Automated, Interactive AARs: A Positive Spin

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ABSTRACT

An effective student performance review strategy is to provide positive feedback before providing critical guidance, then to intersperse positive feedback throughout the review. The amount of positive feedback must be balanced against the necessity to continuously impart current and relevant information. An early emphasis of positive feedback helps to engage the student, and variably reinforced positive feedback maintains that engagement, resulting in the student remaining open to critical learning content. This demands a high degree of interactivity throughout the review process, a strategy applicable to human instructors and automated intelligent tutoring systems.

This paper describes a strategy for integrating automated, interactive After Action Reviews (AARs) with simulations to provide student-tailored feedback based on positive, session-specific information. The underlying methods rely on the meta-relations among hierarchies, including learning objectives, demonstrated student achievements and weaknesses, simulation events, and scenario-to-learning objective mapping. The generated AAR output allows the student to drill down to specific details of the AAR, explore how student decisions impact results, and obtain recommendations for learning objective–specific remediation. The approach presumes both that the simulation is assessing multiple learning objectives from a single scenario and that a cross-linkage of learning objectives cuts across multiple lessons, systems, and disciplines. These intelligent tutoring strategies were derived using a Force XXI Battle Command for Brigade and Below (FBCB2) simulation, which provided training on the installation, operation, and maintenance of the FBCB2 system of systems, including not only the AN/UYK 128 computer, but also the associated Single-Channel Ground and Airborne Radio System and Enhanced Position Location Reporting System radios and the Precision Lightweight GPS Receiver global positioning system.

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[1] RTI International is a trade name of Research Triangle Institute.

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INTRODUCTION

A significant risk for computer-based training systems is losing the student's engagement in the training (Abell, 2000). Therefore, it is valuable to use training methods that help to ensure a positive attitude on the part of the student. Positive reinforcement is known to improve the attitude of a student toward a learning experience (Peat et al., 2004). A student performance review strategy that has proven effective is to provide positive feedback before providing critical guidance, then to intersperse positive feedback throughout the review.

Strategies for providing positive reinforcement in simulation-based training systems are described herein. The primary focus in these training systems is on supporting deliberate practice through the following:

- The set of scenarios and the initial conditions for those scenarios that are supported by the simulation
- The instructional modes supported by the training system
- The feedback provided to the student both during the scenario and in an After Action Review (AAR).

An Intelligent Tutoring System (ITS) employing these strategies was developed to implement lessons learned from a baseline simulation for training maintainers of Force XXI Battle Command for Brigade and Below (FBCB2) systems. Both the baseline trainer and the ITS were designed to teach maintainers how to install, operate, and maintain the FBCB2 system of systems, including not only the AN/UYK 128 computer with its FBCB2 software, but also the associated Single-Channel Ground and Airborne Radio System (SINCGARS), the Enhanced Position Location Reporting System (EPLRS) radios, and the Precision Lightweight GPS Receiver (PLGR) global positioning system.

This paper describes four instructional modes relevant to simulation-based training. These instructional modes (Whiteford et al., 2003) have been adopted as a standard by the U.S. Army Signal Center and are now being considered as a conceptual reference for IEEE standards (Dargue et al., 2006).

A use case is presented that describes how students interact with the baseline FBCB2 training system. This use case is based on the observation of training by the Signal Company of a Stryker Brigade Combat Team (SBCT) (Frank et al., 2004). Although the simulation was designed for the critical tasks of the 25U military occupational specialty (MOS), SBCT Signal Company NCOs with several different MOSs used the simulation. The lessons learned from this use case provided guidelines that were used to develop an ITS for the FBCB2 training system.

This paper describes strategies for designing interactive AARs for the FBCB2 ITS. A goal of that effort was having the ITS provide positive reinforcement for students learning about the system. The paper also describes strategies for sequencing lessons to smooth the learning curve and improve the probability of having positive feedback to share in the AARs.

