Web-Delivered Simulations for Lifelong Learning

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ABSTRACT

The U.S. Army has started transforming its training approach to focus on lifelong learning. A key piece of this transformation is shifting the role of the Training and Doctrine Command (TRADOC) schools from a focus on resident training to a mix of resident training and support of distance learning in the units. This is a paradigm shift that requires a major shift to the development and support of distance learning simulations.

The Signal Center at Ft. Gordon is leading the implementation of lifelong learning. It is creating the University of Information Technology (UIT), and is using assignment-oriented training to reduce the time for new recruits to get to their units, trained in the skills needed for their first assignment.

The Signal Center is using Virtual Reality simulations that are delivered over the Internet from the UIT website to unit computers for training soldiers going to different assignments. These simulations must meet stringent requirements. The missions of the units may preclude extended access to the Internet, so the training must operate in stand-alone mode, and must be downloadable in segments using a modem and a phone line in under 15 minutes. The simulations must run on a broad range of computers with varied performance capabilities.

This paper describes two simulations developed for the UIT. The first trains operation and maintenance of the AN/TRC-173B, a Radio Terminal Set. The second trains operation and maintenance of the FBCB2 command, control, and communication system. These simulations contain a series of lessons for each skill that help the soldier go through the learning stages of Familiarization, Acquiring the skill, Practicing the skill, and Validating the skill, while teaching the soldier to use the Technical Manuals. They combine high fidelity 3D virtual reality views with 2D displays to bring the technical manual alive.

ABOUT THE AUTHORS

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INTRODUCTION

The U.S. Army has started transforming its training approach to focus on lifelong learning. A key piece of this transformation is shifting the role of the Training and Doctrine Command (TRADOC) schools from a focus on resident training to focus on lifelong learning (Cavenaugh 2002). This is a paradigm shift that requires a major shift to the development and support of distributed learning. This shift is also benefiting the Army Reserve Component and the Army National Guard by making the same training resources available to Active and Reserve Components.

The Signal Center at Ft. Gordon is leading the implementation of lifelong learning (Wilson and Helms 2003). It is creating the University of Information Technology (UIT), and is using Assignment-Oriented Training (AOT) to reduce the time for new recruits to get to their units, trained in the skills needed for their first assignment. The Signal Center is using Virtual Reality simulations that are delivered over the Internet from the UIT website to unit computers for training soldiers going to different assignments (Helms, Frank, Morris 2001).

This paper describes two simulations developed for the UIT. The first trains operation and maintenance of the AN/TRC-173B, a Radio Terminal Set. The second trains operation and maintenance of the FBCB2 command, control, and communication system. These simulations consist of a series of lessons for each skill that help the soldier go through the learning stages of Familiarization, Acquiring the skill, Practicing the skill, and Validating the skill.

SIMULATIONS FOR DISTRIBUTED INDIVIDUAL TRAINING

Overview of the Simulations

RTI is developing Virtual Reality simulations that are delivered over the Internet from the Signal Center website to unit computers for training soldiers going to different assignments (RTI 2003). The missions of the units may preclude extended access to the Internet, so the training operates in stand-alone mode, but is downloadable as SCORM-compliant SCOs.

The simulations use a combination of World Wide Web (WWW) pages and simulated 3D environments, which allow a user to experience situations and manipulate job materials and equipment as if they are in the actual, physical environment. These simulations enable users to interactively practice concepts in an environment much more engaging than an online manual or passive video playback.

The goal of these simulations is to teach the soldiers how to use their Technical Manuals (including both paper manuals converted to pdf format and Interactive Technical Manuals). We use a combination of Virtual Reality, simulation, and other visualization techniques to create training based on government furnished programs of instruction, and to link this training to specific elements of the technical manuals (McMaster 2002).

