies for success?

Figure 1. Structure for a Decision Requirements Exercise

Step 3.
The *Decision Requirements Exercise* helped the SGIs think about the problems their students would be facing in the field from a cognitive perspective. Once they had completed this phase, they were asked to come up with specific, concrete examples that illustrated this task or decision. The interviewers assisted the SGIs in recalling examples through the use of probes from the *Knowledge Audit*. Perceptual, diagnostic, recognitional, and metacognitive skills were of the most interest. For example, interviewers asked the SGIs questions such as:

- *Noticing:* Have you had experiences where part of a situation just “popped” out at you, perhaps where you noticed things going on that others didn’t catch? What is an example?
- *Spotting Opportunities/Improvising:* Can you think of an example when you have improvised in [task of interest] or noticed an opportunity to do something better?
- *Anomalies:* Can you describe an instance when you spotted a deviation from the norm, or knew something was amiss?

Step 4.
Once the SGIs recalled specific examples of a task or challenge, the research team asked them to walk through the steps for turning that example into a scenario for training. They were reminded that they could use the *Task Diagram* to fold in other tasks or challenges, as well as the *Decision Requirements Exercise* to help them populate the content of the scenario. The purpose of this stage was to determine if and how the information elicited in Steps 1-3 helped the SGI formulate a scenario.

FINDINGS

Conducting the CTA study with a broad group of scenario experts greatly influenced the subsequent vision for the intended authoring tool. The hope was that by including a range of military scenario developers in the sample, the subsequent analyses of best practices would have far greater impact than if the study focused on one subset of intended users. Thus, the benefits and applicability of the tool could be easily expanded to other user groups in the military, and even to government and commercial market trainers. Furthermore, the development and testing of the streamlined CTA techniques between an experienced CTA practitioner and an SGI before attempting to program the methodology into the authoring tool helped the design team identify problematic areas for revision and simplification.

Forming a Scenario Development Process for the Instructional Architecture

Seasoned SGIs and instructional designers took various approaches when developing scenario-based training.

Some developers followed a very structured approach, beginning first with the identification of learning objectives, for example, to frame the focus of the scenario. Other developers preferred to start with a map of the terrain that would support the text in the scenario. These developers had difficulty imagining a challenging context or problem until they could draw or find a map with a sufficiently complex battlefield situation that included items such as routes, choke points, obstacles, and potential enemy, friendly, and neutral positions. Some developers even liked to go out and walk the terrain that they would use for their scenarios. This activity helped them imagine what kinds of dilemmas they could pose to their students.

Evaluating Streamlined CTA Techniques

Steps 1-4 described in the preceding paragraphs yielded a lot of good CTA data that, if used by an experienced developer, could produce excellent training materials. We learned many lessons from our initial attempt to simplify CTA techniques for authoring instruction. The key findings included the identification of techniques most useful in constructing a scenario, the need to demonstrate a return on investment for time spent using the techniques, and the importance of brevity and simplification.