SIMULATION-BASED TRAINING

One goal of this paper is to describe how good instructional design can introduce opportunities for positive reinforcement into simulation-based training and at the same time reduce student frustration. A key strategy for creating positive reinforcement opportunities is to adapt the training to individual learning approaches and to provide a gradual learning curve. The instructional modes described below are some of the tools that we have used to adapt training to individual learning approaches and to spread the learning curve across multiple student sessions.

Familiarize, Acquire, Practice, and Validate Modes

Our simulation-based trainers use a combination of Familiarize, Acquire, Practice, and Validate modes to lead the student through a form of guided experiential learning (Clark, 2005).

In the Familiarize mode, the simulations use 3-D models and other dynamic visualization techniques to explore and learn the prerequisites to performing a task, such as equipment, tools, and terminology.

In the Acquire mode, or "show me" mode (Dargue et al., 2006), the student acquires 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 the Acquire mode, the simulation leads the student through the sequence of steps to be performed to accomplish a particular task, and the level of free play available to the student is restricted.

The Practice mode, or "let me try" (Dargue et al., 2006) mode, provides free play for the student and at the same time provides a variety of training help, including hints and immediate error feedback. During the Practice mode, the simulation immediately informs the student when he or she makes a mistake. The mistake is prevented from damaging the simulation state by trapping the error before it changes the simulation state.

At the end of the lesson, the student is provided with a formative assessment in an AAR format.

In the Validate mode, or "test me" (Dargue et al., 2006) mode, all the feedback is saved to the end of the lesson and is documented in an AAR that can be uploaded to a SCORM-conformant LMS. 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.

After Action Reviews

The AAR has proven to be effective as a training aid by the U.S. military since its development during World War II (Morrison and 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 the key events happened
- 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 (Jensen et al., 2006; Nullmeyer et al., 2006).

Based on the success of instructor-moderated AARs as a method for providing feedback after live training exercises, AAR strategies are being automated to provide feedback for many simulation-based training applications (Dargue et al., 2006). The simulations described in this paper use the AAR concept to support distributed individual training, giving the student feedback that is directly related to critical tasks and performance measures identified with the student's MOS.

A USAGE EXAMPLE

As mentioned earlier, the AAR design strategies described here are derived from a simulation developed for the training installation, operation, and maintenance of the FBCB2. The retransmission vehicle used as the base example for training 25U MOS soldiers is a system of systems, including multiple SINCGARS, EPLRS, Near Term Data Radios (NTDR), and a PLGR, as well as the AN/UYK 128 processor, display, power supply, and FBCB2 software. These components need to be connected and configured properly to serve the function of a retransmission vehicle, including retransmission of voice and data on different radio protocols and frequencies.

The ITS described in this paper was developed using the experience of 48 soldiers during Signal Company Cohesion Operational Readiness Training for the Alaska SBCT. Experience with soldiers' use of these simulations (Frank et al., 2004) indicates a consistent focus on completing the training with a minimal number of practice sessions and a low tolerance for additional information that is not needed to "fix" the problems that occurred in the previous session. Therefore, the amount of positive feedback must be balanced against the necessity to continuously impart current and relevant information.

Figure 1 indicates lesson difficulty for the FBCB2 training based on the experience of 25C SINCGARS Radio Network Operators. It plots the average number of practice sessions to get a GO for the entire lesson (Frank et al., 2004). The lessons are organized around four critical tasks: Install, Power Up, Troubleshoot, and Shutdown. The lessons associated with these tasks are shown in the green background section of Figure2. Each of these tasks has at least one Acquire and one Practice mode lesson. There are five scenarios associated with the Troubleshoot task: PLGR Setting, PLGR Cable, SINCGARS Timing, FBCB2 Display, and FBCB2 Hard Disk. Lessons shown in the blue background were included in the training system to help students succeed on the remaining lessons.