How the Simulations Support Army Training

The US Army Signal Center at Ft. Gordon (USASC&FG) is developing the University of Information Technology (UIT) (Helms 2001). They are developing the UIT to support lifelong learning for the signal soldier, which includes the use of simulations for 'learning by doing' wherever signal and information technology soldiers, leaders, and units are located. The USASC&FG has started the transition to Assignment Oriented Training (AOT) for MOS 31R, 31P, and 31S, beginning in February 2002. The AOT for MOS 31S focuses on tactical satellite systems. This presents an immediate need for Field Oriented Training (FOT) for soldiers transferring from tactical assignments (such as MSE duty for 31R and 31P soldiers or tactical satellite duty for 31S soldiers) to strategic system assignments (such as AN/TRC-173B duty for 31R and 31P soldiers or AN/GSC-52A duty for 31S soldiers). Simulations are targeted to support AOT and Sustainment Training.

Experience with desktop maintenance trainers (McMaster 2002) for the Army has shown that computer simulations of operation and maintenance functions can be used effectively as qualifying gates before hands-on access to live equipment. In this approach, learners are required to show competency with cognitive skills using the simulations before they are allowed on the live equipment, thus improving safety and reducing damage due to accidents on the live equipment. Computer simulations also provide much greater practice time for the learners than the closely scheduled training time on the live equipment.

Application of FAPV Training Methods to Distributed Training

Simulation-based training is inherently problem-centered. This is consistent with our training philosophy of learning by doing. The starting point in the development of a simulation for an existing course is to review the Practical Exercises and Performance Exams. From these we get an initial set of options for scenarios. These exercises and exams are reviewed to assess coverage of the critical tasks and Performance Measures specified for MOS qualification and documented in the Army ASAT database, and to fill in gaps or allocate training on some Performance Measures through other means besides simulation.

We have developed the Familiarize, Acquire, Practice, and Validate (FAPV) method for self-paced learning by doing (Frank 2000). The FAPV method provides multiple scenarios for learning a specific set of tasks and associated Performance Measures. A typical major task will have a single Acquire lesson, and several Practice and Validate scenarios. In the Acquire mode, the learner is shown the process for the task in a lock-step format. However, the learner is expected to perform the relevant tasks in the simulation environment, so that by the end of the Acquire lesson, the student will know how to operate the simulation as well as having participated in performing the task according to the "school solution."

For the Practice mode, multiple scenarios are provided so that the learner can accomplish the task under a variety of realistic scenarios. The learner can cycle through all of the scenarios as many times as is needed to understand the task process and variations in the process associated with different scenarios.

For the Validate mode, the learner is required to perform the task under one or more scenarios. The simulation selects the scenarios in order to ensure that the learner can perform the task under a variety of circumstances, as they will have to do in real life.

Familiarize Mode Training

In Familiarize Mode, the simulations use 3D virtual reality models and other dynamic visualization techniques to explore and learn pre-requisite knowledge for performing a task, such as equipment, tools, and terminology. The simulations provide a variety of navigational aids based on the Technical Manuals to help the learner navigate through the 3D environment and learn about the location, visual context, and attributes of a piece of equipment. The simulations help the learner understand system block diagrams and schematics, learning which box represents which equipment and which line represents which cable or wire. Familiarize lessons also help the learner understand how to interpret orders in terms of how to configure a system to be consistent with an order.

More recently, we have been adding Familiarize lessons based on the 'Theory of Operations' section of the TM to the simulations. In these lessons, the design effort is focused on using animations, block diagrams, and other visualization techniques to explain the function of the system and explain which components of the system are responsible for which parts of the system operation.

Acquire Mode Training

In Acquire mode, the learner is acquiring the knowledge of how to accomplish a task in terms of a sequence of actions to be taken, the objects (or subjects) to act on, how the objects (or subjects) react, and what tools to use to perform the actions. During an Acquire mode lesson, the learner is shown the sequence of steps to be performed to accomplish a particular task. The textual definition of these steps is taken directly from the appropriate TM; the student has to complete the required action in the appropriate 3D or 2D environment. The learner is shown the "school solution" for a sample problem in lock-step fashion. The simulation provides hints on what has to be done for each step using text from the TM and context specific hints about what to do to make the simulation work. However, the learner is expected to make the changes in the simulation environment, so that by the end of the Acquire lesson, the student will know how to operate the simulation as well as having participated in performing the task according to the "school solution."

