Performance Assessment for Distributed Learning Using After Action Review Reports Generated by Simulations

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ABSTRACT

Military training doctrine encourages the use of performance assessment for evaluating students. The use of simulations for distributed learning can fill a desire for performance assessment that is not being met by Interactive Media Instruction (IMI) and multiple-choice tests. Simulations can collect an enormous amount of data about student actions, but that data needs to be processed to get meaningful information about specific student skills.

This paper describes the design of After Action Review (AAR) reports for web-delivered simulations. Like the instructor score sheets used for practical exercises during live training, these AAR reports provide GO/NOGO on the performance measures defined by TRADOC schools for the critical tasks that soldiers must be able to perform. The AAR reports also provide feedback to the student, showing in the history of a session exactly which actions completed required tasks or caused the student to fail a performance measure. The combination of simulations and AAR reports is an essential element of Lifelong Learning Centers like the University of Information Technology (UIT) at the US Army Signal Center. The UIT web site allows students to download simulations, and to report back on a completed simulation by filing an AAR. This paper also describes how aggregating AAR data across students is supporting the ISD evaluation process.

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INTRODUCTION

Military training doctrine encourages the use of performance assessment for evaluating students. The use of simulations for distributed individual learning can fill a desire for performance assessment that is not being met by Interactive Media Instruction (IMI) and multiple-choice tests. Simulations can collect an enormous amount of data about student actions, but that data needs to be processed to get meaningful information about specific student skills.

This paper describes the design of After Action Review (AAR) reports for web-delivered simulations directed at individual training. Like the instructor score sheets used for practical exercises during live individual training, these AAR reports provide GO/NOGO feedback on the performance measures defined by TRADOC schools for the critical tasks that soldiers must be able to perform. The AAR reports also provide feedback to the student, showing in the history of a session exactly which actions completed required tasks or caused the student to fail a performance measure.

ASSESSMENT OF LEARNING BY DOING

Cognitive science has demonstrated the benefits of learning by doing (Pellegrino, Chudowsky, & Glaser, 2001; Bransford, Brown, & Cocking, 1999; Fletcher, 2002). However, the integration of learning activities and performance-based assessment has not been implemented widely (Russell, 2002). Tightly coupling assessment and instruction provides information to guide students in improving their skills and to aid instructors in knowing how to help students. A key challenge for learning by doing is objective assessments of the learning. In an institutional setting, assessments can be done by the instructor, although this typically requires a one-on-one session where the instructor can observe the actions of the student. For distributed learning, the instructor is not locally or even synchronously available to perform the assessments, so this task must be automated.

THE NEED FOR DISTRIBUTED TRAINING

Distributed learning is essential to lifelong learning, which supports the lifelong student by making training available anywhere and anytime the student is willing to study (Wilson and Helms, 2003). This is distributed individual training where the learner, the instructor, and the content provider are physically separated. There are several situations where simulation of equipment is particularly valuable to the military:

- **Assignment Oriented Training**, which focuses training on initial assignments in the schoolhouse and provides distributed learning for soldiers changing assignments to different types of units.
- **Preparation for Arrival of New Equipment.** Often a unit knows in advance that it is being re-equipped, but has few options for training before the equipment arrives. Then the unit must absorb training from the New Equipment Training (NET) team in a short and intense burst. Inevitably, there are some soldiers needing the training who are not able to participate in NET.
- **New Personnel Training Without Equipment.** The constant turnover of teams means that once a unit works through NET when equipment is delivered, the unit is responsible for training new personnel on the equipment and configuration in the unit. Commanders in the field are reluctant to take critical communications resources out of service just to provide training, so the newcomers may not have access to equipment for learning by doing in a forgiving environment that allows students to learn from their mistakes. Simulations provide this opportunity without risking life,

health, equipment damage, or even temporary loss of communications during training.