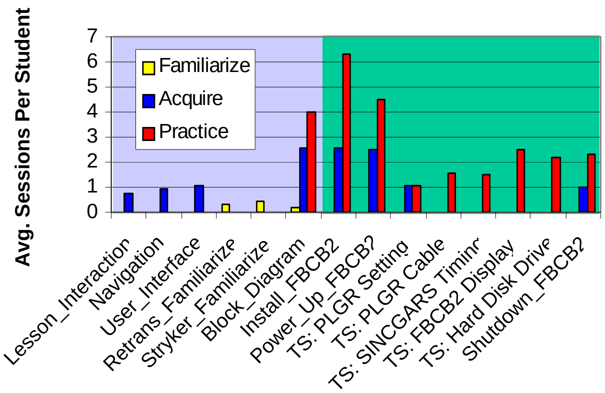


Figure 1. Evidence of FBCB2 Lesson Difficulty

Figure 1 provides evidence of the difficulty of the lessons, with more sessions per student indicating more practice sessions needed to succeed, and therefore, the more difficult lessons. Figure 1 implies that the Block Diagram, Power Up, and Install practice lessons were the most difficult, particularly the Install lesson. This data is consistent with comments made by the students. In fact, an instructor suggested the Block Diagram lesson as a good way to help students learn how to do installation because it uses a simplified format (the block diagram) to practice a subset of the skills needed for installations (connection of cables).

INTERACTIVE AAR DESIGN

The design for an automated, interactive AAR must meet several challenges. The first challenge is to provide feedback to the student across the full range of assessments required. Part of this process is mapping learning objectives to lessons and tracking coverage of the assessments across the set of lessons in the course. The second challenge is to organize the assessment data so that students can get an overview of session feedback quickly and the details of their performance assessment easily through interactions with the ITS. There are two aspects of this organization: designing a hierarchy of learning objectives and mapping learning objectives to simulation events.

Meeting Assessment Requirements

The FBCB2 simulation was developed to provide training on specified critical tasks and performance measures for the 25U MOS, although the training was used by other MOSs. Critical tasks and performance measures were required assessment metrics for this and other simulation-based training systems (Whiteford et al., 2003). These critical tasks and performance measures were incorporated into the hierarchy of

Terminal Learning Objectives (TLOs) and Enabling Learning Objectives (ELOs), as described below.

The assessment requirements for the FBCB2 simulation defined the roll-up function for the hierarchy of TLOs and ELOs. Each critical task would be assessed as a NOGO if any subordinate performance measure was assessed as a NOGO. This strict interpretation limited high-level options for positive feedback.