Practice Mode Training

Practice Mode provides free-play for the learner while at the same time providing a variety of training scaffolding, including hints and immediate error feedback. During Practice mode, the simulation provides immediate feedback to the student when they make a mistake. The mistake is not allowed to damage the simulation state, since errors are trapped before they affect the simulation state.

For the Practice mode, multiple scenarios are provided for learning a specific set of tasks and associated Performance Measures. The scenarios are selected so that the learner can accomplish the task under a variety of realistic scenarios, such as performing similar tasks on different pieces of equipment.

In Practice Mode, these simulations are near real-time, in the sense that one of the standards for most tasks is that they be completed within a time limit. However, times when the equipment is busy but the learner is idle are shortened to keep the intensity of the training high. To make the learner aware of the time limit during practice, the learner is informed when the time limit has been reached, but he or she is allowed to continue practicing. The simulation provides a "stopwatch" running in the upper right of the simulation (see ***Figure 2***).

Hints are available to the learner during Practice Mode. They describe what the soldier should be doing to meet the next objective in the school solution.

Validate Mode Training

In Validate mode all the feedback is saved to the end of the lesson and is documented in an After Action Review that is sent back to the Signal Center web site.

In Validate mode, the lesson is automatically ended when the time limit is reached. This gives the training a real-time aspect that is appropriate for these critical tasks.

For the Validate mode, the learner is required to perform the task under one or more scenarios. The simulation selects the scenarios in order to ensure that the learner can perform the task under a variety of circumstances, as they will have to do in real life.

THE AN/TRC-173B SIMULATION

We have developed a simulation of the AN/TRC-173B Radio Terminal Set that gives the soldiers the ability to familiarize themselves with the equipment, place it into operation, troubleshoot, and repair individual subsystems. A screen shot of this simulation is shown in ***Figure 1***. The AN/TRC-173B is a legacy system used for line-of-sight communications at Echelons Above Corps, and is used by the Signal Center to support its EAC track for Assignment Oriented Training of 31R and 31P MOS soldiers. It is based on the technical manuals for the shelter and its components.

Figure 1: AN/TRC-173B Simulation

Lessons Included in the AN/TRC-173B Simulation

This simulation includes operator and organizational maintenance training for 31R operators as well as direct support maintenance training for 31P maintainers. This simulation provides After Action Reviews that provide GO or NOGO results on specific performance measures.

This simulation includes several Familiarize mode lessons specific to the application. A standard Familiarize mode lesson for all our simulations links the 3D environment to the "Controls and Indicators" section of the Technical Manuals. For the AN/TRC-173B, we included lessons on the Cut Sheet (i.e., how orders for a mission are presented to the crew), on the Schematic portion of the Cut Sheet, and on the SG-1139 signal generator, a piece of test equipment.

THE FBCB2 SIMULATION FOR SIGNAL SOLDIERS

An FBCB2 communication system simulation shown in ***Figure 2*** has been delivered to the Signal Center to provide initial and sustainment training for MOS 31U soldiers. The FBCB2 communication system simulation provides initial and sustainment training for MOS 31U soldiers on installation, startup, shutdown, and troubleshooting of the SINCGARS ASIP, EPLRS, and PLGR interactions with FBCB2 command and control system.

An initial version of the 31U was demonstrated at the Digital Training Conference, Ft. Huachuca, AZ in January 2003. Reaction to the simulation was so positive that the prototype was immediately incorporated into the training plan at Ft. Hood TX, home of the 4th ID (the first Army digital division) and of the 1st Cav, which is also being converted into a digital division.

The prototype version of this simulation is in use by 4th Infantry Division, now in Iraq. The Training System Manager for FBCB2 obtained copies of the prototype from the Signal Center and took them to Kuwait. There it was used by the 3rd Infantry Division, which was equipped with FBCB2 equipment in the field.