SIMULATIONS FOR DISTRIBUTED LEARNING

The instructional design of the simulations described in this paper is based on the cognitive models of constructivism and situated learning. In a constructivist setting, learners gain knowledge and acquire skills most effectively when they are engaged in creating something meaningful (Anzai & Simon, 1979; Piaget, 1973; Resnick, 1989; Schön, 1987). These simulations provide learning activities that form a kind of "cognitive apprenticeship," supporting learning by enabling learners to acquire, develop, and use cognitive tools in authentic domain activity (Collins, Brown, & Newman, 1989).

The University of Information Technology (UIT) has adopted the Familiarize, Acquire, Practice, and Validate (FAPV) method for self-paced learning by doing (Frank, Helms, Voor 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.

Within the context of a course module (such as Troubleshooting) the student is learning a collection of related skills, and will go through a cycle of familiarization with knowledge specific to a topic, acquiring the basic skills associated with that topic, practicing those skills, and then demonstrating mastery of those skills. The sequence of lessons is not prescribed, so the student can adopt a sequence that is most natural. The simulations use different scaffolding structures for the familiarization, skill acquisition, practice, and validation modes of instruction.

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 random order to ensure that the learners can perform the task under a variety of circumstances, as they will have to do in real life. For assignment-oriented training and MOS Qualification, Validate lessons are required and the AARs can become part of the student records for the class. For sustainment training, Validate lessons are not required, but the student's supervisor is likely to review the AARs from the Practice lessons.

In Practice and Validate mode lessons all the feedback is saved to the end of the lesson and is documented in an AAR report. UIT students can submit Validate mode AAR data to the Signal Center web site. Student records are maintained that include which lessons have been completed (and in what order). The AAR contains GO/NOGO data on each Performance Measure that is associated with a Validate lesson. 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 Army System Approach to Training (ASAT) database for this MOS.

Cognitive learning models emphasize the need for practice with feedback for learning skills (Thorndike, 1931; Anderson, 1982; Rosebloom and Newell, 1987). For a simulation to serve stand-alone as an instructional device, it must provide feedback. In Practice mode, the simulations also provide hints, which reference familiarization information about related principals (such as use of schematics from the appropriate unit maintenance technical manual). Also in Practice mode, the simulations currently use a combination of positive and negative feedback during practice (for example, notification when the requirements of a Performance Measure have been achieved). In Validate mode, these cues are not available, and feedback is reserved until the student has completed a simulation exercise. (In Acquire mode they are not needed, because the simulation guides the student through the learning.)

AARS FOR SIMULATION-BASED TRAINING

After Action Reviews

AARs have been proven effective as a training aid by the US military since World War II (Morrison & Meliza, 1999). A good AAR has the following key elements:

- Concrete, objective evidence of what happened, both good and bad,

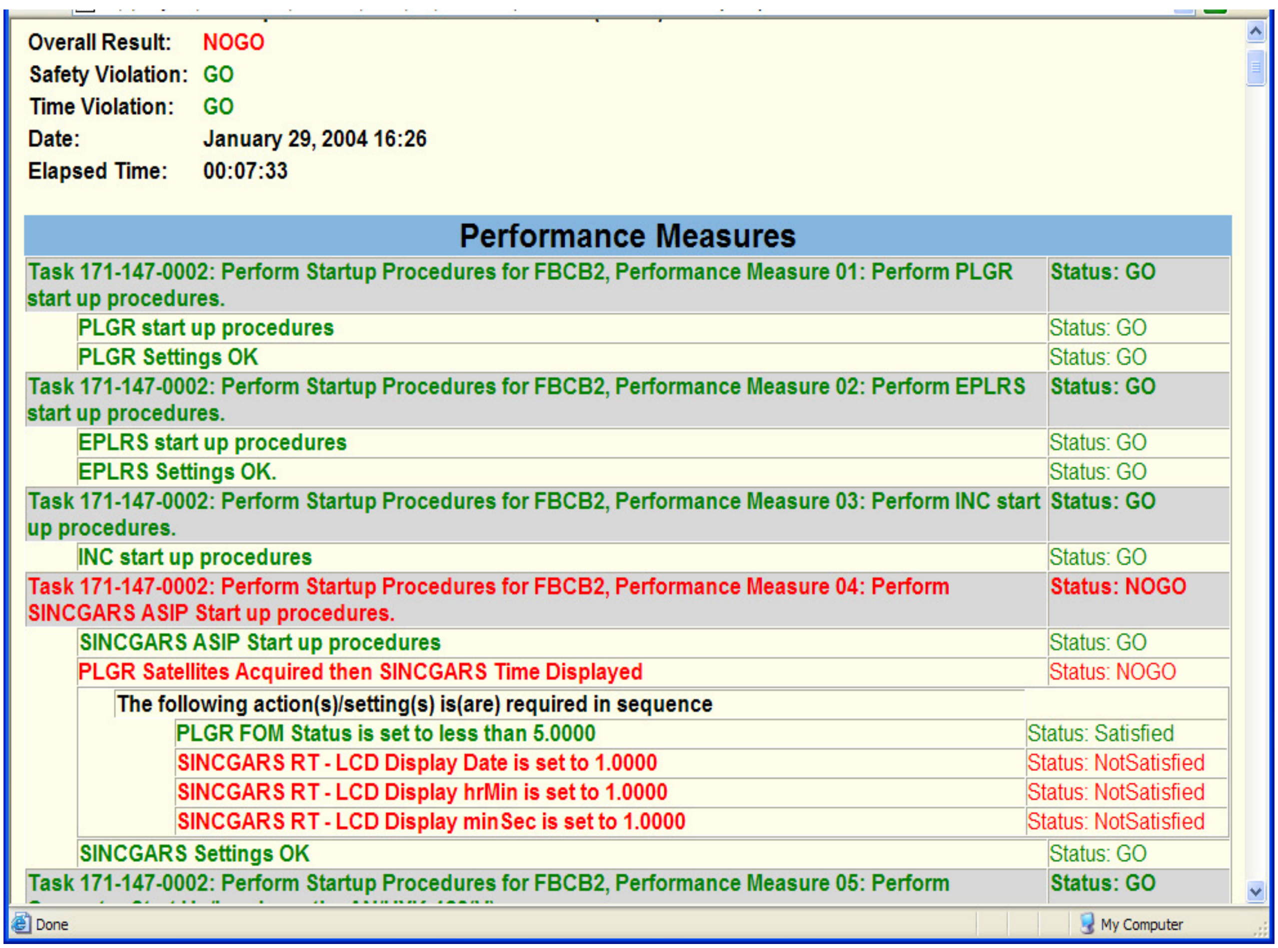
- Processes for determining how and why did the key events happen,
- Methods for determining how to fix what is broken and sustain what is good.

The AAR technique has been used extensively as an aid for collective training, and tools have been integrated into collective training simulations to support AARs. The simulations described here use the AAR concept to support distributed individual training, giving feedback to the student that is directly related to critical tasks identified with the student's MOS.

AARs for Individual Training

Recent work on simulations has focused on providing instructional scaffolding for simulations that will support distributed training where an instructor is not present at the same time or in the same place as the learner during a lesson (Frank et al., 2003). AARs are being used to integrate assessment into the learning process in a way that is consistent with other work on computer-based learning (Russell, 2002; Schwarz & Sherin, 2002; Wilson & Sloan, 2000). The AAR is providing a form of interactive reflective learning.