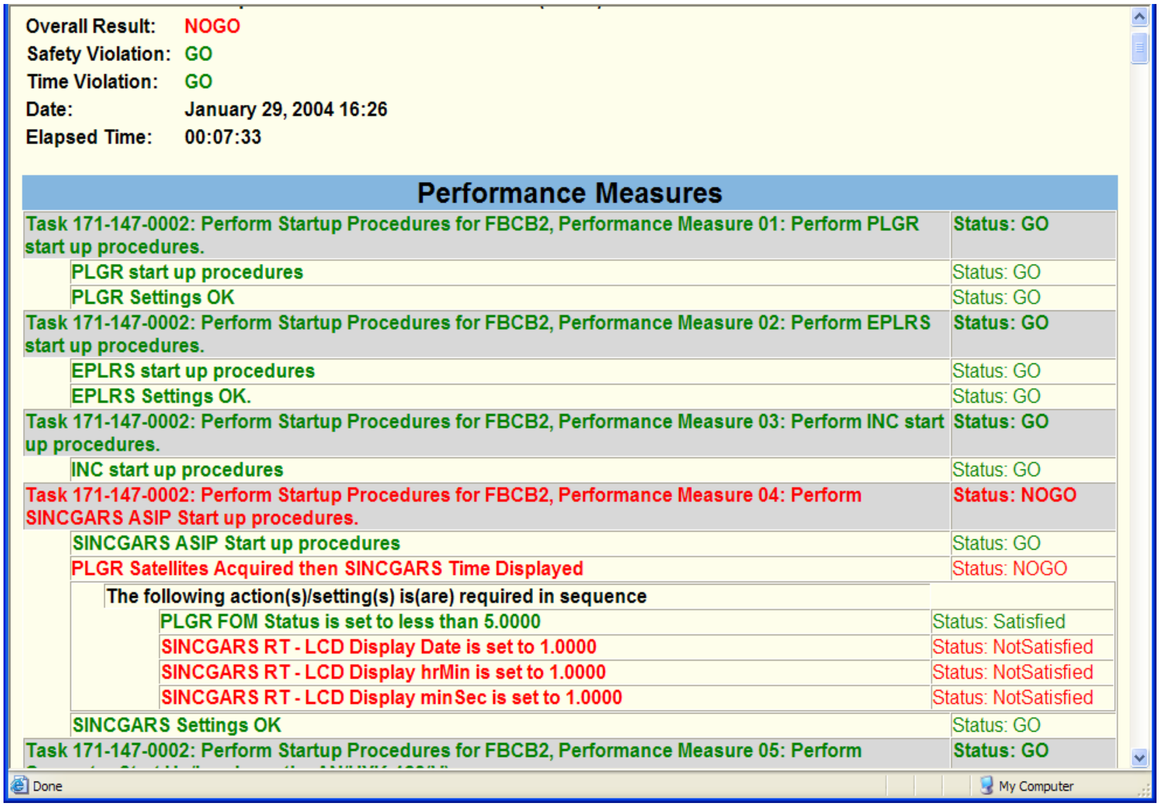
Constructing Hierarchies of Learning Objectives

Figure 2 shows an example AAR report for a Start-Up lesson. The AAR contains GO/NOGO data on each critical task and performance measure that is associated with a lesson in the Validate mode. The tasks are color-coded green and red to indicate GO or NOGO assessments. The top-level headings show performance measures that are used to assess student performance in this scenario.

The indenting of text in Figure 2 indicates the learning objective hierarchy for the baseline FBCB2 simulation:

- Performance measures for the primary critical task of the lesson
- Simulation assessment criteria
- Simulation event sequences and end-state values used to compute the assessment criteria.

The generated output allows the student to drill down to specific details of the AAR, explore how his or her decisions impact results, and obtain recommendations for learning objective-specific remediation.



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 2. After Action Review Report for the FBCB2 System with a Hierarchy of Critical Tasks and Performance Measures (Frank et al., 2004)

For the FBCB2 ITS, the hierarchy of critical tasks and performance measures shown in Figure 2 was extended to identify specific subsystems, such as the SINCGARS, EPLRS, and PLGR. This allowed the ITS to configure lessons on a specific subsystem as remediation for scenarios where the student did not meet the standards for the subsystem performance measures. This is not as simple as turning off assessments because some remaining assessments may depend on the successful completion of tasks that are not being assessed. Instead, the initial conditions for the scenario must be aligned with the assessments. The relationships between the subsystems, critical tasks, and performance systems were captured in a database that was inputted to the ITS.

Mapping Learning Objectives to Simulation Events

Student assessment for simulation-based training requires relating the learning objectives to artifacts of the simulation, such as student actions or simulation events or the state of simulation objects. Although critical tasks and performance measures were used as part of the TLO/ELO hierarchy for simulations, including the FBCB2, they did not define the complete TLO/ELO hierarchy.

As indicated in Figure 2, two additional levels of ELOs were added below the performance measures to link the performance measures to simulation events. Part of the design effort was developing these additional items and defining how they determine the GO/NOGO values for the performance measures. These lower-level ELOs were defined in terms of the final state of simulation variables and on the sequence of simulation events (Frank et al., 2004).

The FBCB2 ITS used the same mapping of learning objectives to simulation events as the original FBCB2 trainer. However, tools are being developed to capture expert action patterns and then compare student action patterns against the expert patterns.