Lessons Included in the FBCB2 Simulation

This simulation was developed to train the ABCS common core tasks that are specific to the FBCB2 system. The screen capture below shows the FBCB2 system as installed in a HMMWV. The final version of the simulation provides self-paced training for digital and voice radios linked with Command and Control Computers in how to:

- Operate (particularly Startup and Shutdown)
- Install (including connections and equipment placement)
- Maintain (including operator and maintainer troubleshooting scenarios)

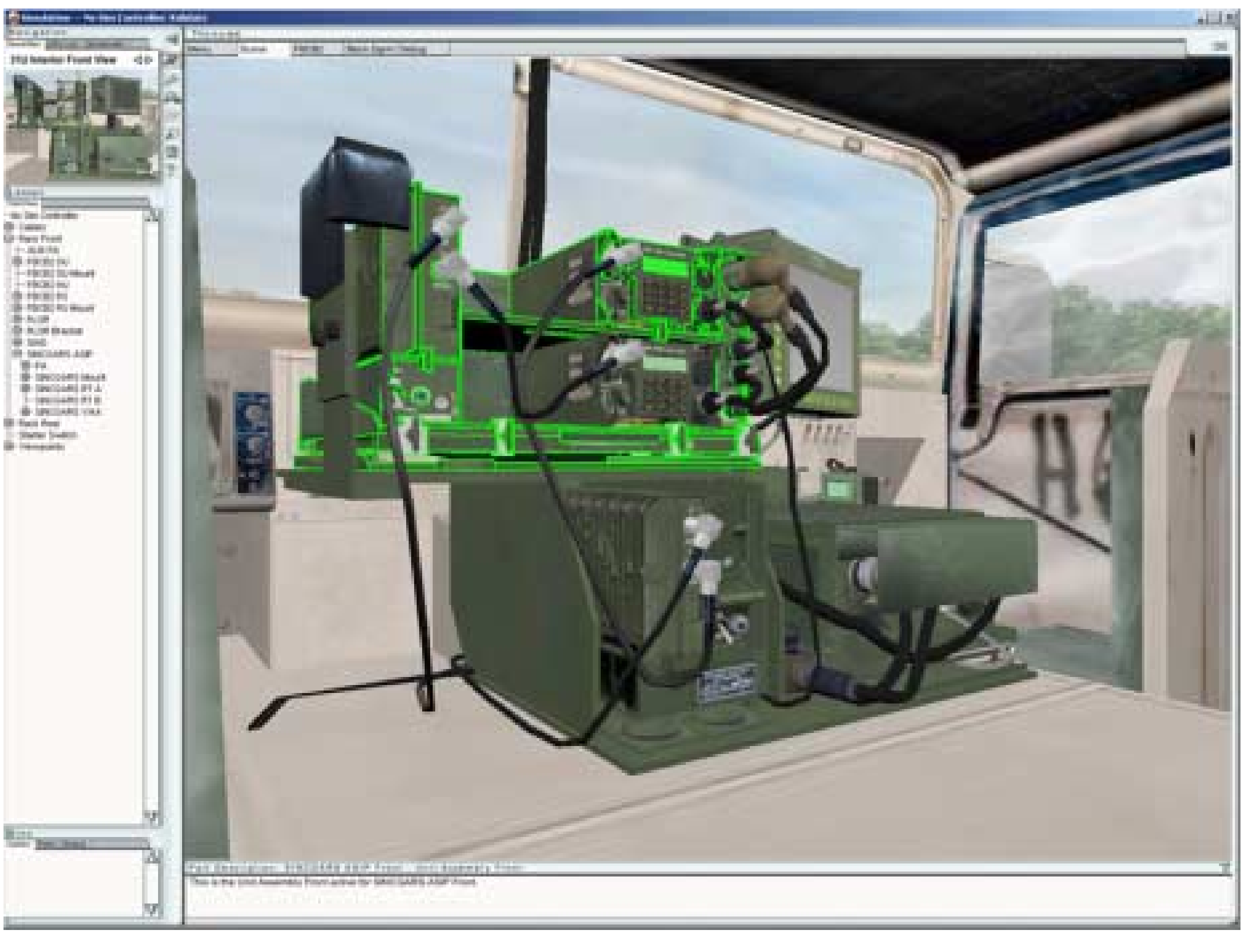

Figure 2: Screen Shot of FBCB2 Simulation

Support for Stryker Brigade Combat Team

Training

The 31U FBCB2 simulation was developed to support COHORT training by the Signal Center for the Stryker Brigade Combat Teams. Initial user testing of the complete simulation was the COHORT training for the Alaska SBCT signal company.

A challenge for FBCB2 training is that the FBCB2 system is installed in multiple vehicles. The simulation includes a familiarize lesson for the FBCB2 equipment as installed in a Stryker command vehicle. This allows the SBCT soldiers to learn the processes in the signal company retransmission vehicles, and then become familiar with the system layout in the Stryker vehicle. The screen capture in ***Figure 3*** shows the FBCB2 system as installed in a Stryker command vehicle.

Figure 3: FBCB2 Equipment in Stryker Command Vehicle

WEB DELIVERY REQUIREMENTS FOR UNIT TRAINING

Key to the concept of lifelong learning is the idea that learning materials will be readily accessible. The Internet and the World Wide Web provide a solution for ready accessibility. However, to achieve this goal there are several implied requirements for developing training materials. In the following sections, we describe how the UIT simulations address these requirements.

SCORM-Compliant

The Army has great expectations for the reuse of simulations as training materials. As the different schoolhouse develop their own resource centers, the issue of compatibility of training materials grows. The Army is requiring that training materials be SCORM compliant (ADL 2001). This simulation meets the SCORM 1.2 level tests.

Stand-Alone Execution