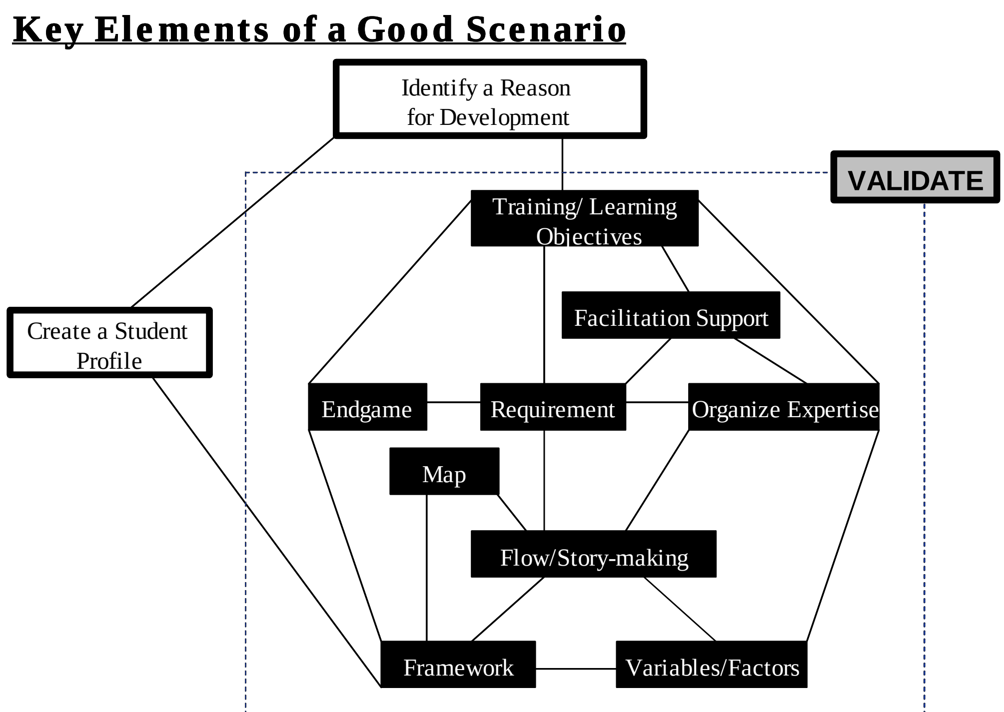

Figure 2. Relationships and Interdependencies in scenario development

It became evident very quickly that collating a *specific best process* from these experts would be impossible. For example, including a map of the terrain and posing a challenge to the student were elements common across all the interviews. However, the order in which different authors worked on these sections varied, as did the information they used to construct those pieces. This led the research team to focus on extracting the best *features* or *elements* of successful scenario design, represented in Figure 2. The lines connecting the elements highlight the interdependence and interconnectedness of the various building blocks in scenarios. These elements became the foundation of the instructional modules in the tool.

Usefulness of the CTA Techniques

The *Decision Requirements Exercise* was the most useful and productive CTA tool for the building blocks for creating cognitively authentic scenarios. It yielded specific information that helped interviewees pose dilemmas, increase complexity, build in relevant background information, and create opportunities for students to make errors or utilize strategies. In addition, the interviewees found the data structure of the *Decision Requirements Exercise* helpful.

In contrast, the *Task Diagram* did not seem to help the interviewees during Step 4 when they were building scenarios. More often than not, the interviewees recited formal tasks or learning objectives. SGIs do not have the freedom to deviate from the prescribed objectives or tasks for the course. Also, it took several iterations of questioning to help the interviewees isolate the cognitive challenges and demands at the right level for building a scenario. This suggested that the method would not be easily automated in a series of questions and steps in the tool, because of the high risk of confusion on the part of the user and the inability to automate follow-on questions that deepen on individual responses.

It was also determined that using the *Knowledge Audit* probes as the main inquiry for building scenarios was faulty. Of all the tasks they personally teach in their courses, SGIs may have personal field experience with 10% of those tasks. Building a tool that guided the author to develop a scenario almost exclusively from a lived experience would limit the range and depth of the scenarios that could be written. Cognitive authenticity could be achieved if scenarios combined both lived experiences with envisioned world ideas.

Demonstrating a Return on Investment

Data analysis suggested that the CTA techniques were helpful for engaging the author in the decisions, judgments, and assessments important to train through the scenario. However, to almost every interviewee it was unclear how to transfer the results of these exercises into building the actual scenario.

Through further analysis, the team constructed a way for the data collected via CTA to be used in subsequent tool modules. Developers needed to see clear linkages between the exercises they had completed and how that data would be used to build the components of the scenario. For example, the scenario elements in Figure 1 led to the development of major modules that embodied features of good scenario design such as:

- *General Situation,* which provides a framework and context for the scenario,
- *Specific Situation,* which is the center of the story-making that culminates in an endgame,
- *Map,* which is critical for helping to paint the picture of the battlefield, and
- *Instructor Tools,* a module where the author can plan for classroom execution by accessing a library of instructional techniques.