Algorithms have been developed for interpreting the higher-level critical task and performance measure definitions provided by ASAT in terms of student actions that are detected by the simulation and assessment of the final state of the simulation (Frank et al. 2003). This information is saved to the end of the lesson and is documented in an AAR. The AAR contains GO/NOGO data on each Performance Measure that is associated with a Validate lesson. ***Figure 1*** 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. These GO/NOGO evaluations provide objective evidence of what happened, both good and bad. The AAR also includes a log of events showing which particular actions completed the requirements for a GO or triggered a NOGO for a performance measure. This data helps the student determine how and why specific results were reported. In particular, four basic implementation strategies for performance measures as part of simulations have been developed:


Overall Result: NOGO
Safety Violation: GO
Time Violation: GO
Date: January 29, 2004 16:26
Elapsed Time: 00:07:33

Performance Measures	
Task 171-147-0002: Perform Startup Procedures for FBCB2, Performance Measure 01: Perform PLGR start up procedures.	Status: GO
PLGR start up procedures	Status: GO
PLGR Settings OK	Status: GO
Task 171-147-0002: Perform Startup Procedures for FBCB2, Performance Measure 02: Perform EPLRS start up procedures.	Status: GO
EPLRS start up procedures	Status: GO
EPLRS Settings OK.	Status: GO
Task 171-147-0002: Perform Startup Procedures for FBCB2, Performance Measure 03: Perform INC start up procedures.	Status: GO
INC start up procedures	Status: GO
Task 171-147-0002: Perform Startup Procedures for FBCB2, Performance Measure 04: Perform SINCGARS ASIP Start up procedures.	Status: NOGO
SINCGARS ASIP Start up procedures	Status: GO
PLGR Satellites Acquired then SINCGARS Time Displayed	Status: NOGO
The following action(s)/setting(s) is(are) required in sequence	
PLGR FOM Status is set to less than 5.0000	Status: Satisfied
SINCGARS RT - LCD Display Date is set to 1.0000	Status: NotSatisfied
SINCGARS RT - LCD Display hrMin is set to 1.0000	Status: NotSatisfied
SINCGARS RT - LCD Display minSec is set to 1.0000	Status: NotSatisfied
SINCGARS Settings OK	Status: GO
Task 171-147-0002: Perform Startup Procedures for FBCB2, Performance Measure 05: Perform	Status: GO

Done
My Computer

Figure 1: Example After Action Review Report

- **End-State Measures:** These are calculated by assessing the final state of the simulation when the student has completed working with a particular scenario. In ***Figure 1***, **PLGR Settings OK** is an example of an end-state measure.
- **Progress Measures:** These measures are calculated during the simulation and are focused on determining that the student has done selected actions in the correct order. Final errors of omission are detected with progress measures where the student has to perform a particular action before indicating that the lesson is complete (which is a student action). In ***Figure 1***, **PLGR Satellites Acquired then SINCGARS Time Displayed** is an example of a progress measure.
- **System Violations:** These measures are also calculated during the simulation, but they indicate a mistake by a student that is so egregious that the scenario is stopped immediately. For operator or maintainer training, these are typically associated with safety violations derived from cautions or warnings in the Technical Manual. System violations have also been used during the training of processes when the student has deviated so far from the required process that recovery is not possible in the simulation. In ***Figure 1***, no Safety Violations have occurred.
- **Errors of Commission:** Like system violations, these measures give the student a NOGO on the measure if they take a particular action, but these errors do not end the lesson. An example is in troubleshooting, where the student fails the isolate fault to the defective LRU if the student removes a healthy LRU. The student will receive a NOGO, but can continue to work on the lesson.
- **Timing Violations:** The student is given a NOGO on the lesson due to a timing violation when the time allowed for the task in the task standards definition is exceeded. In ***Figure 1***, the elapsed time of 7 minutes, 33 seconds is well within the time limit of 30 minutes stated in the Task standards The student can continue to work on the lesson, but will receive a NOGO for meeting the time standard defined for the lesson.

Note that each training session will have several instantiations of these or other performance assessment algorithms implemented and mapped to the performance measures for the enabling skills.

EXPERIENCE WITH USING SIMULATIONS FOR INDIVIDUAL TRAINING

The combination of simulations and AAR reports is an essential element of Lifelong Learning Centers like the UIT at the US Army Signal Center (Wilson and Helms, 2003). The UIT web site allows students to download simulations, and to report back on a completed simulation by filing an AAR (UIT, 2004).