Stand-Alone execution is critical for AOT or unit training in the field. When the soldier is on assignment, he or she may not have continuous access to the Internet, and must be able to download lesson content in short bursts and then be able to study the lessons at his or her own pace without using up scarce bandwidth. The Signal Center is using Virtual Reality simulations that are delivered over the Internet from the UIT website to unit computers for training soldiers going to different assignments. These simulations must meet stringent requirements. The missions of the units may preclude extended access to the Internet, so the training must operate in stand-alone mode, and must be downloadable in segments using a modem and a phone line in under 15 minutes. This is a difficult requirement that limits the size of a SCO to no more than 3 Mbytes. This should be compared with the size of one of the IETMs, which is 200 Mbytes. We are working on effective ways to meet the evolving requirements to marry our simulations up with the existing assets such as these large IETMs.

The simulations must run on a broad range of computers with varied performance capabilities. This range is increasing rapidly as personal computer capabilities expand exponentially. A further difficulty in this arena is that many personal computers have not been configured with the graphics cards normally used for gaming or higher-end graphics applications.

The UIT simulations can execute in a stand-alone mode allowing the learner to perform the assigned training task(s), which have been downloaded from the Lesson Management System (LMS). In stand-alone mode these simulations are not connected in any way to the LMS server. The Resource Center provides links to download appropriate Technical Manuals to serve as resources during training.

Support for Student Record-Keeping

The UIT simulations maintain the learner lesson information locally in an encrypted form. The learner can copy this data onto a file. When Internet bandwidth is available, the learner can upload the data to the Resource Center.

Student records that are maintained include which lessons have been completed (and when), and GO/NOGO data on each Performance Measure that is associated with a Validate lesson. ***Figure 4*** shows an example AAR report. Consistent with the way that Performance Exams are graded at the Signal Center, the student is graded in terms of GO/NOGO evaluations of the critical tasks and Performance Measures extracted from the ASAT database for this MOS.

For interactions with the Resource Center, the soldier uses Army Knowledge Online (AKO) to authenticate the records. For Validate mode performance exams, the soldier must have a proctor who is recognized by the Resource Center. The proctor provides an encrypted signature on simulation results.