The data an author would produce during the *Decision Requirements Exercise* (as shown in Figure 1 and represented in light shading in Figure 3) was then mapped to each of these main components of the tool (shown in dark shading in Figure 3). For example, considering perceptual cues is most applicable to the construction of a *Specific Situation,* where the student must recognize critical information and make sense of complex and ambiguous data. The information about cues that an author provides during the *Decision Requirements Exercise* early in the authoring process would come into play later when developing a *Specific Situation.*

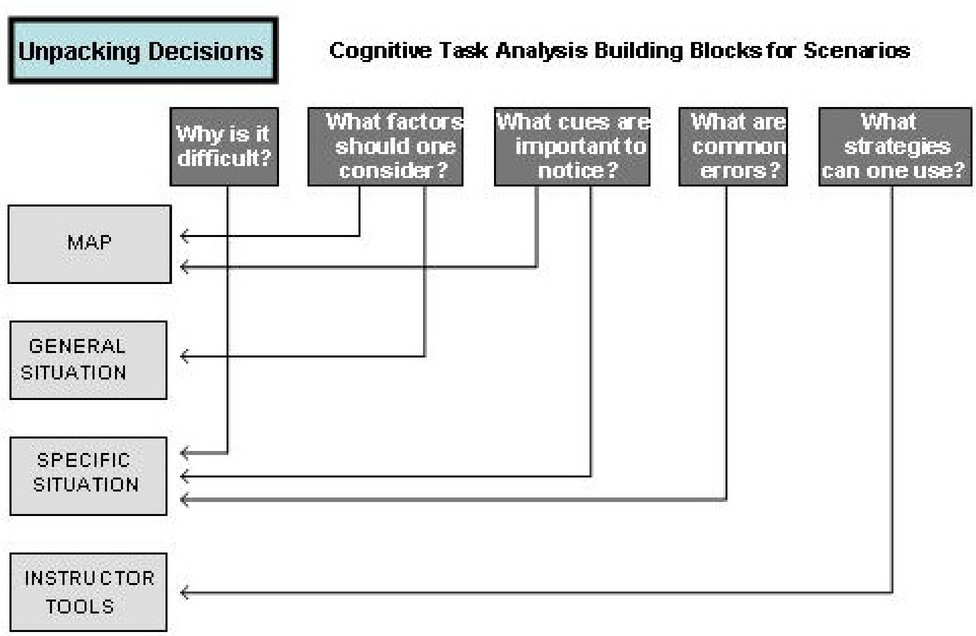

Figure 3. Linking CTA Questions and Responses to Scenario Components

Importance of Brevity and Simplification

One of the most important lessons learned has practical and motivational issues associated with it: the importance of brevity and simplification in the streamlined technique. The process used with the SMEs took at least 45 minutes to complete Steps 1-3. (Step 4, the creative portion of scenario design, was not timed as its purpose was to determine what information was most useful from Steps 1-3). Although 45 minutes constituted a significant step forward in streamlining the CTA process (a typical CTA interview often takes two hours), it was still too long to be useful to the target audience.

The envisioned module for getting the author to focus on cognitive skills needed to be designed so it could be completed in under 10 minutes. The point was to simultaneously teach a developer where cognition comes into play and how to elicit and incorporate it in a scenario. The struggle was to find a way to do this without making it boring, academic, time-consuming, or complicated.