A simulation of the Force XXI Battle Command Brigade and Below (FBCB2) communication system 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 III Corps training plan at Ft. Hood TX, home of the 4th Infantry Division and of the 1st Cavalry Division. The Training System Manager for FBCB2 obtained copies of the prototype from the Signal Center and took them to Kuwait for training the 4th Infantry Division before it entered Iraq.

Lessons Included in the FBCB2 Simulation

This simulation was developed to train the Army Battle Command Systems (ABCS) common core tasks that are specific to the FBCB2 system. The screen capture in ***Figure 2*** shows the FBCB2 system as installed in a HMMWV. This 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)

The Maintain module of the training includes five troubleshooting scenarios of varying difficulties:

- An incorrect setting on the PLGR,
- A bad PLGR cable,
- A problem with SINCGARS timing
- A bad FBCB2 display
- A hard disk drive failure

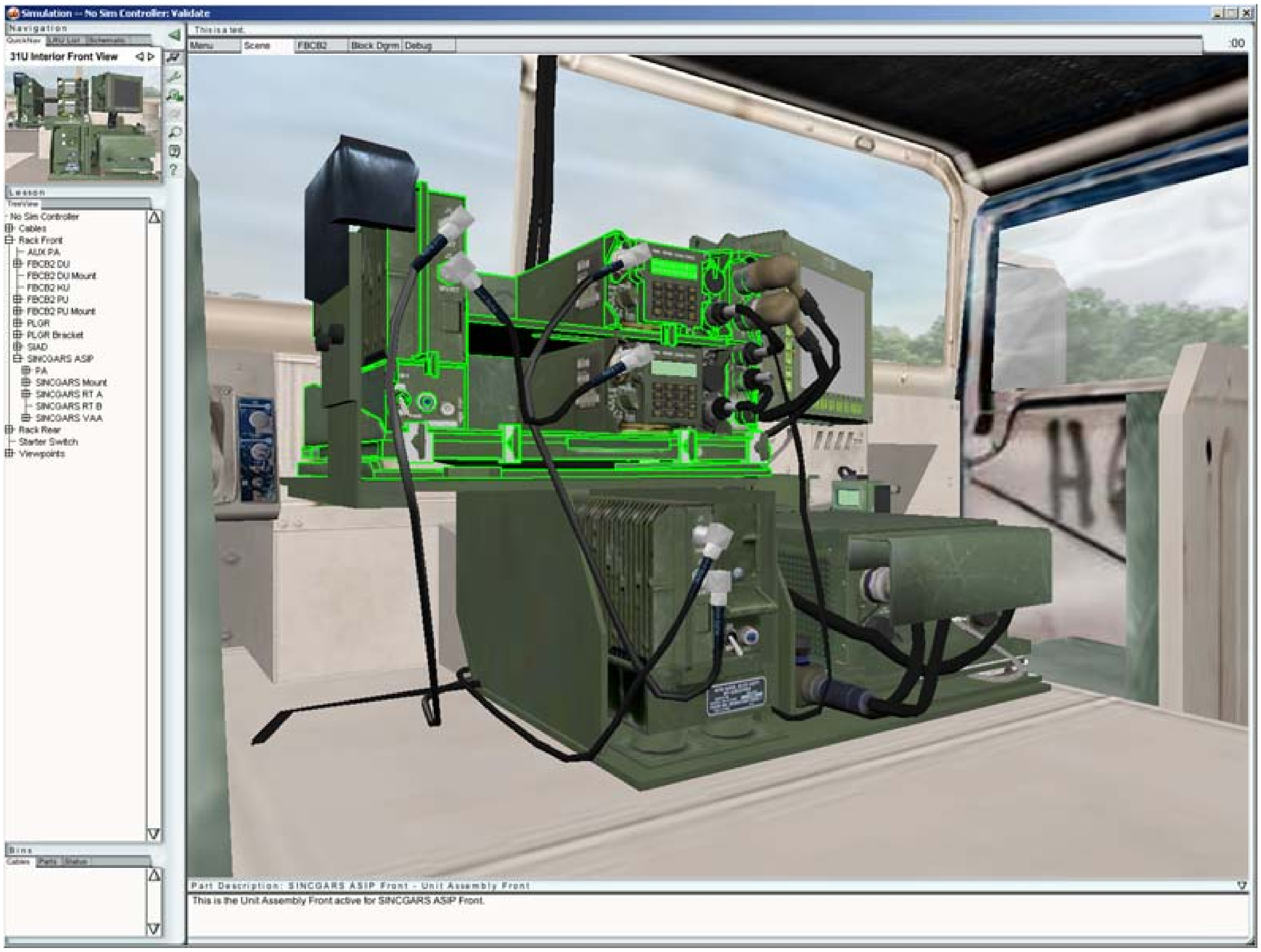


Figure 2: Screen Shot of FBCB2 Simulation

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.

Support for Stryker Brigade Combat Team Training

The FBCB2 simulation was originally developed to support COHORT training by the Signal Center for the Stryker Brigade Combat Teams (SBCT) (Arnold, 2004). Initial user testing of the complete simulation was the COHORT training for the Alaska SBCT signal company.

ANALYSIS OF AAR REPORTS

The AAR data collected from the user testing is being analyzed to provide empirical data that can be used to improve the simulations. In particular, the analysis is designed to take advantage of the instructor availability for the COHORT training to improve the experience for soldiers that do not have access to an instructor while they are training.

This analysis is ongoing. The two hypotheses analyzed below are:

- The soldiers will use Acquire mode lessons for remediation if a relevant Acquire mode lesson is available.
- The lessons developed for the simulation provide a good mix of difficulty.

Figure 3 shows the number of lesson repetitions by 48 soldiers during Signal Company COHORT training for