Consistent with Army Standards

In order to increase the potential for reuse, the simulations are closely linked with three Army Standard databases:

- The critical task lists specific to the Military Occupational (MOS) to be trained. These critical tasks are usually maintained in the Army's ASAT database.
- The performance measures associated with these tasks. Again, this data is in the ASAT database.
- Technical Manuals.

OVERCOMING BARRIERS TO DISTRIBUTED LEARNING

Dr. Abell describes several barriers to distributed learning (Abell 2000):

- Reduced feedback to distributed learners
- Increased passivity of distributed learners
- A tendency of distributed learners to lose a sense of where they are in the course.
- A difficulty motivating distributed learners

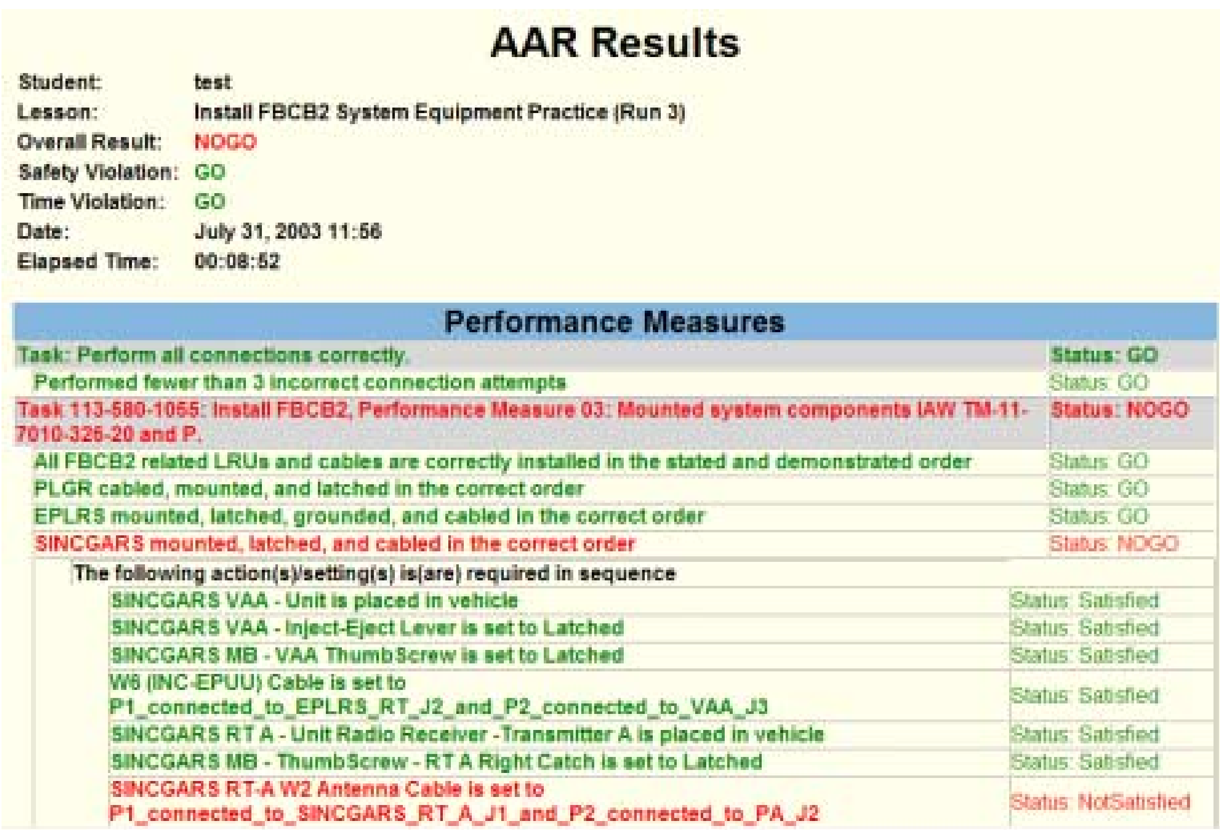

Figure 4: After Action Review Page

In this section, we discuss how these Virtual Reality simulations address the barriers identified above.