BUILDING THE AUTHORING ASSISTANT

CTA Implications for Design

CTA revealed that effective scenario development processes are very convoluted and constantly changing. Expert developers have routines and strategies, yet each new scenario poses a unique set of circumstances to be addressed. Those circumstances, such as the amount of time available to create the scenario, the training need for a particular group of students, or doctrinal changes that need to be reinforced in the training, mean that expert developers rarely follow predictable development processes. Beyond the mention of key scenario components, only two consistencies stood out in the data: 1) the iterative nature of authoring means that it is impossible to teach this process in a lockstep fashion, and 2) there is a certain amount of creativity required to tie all the components together to create an engaging story. This cannot be taught explicitly.

Thus, in designing a tool to help expedite the scenario development process the team constructed a framework, not necessarily a process, to support the range of authoring strategies and preferences. There was a need to help *teach* novices the important parts to include in a scenario and also to provide them with guidance and instruction on how to craft the content. Additionally, the framework needed to allow for individual flexibility in navigation and creativity. All in all, the tool had to be adaptable to experience level and individual creativity.

Key Features of the Prototype

The prototype has been named eMAGINE, which stands for *electronic Method for Authoring and Generating INstructional Exercises.* There are several key features that have been specified in the design requirements for the authoring tool.

A multimedia introduction offers an overview and specific instructions on functionality and purpose. It also introduces the concept of building scenarios to get the student in the "right decision space" so that the streamlined CTA questions encountered later on are understood. Additionally, the authoring guidance changes based on the tasks and objectives selected for the scenario, thus allowing the author to tailor a scenario to exercise higher order cognitive skills such as sensemaking, decision making, planning, and coordination.

Developers frequently noted that when creating scenarios in teams, it is difficult to maintain common ground during synchronous or asynchronous development. The envisioned system will incorporate methods to help team members communicate and coordinate with each other when working on a scenario at different times.

The database is potentially the most powerful component of the system. As more users create scenarios and maps, the database will serve as a powerful repository. New users will be able to quickly find, retrieve, and modify existing scenarios rather than having to start from scratch. A search engine will allow them to find scenarios on specific learning objectives, roles for the student, geographical locations, or types of terrain.

Developers can also take advantage of previously created maps. For example, the *eMAGINE* allows a user to select from a set number of backgrounds and create overlays with icons representing terrain, units, weapons, and vehicles. These overlays can then be saved to the database or a computer and recalled by another user later on for modifications. A screen shot of the *Map* drawing tool in Figure 4 shows an icon builder tool on the left side of the screen. Other features include a freeform drawing tool and a map selection tool.