Mapping Learning Objectives to Scenarios

Mapping learning objectives to scenarios is an essential part of the task analysis and scenario selection for simulation-based training because most scenario-based training environments do not provide a one-to-one association of scenarios with critical tasks. For example, five scenarios are associated with the Troubleshoot task, as shown in Figure 1. On the other hand, multiple critical tasks are often associated with a single scenario. For example, there are separate performance measures for the different subsystems of the FBCB2. This is demonstrated in Figure 2, where five performance measures are shown in the AAR report for the start-up lesson.

There are also global learning objectives that are derived from other sources besides critical tasks. These include avoiding safety violations and meeting time limit standards for the lesson. For example, taking appropriate safety precautions was a TLO associated with each of the lessons. The ELOs associated with this TLO were extracted from the cautions and warnings documented in the technical manuals. This TLO was assessed parallel to the operational critical tasks for these lessons.

Mapping is a valuable tool for selecting scenarios for lessons. For the FBCB2 ITS, we looked at ways of creating prerequisite lessons by reducing the complexity of the difficult lessons. One goal for prerequisite lessons was reducing the number of ELOs that were assessed by the prerequisite lesson as compared with the difficult lesson. Mapping was used to distribute the ELOs across the prerequisite lessons. Tracking the mapping has turned out to be even more useful for scaling-up the design of training systems with hundreds of tasks and lessons.

During the design of the FBCB2 ITS, we noted that different performance measures addressed different subsystems, and we designed prerequisite lessons for the start-up and installation of subsystems. Prerequisite lesson rules were incorporated into the ITS rule base.

Creating Informative AARs with Positive Spin

The primary goal for an AAR is to provide the information needed for the student to succeed in meeting the learning objectives for the course. This means providing the student with access to assessment data on all the learning objectives associated with the session.

At the same time, the AAR should assist the student in focusing on specific areas for improvement in the next session. When there are many performance measures being tracked that the student has not mastered, it is easy to overwhelm the student with discouraging feedback.

The strategy used in the baseline FBCB2 AAR (i.e., using no ITS) was to show no details for any performance measure that received a GO, but to provide details for all performance measures that received a NOGO. This is shown in Figure 2, where four of the five performance measures received a GO and are summarized at the top level, and the one NOGO performance measure is expanded to provide a more detailed explanation of the problem using the hierarchy of learning objectives.

For the FBCB2 ITS, we wanted to keep the student engaged in the learning process, primarily through making the AAR interactive. We were cautioned by our Subject Matter Experts (SMEs) not to overwhelm the student with superfluous decisions during the AAR. Therefore, we looked for ways to provide comprehensive summaries, quick and simple access to additional details, and good explanations for assessment results.

Another strategy is to encourage the student to engage through interaction to select one of multiple views of the assessment data.

Presentation of Multiple Views of Assessment Data

During the design of the FBCB2 ITS, we developed several different views of the collected assessment data:

- A summary of the status of achieving learning objectives in the last practice session
- Presentation of the sequence of what happened during the session, including explanations of cause and effect relationships
- A history of improvement over several practice sessions
- Presentation by different subsystems, such as the different radios of the FBCB2 system.

These views are discussed below.

Summary of Status on Learning Objectives

For the FBCB2 ITS, we made the AAR interactive and provided rolled-up results, but allowed the student to expand the details under a high-level ELO. The format used the same TLO/ELO hierarchy as the baseline FBCB2 simulation. Experience with this hierarchy revealed a need to display additional summary data that could help the student decide where to drill down. We adopted Army collective training codes (i.e., trained, needs practice, untrained); applied the usual color codes of green, amber, and red; and assigned thresholds for the number of ELOs in each category as an initial approach to assist students in deciding what data to expand.