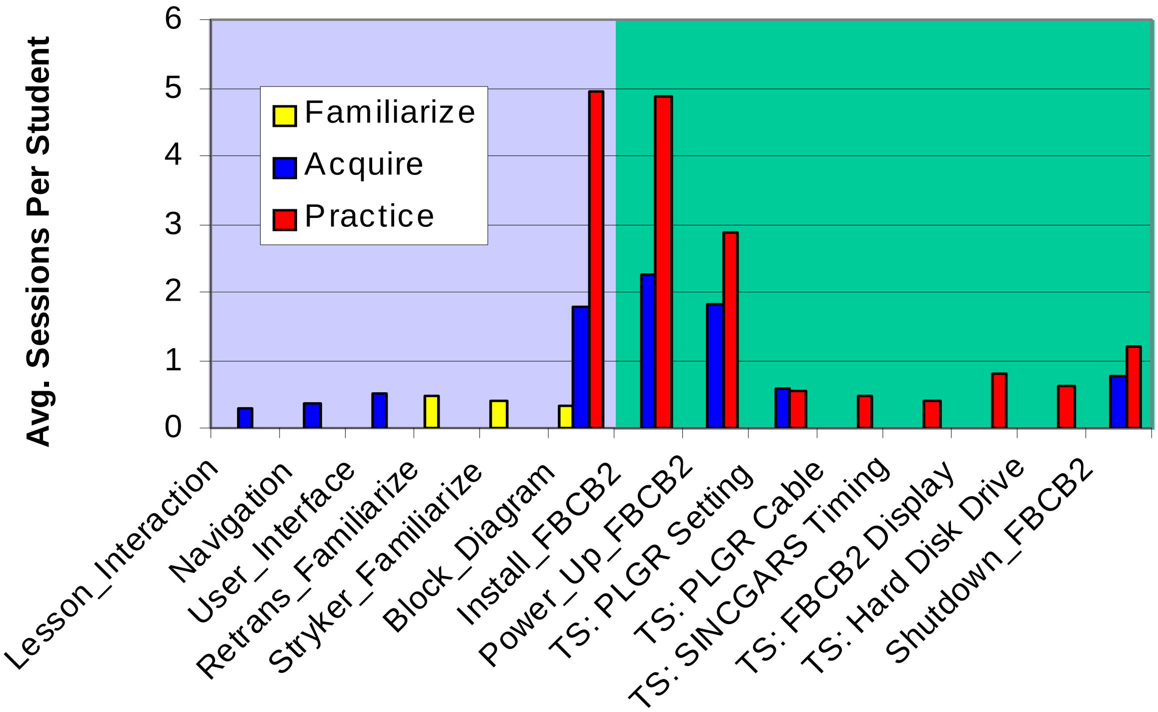


Figure 3: Practice Lesson Sessions for COHORT Training

the Alaska SBCT. The lessons are organized around four critical tasks: Install, Power Up, Troubleshoot, Shutdown, which are shown in the green background section of ***Figure 3***. Each of these tasks has at least one Acquire and one Practice lesson. This figure emphasizes the power of practice lessons as the primary learning experience.

Remediation Options

Design of a training package must balance two requirements (Abell 2000):

- Allowing the student control over the learning experience, and
- Preventing the student from getting lost in a labyrinth of options.

The FBCB2 simulation provided the student with an annotated menu of lessons; the soldiers were allowed to proceed through the lessons in any order. For COHORT training, the soldiers were given the goal of providing all GO AARs on all the Practice mode lessons.

The multimedia scaffolding around the simulation provides a variety of remediation options for students. In Practice or Validate modes, these options fall into four categories:

- Repeat the Practice or Validate mode lesson again. Repeating a Practice mode lesson was the most common reaction to an overall NOGO. During testing, the students were observed using the log sections of the AAR reports to determine where their errors occurred.
- Shift to a different learning mode. For example, if the student does not succeed in a Practice mode lesson, they may prepare with an Acquire mode lesson. The numbers of Acquire mode sessions shown in ***Figure 3*** indicate that students are using this strategy.
- Shift to an analogous lesson, particularly to learn key concepts. For the FBCB2 simulation, the two lessons with the highest number of sessions were Practice mode lessons on understanding block diagrams and installing the equipment. Observation of the class indicated that soldiers having difficulty installing equipment in the virtual environment (the Install lesson) shifted to a more abstract lesson (the Block Diagram lesson). This shift reduced many of the distracters occurring in the virtual world and provided a simpler environment to learn analogous skills. Soldiers were then able to transfer skills from the abstract environment into the more realistic environment.

- Shift from a skill Acquisition or Practice mode lesson (focusing on procedural knowledge) to a Familiarize mode lesson to obtain needed declarative knowledge. For example, if the soldier does not understand that the hard disk drive error LED is inside the processor unit, he or she may shift to a familiarize mode and review controls and indicators to get this information. This happened only rarely, as indicated by the small number of Familiarize mode sessions.

Lesson Selection

As shown in ***Figure 3,*** the two lessons with the most sessions were Practice mode lessons on understanding block diagrams and installing the equipment. On the recommendation of a Subject Matter Expert, block diagram lessons were created to help the students learn how to cable together the FBCB2 components. As described in the discussion of a shift to analogous lessons, the Block Diagram lessons improved the training beyond the original estimates.

In order to help the students generalize the troubleshooting procedure, there are five different troubleshooting scenarios. ***Figure 4*** shows the times for achieving an overall GO on the lessons. The standard as established by the Subject Matter Experts for these lessons was 30 minutes. There are a total of 9 Practice lessons in the training package: 8 are derived from critical tasks (Install, Startup, the five Troubleshoot, Shutdown), the ninth (block diagram) supports the install task.