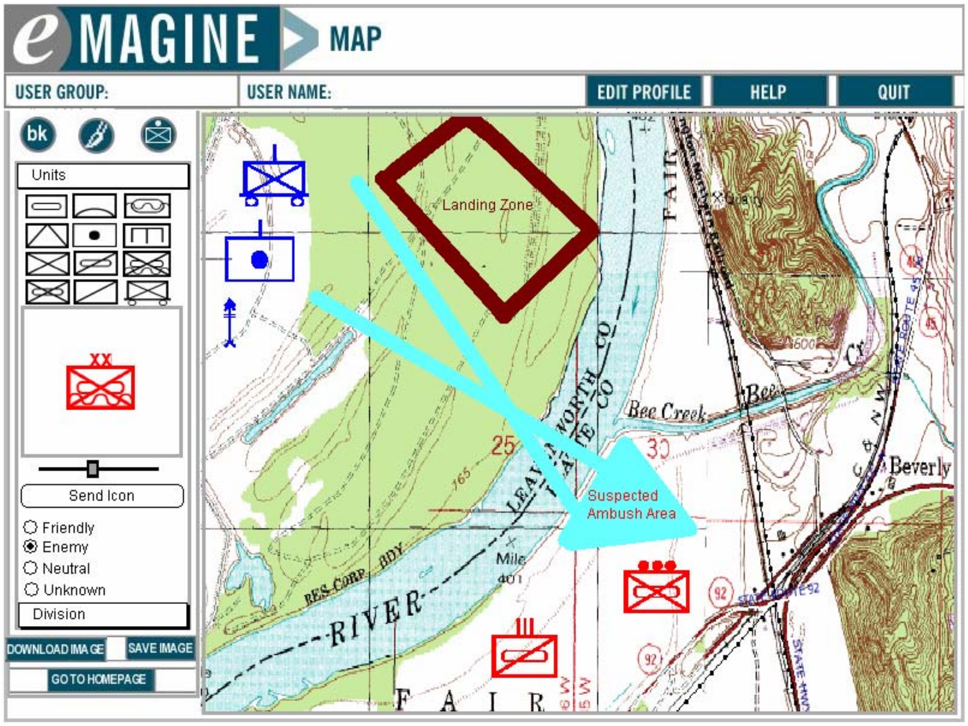

Figure 4. Screen Shot of the Map Module and Drawing Tool

Lastly, a section called *Instructor Tools* catalogues several techniques and methods for facilitating scenario-based training described in Pliske et al. (2001). This section allows a developer to create an Execution Plan for the current scenario and also provides several different tutorials and tools that illustrate different approaches to facilitating a scenario, which might be helpful to incorporate into the classroom for the dissemination of the scenario.

Plans for Test and Evaluation

There are five elements that will comprise this evaluation: *usability, acceptability, functionality, generalizability* and *effectiveness.* Much of this data will be collected in a distributed fashion, with users logging on and using features of the tool at their leisure. *Usability, acceptability,* and *functionality* data will be collected via “cognitive walk-throughs” with various potential users and by testing the database performance at various times with multiple users accessing the site.

To address the question of *generalizability*, the design team will recruit scenario developers who are not associated with the Army Engineer School. Our intent is to examine whether the instructional principles of good scenario authoring translate to other domains irrespective of the Army-specific content built into this prototype.

A formal test and evaluation is scheduled for the fall of 2004 that will focus on *effectiveness*. Its primary objectives are to 1) determine whether the instructional processes actually help an SGI create a scenario, and 2) establish ratings on the quality of the scenarios that are produced using the tool. The ratings will be based on the findings of the CTA, previous research on what makes for “good” cognitively authentic scenarios, and independent SME ratings.

The overarching question of effectiveness should be impacted by success on the other four measures, which will be examined throughout the iterations of the tool. The results from the evaluation study will be available in December 2004.

CONCLUSION

The goal of this research was to identify and support effective scenario development processes that help authors incorporate the elements of an assessment or decision that are critical to stimulating realistic cognitive processes during training. The CTA study demonstrated that there is not one “best” process, but rather, multiple processes and components to support. This insight helped drive the creation of a modular framework as opposed to a lock-step process.

However, there are limitations to this approach. In trying to streamline any process, one runs the risk of sacrificing quality and depth, and restricting creativity. Despite our successes in incorporating streamlined knowledge elicitation processes into the instruction, the value of a CTA practitioner or a domain expert can never be fully replaced. Also, controlling quality of the scenarios that are uploaded to the database is a problem that has not been resolved. For now, administrator privileges allow a superuser to remove material that is inappropriate, doctrinally incorrect, or under-developed.

Future research endeavors should continue to improve and test the streamlined knowledge elicitation process and should also look at creating a system architecture that would allow for continuously expanding user group databases. This would in turn create a larger community of practice where 1) additional developers help modify and improve the current framework, and 2) additional evaluations could help determine the effectiveness of the instruction across different domains and users.

Finally, eMAGINE could be expanded to include additional features. The current effort is the first leg of a robust Web-based training system that addresses the authoring component. The next leg could be the delivery platform and introduction of authoring for simulations. There is also a need for strong synchronous and asynchronous instruction to accompany the scenario-based training. As the tool expands and more insights are gained from the community of practice, modifications could be made to the database and specific sections within the tool, such as the *Map* drawing tool, which would allow for increased functionality. Despite the questions that still need to be answered, eMAGINE is a first step towards creating a higher quality training product through a more efficient scenario development process.

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