This AAR summary presentation format is particularly important for the scaling-up of AARs for scenarios with multiple tasks, tens of performance measures, and hundreds of simulation-specific ELOs. We have been extending the TLO/ELO hierarchy with additional levels to provide more guidance to the student in how to review the AAR data.

Review of Session Events

The baseline FBCB2 simulation provided two views of assessment results: a summary based on the learning objective hierarchy and a sequential history of the simulation events of the session, as shown in Figure 3.

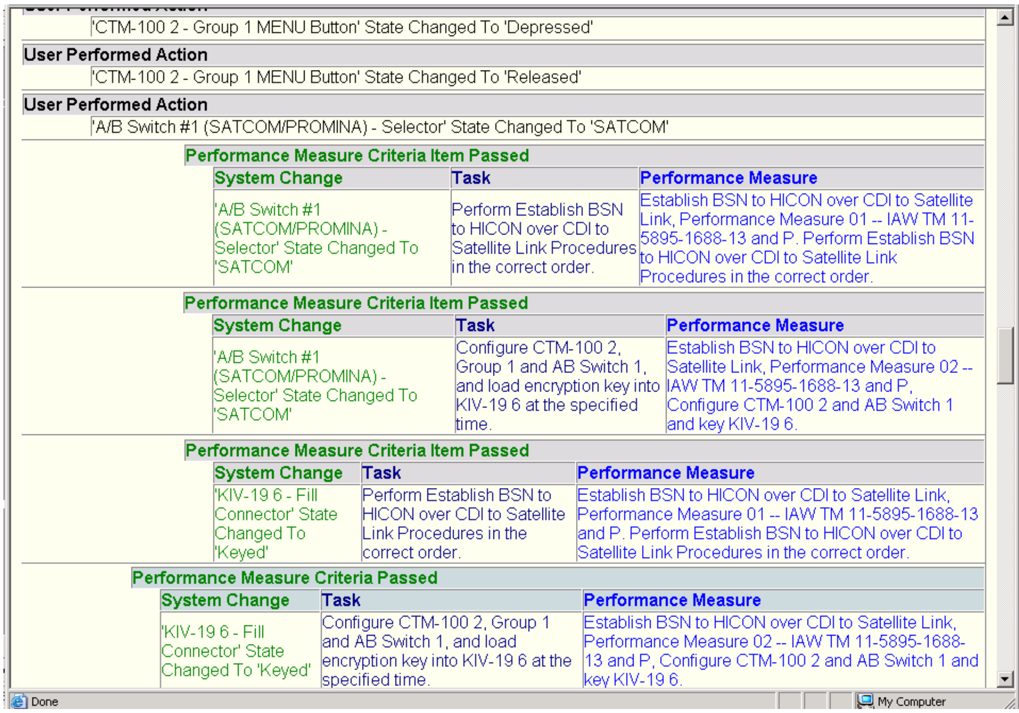


Figure 3. Event History Section in the AAR

The events were characterized as user-performed actions or as simulation behaviors. Those events that had triggered success on a performance measure were tagged with data on the critical task and performance measure as a way of informing the student of the consequences of his/her action. We observed this log being used by students to figure out their mistakes and develop strategies for succeeding in another session.

Experience with these logs quickly points to the need for methods for summarizing this data and helping the student find the relevant sections of the history of events. As shown in Figure 3, a single student action can trigger a cascade of performance measure completions or a cascade of error messages. At the same time, there may be long series of events with no change in learning objective status. We are exploring ways of hierarchically organizing the event stream data so that the student can use a common interface for drilling down on the ELO/TLO hierarchy and on a time-sequenced hierarchy of events.

A History of Improvement

A design goal for the FBCB2 ITS was to provide positive feedback early and to help the students understand and appreciate their progress in learning. For the FBCB2 ITS, the lesson selection function was modified to provide feedback on how much of the required scenarios for the course had been covered.

This history data was also important information that the ITS used to recommend lessons to the student. For example, the ITS rule base included rules to avoid repeating a scenario when multiple scenarios were available for the same lesson.