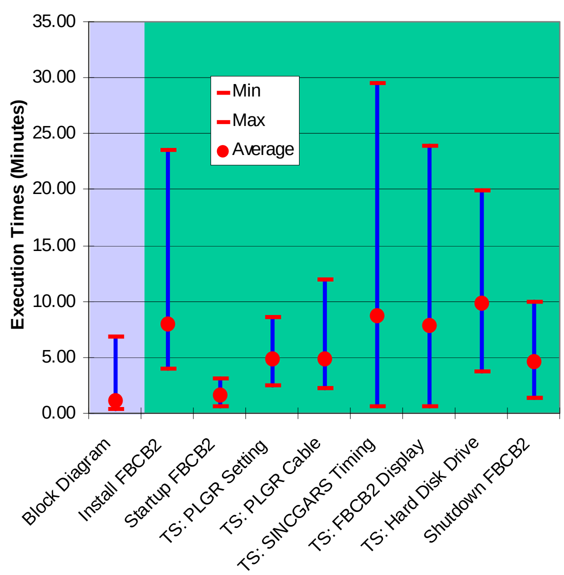


Figure 4: Practice Lesson Execution Times for COHORT Training

In terms of elapsed time to complete the repair, the hard-disk-drive crash is perhaps the most difficult scenario, with a wide range of run times and the highest average time. However, the SINCGARS timing scenario provided even wider ranges of run times. The lessons were designed to focus on the fault diagnosis and isolation process. Once the fault was diagnosed, the fixes were relatively quick to implement in the virtual world (This was not true for the hard-disk crash, which required a complete boot cycle). The time variations may also depend upon facility in using the TM as a diagnostic tool. Observation of the training indicated that some soldiers were competing to minimize their times.

As shown in ***Figure 5***, further analysis of the variation of lesson execution times shows a strong learning trend over the different sessions. In this figure all student sessions are considered, including sessions where the student didn't get an overall GO. The rise in average and minimum times for Runs 4 and 5 reflects the fact that faster learners who have already mastered particular skills move onto other lessons, so the sample pool down-selects to slower learners.

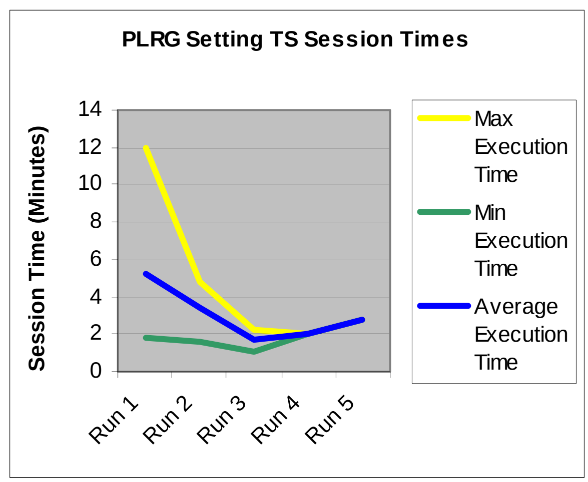


Figure 5: Convergence of Practice Lesson Times

FUTURE DIRECTIONS

We are still analyzing the AAR reports, logs, and other data to better understand the soldiers' activities. As these training materials are used for sustainment training in the units, we are looking forward to analyzing data from the field to see if there are different patterns of use for the simulations in training in the field. Another form of feedback will come from the use of UIT simulations to support training of the Pennsylvania National Guard SBCT over the next two years.

The Signal Center is working with CECOM 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 its initial test. The training is task-based from SBCT tasks and the BSN NET materials, and includes both operator and manager training. This simulation will be incorporated in the SBCT COHORT training at Ft. Gordon that will be conducted during July and August of 2004. During the summer of 2005, the signal companies of two SBCT will be conducting COHORT training concurrently using these simulations.

CONCLUSIONS

Simulations provide a major opportunity to unobtrusively and continuously collect data on student behavior and support learning by doing. Careful crafting of the scaffolding surrounding the simulation will improve the learning experience.

AAR reports provide feedback that students can use to adapt their learning experiences and sequence a series of simulation sessions. The AARs should be based on critical tasks required for the soldier's success.

AAR reports also provide data on student behavior that can be used to evaluate the simulation design, consistent with Instructional Systems Design principles.

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