Reduced Feedback to Distributed Learners

The use of virtual reality simulations for training ensures a very high level of visual feedback to the learner. The simulations also provide audio feedback, although the focus is on the audio feedback required for realistic simulations, such as engine noises and audible alarms. A current area of research is how to use audio as an effective parallel communication channel during training, and how to keep the audio information synchronized with what is happening in the simulation (i.e., what are the events in the simulation that mark the appropriate scope for an audio communication).

Preventing Distributed Learners from Becoming Passive

Negroponte (1995) points out that most computer-based training encourages passive behavior by the learner through minimal levels of interaction. The 'learning by doing' nature of simulations effectively prohibits the learner from being passive and still successfully completing a lesson.

The Familiarize, Acquire, Practice, Validate model provides multiple levels of participation by learners so that they can become more active as they gain confidence in their skills.

Preventing Distributed Learners from Losing Track of Where They Are in Instruction

The initial simulation, the AN/TRC-173B, provided the learner with complete control over which lesson they would take next. The simulation controlled which scenario would be used for a specific iteration of a lesson, but the scenarios were selected randomly from a pool. More advanced approaches take into account the past performance of the learner in selecting a scenario.

Hierarchical step lists in our Familiarize lessons assist the learner in getting the specific information that they need, while at the same time providing context. This approach is used to explain concepts such as signal flow and fault tolerance.

After Action Reviews provide a way of reviewing the results of a simulation session. We are exploring ways of making the AARs more interactive so as to increase learner retention.

Motivating Distributed Learners

One of our goals is to get the student successfully engaged early. This involves increasing the ease of use of the training while the technology draws the student into the training. We use computer gaming techniques and virtual reality, and we are continuing to evolve methods to increase the intensity of the experience.

One option included in the simulations to ensure a sense of increasing competence is the availability of different levels of scaffolding to support the learner. The User Interface employs a combination of training aids such as hints; step lists, or dynamically highlighted diagnostic trees to assist the learner in recognizing and understanding the progress they have made and the current context in the lesson

Different models for negative feedback are used in the Practice and Validate modes. For example, in Practice mode the learner is provided immediate feedback if he or she commits an error. As a result, the learner in a Practice mode lesson cannot commit an irrevocable error, although they may quit the lesson without completing all the required actions. In Validate mode, the learner is not provided feedback until after completing the exam. After the exam is completed, the learner is provided with an AAR.

VISUALIZATION TECHNIQUES FOR BRINGING TECHNICAL MANUALS ALIVE

These simulations are focused on 'learning by doing', as opposed to the typical IMI focus on telling the learner facts about the system. Numerous studies have shown how much more effective being shown how to do something is as compared to being told how to do it (Rose and Nicholl 1998).

During the development of these systems by the Integrated Product Team, computerized visual aids are designed to assist the learner in understanding the system and the documentation of the system, consistent with adult learning theory (Cyrs 1998, Pike 1994). For example, the 31U simulation includes a Block Diagram Familiarization lesson that links together multiple block diagrams from the Operation and Unit Maintenance Manuals for the different component systems, and ties these block diagrams to the 3D visualization of the equipment. This is a powerful visual metaphor to assist the learner in understanding the documentation. Experience with the Alaska SBCT COHORT training showed that soldiers find the block diagram lessons as a valuable prerequisite for the Install lessons.

The AN/TRC-173B simulation includes a 2D view of the patch panel (shown in ***Figure 5***), which allows the learner to interact precisely with the high density of cables and connectors, including the orientation of cable ends appropriately for the task.

The FBCB2 simulation includes a 2D view of the FBCB2 Display Unit screen, which must display high-resolution topographic maps.

The simulations provide several synchronized views. The learner can switch between views using a "tab" at the top of the major viewing area. Typically there is one 3D scene tab along with one or more 2D tabs for 2D environments.

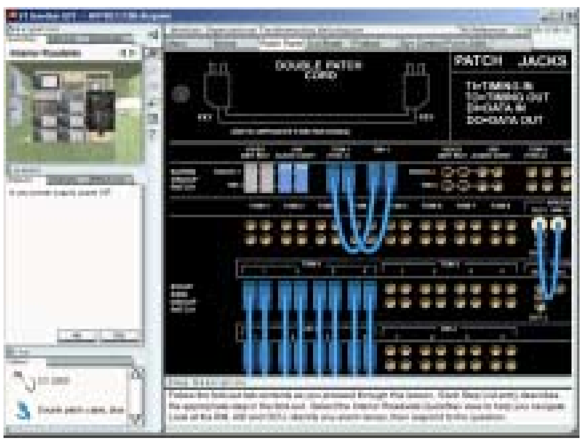

Figure 5: AN/TRC-173B Simulation 2D Patch Panel

In the simulations, the learner uses a variety of available cues to keep track of where he or she is in the training. The most important set of cues are provided by the simulation itself, through the combination of 3D and 2D views and associated audio cues that occur in the real world. Other cues include a running "stop watch" and a tab describing the task, conditions, and standards for the lesson, the list of performance measures that are being used for the lesson and how they are evaluated, and any cautions or warnings from the Technical Manual relevant to the lesson.

Another technique used for linking the Technical Manual to the 3D scene is highlighting of objects based on the component names. For example, ***Figure 2*** shows the SINCGARS system highlighted when the user clicks on the SINCGARS ASIP entry in the component list.

The original concept for camera viewpoint changes was through image 'cuts'. Our graphics team quickly changed that approach to smooth transitions from one viewpoint to the next (occasionally flying through the wall of a shelter or an antenna dish). The result was a much better sense of the relative position of an item. This is consistent with the results that Dr. Abell cites which indicate that fewer cuts are less distracting for training.

The simulations still have what effectively a "cut" in the visual scene. Now the "cuts" are associated with the student action of switching from one tab to the next.

VR SIMULATIONS AS IMMERSIVE TRAINING

Mr. Gary Wright has described the characteristics and benefits of immersive training (Wright 2003). He used the FBCB2 simulation as an example of immersive learning.

Immersive training provides many important benefits for distributed training, including motivating learners, and requiring a higher level of attention during the training and consequently a higher level of retention after the training. Immersive training is also particularly appropriate for generation X and Y learners who have extensive experience with TV and more recently computer games and the Internet as a means of acquiring knowledge and also being entertained.

FUTURE DIRECTIONS

We are developing a simulation for the AN/GSC-52A ground strategic satellite communication station. The simulation will train 31S MOS soldiers how to operate and maintain each piece of equipment individually and as a system. Operation lessons include pre-operational checks and restoration of communications links. Troubleshooting lessons include the use of test equipment and spectrum analyzers.

We are working closely with the Signal Center, CECOM, and PM WIN-T to develop a Brigade Subscriber Node (BSN) simulation in parallel with development of the actual system, so that the simulation can be delivered ready for training at the time when the system completes IOT&E. The training is task-based from SBCT tasks and the PM

WIN-T NET materials. The training includes both operator and manager training.

ACKNOWLEDGEMENTS

These simulations were developed by working very closely with representatives from Ft. Gordon as we explored new ways to train that are appropriate for AOT. Two individuals led this effort and provided essential guidance, which shaped these products.

LTC Heather Meeds was head of the Systems Integration Branch of the Directorate of Training for the development of the AN/TRC-173B simulation. She provided the right combination of experience, a strong will to support the soldiers with muddy boots trying to learn in the field, and a willingness to experiment to find better training solutions.

SFC Phillip Arnold heads up COHORT training for Stryker Brigade signal companies. He also provided the appropriate experience and a strong desire to support the soldiers in the field. He went beyond the call of duty to arrange access to vehicles and equipment needed to create accurate simulations.

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