To add more positive reinforcement to the training, we looked at presenting progress data as part of the interactive AAR. The ITS compared the student's past successes and failures during lessons on the same learning objectives and then provided a report of new successes (i.e., ELOs that received a GO during this scenario, but were NOGO on previous scenarios) and regression (i.e., ELOs that received a NOGO during this scenario, but were GO on the last scenario).

Summarizing new successes and regressions by rolling-up counts was not successful because of the "one step forward, two steps back" phenomena, where the student overcomes a significant barrier, only to be overwhelmed by new decisions not addressed in previous scenarios. This situation is illustrated in Figure 4, which plots session number along the X-axis

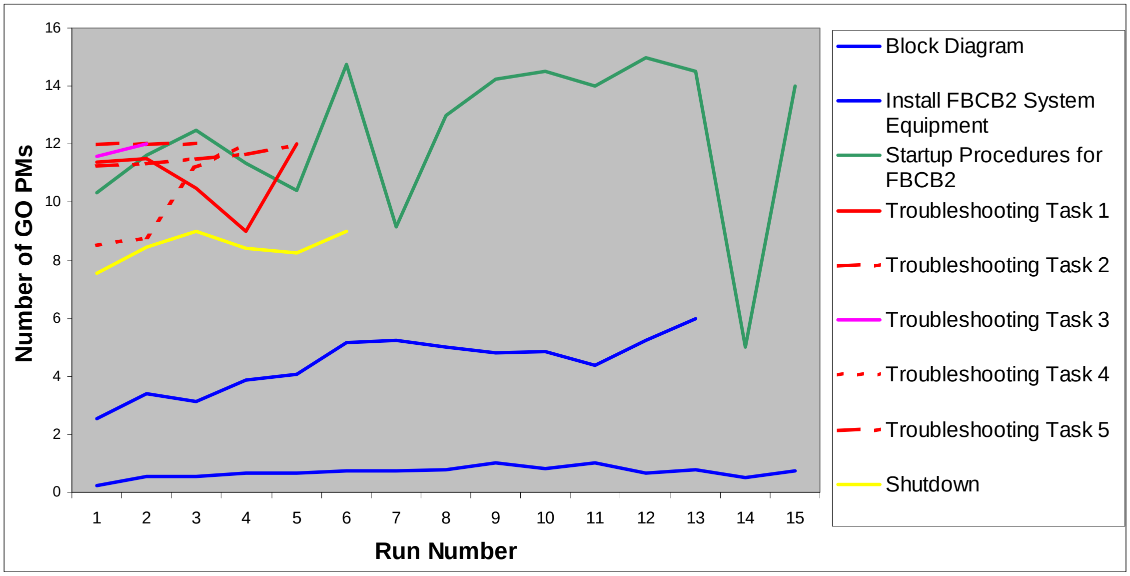


Figure 4. Average GO Performance Measures Per Step: One Step Forward, Two Steps Back

and the average number of performance measures receiving a GO along the Y-axis. In an ideal training situation, the number of performance measures receiving a GO would increase monotonically. The plot illustrates a very different situation. This situation requires a good explanation facility in order to provide accurate and relevant feedback, with an emphasis on positive reinforcement. The number of performance measures associated with a lesson is an upper bound on the associated plot. For example, the Block Diagram lesson (the bottom line in Figure 4) has 1 performance measure, the Install lesson has 6, the Troubleshooting lessons have 12 each, and the Start Up lesson has 16.

Presentation by Subsystem

The interactive AAR could help tailor feedback to the student consistent with student experience. One approach for doing this is to provide feedback by subsystem, such as the different types of radios in the FBCB2 system. This strategy requires hierarchies other than the critical task and performance measure hierarchy. Note that in Figure 2, the performance measures are specific to the hardware components, but the critical task is all encompassing.

Organizing the AAR feedback by subsystem may help the student understand strengths and weaknesses derived from experience. This view is supported by the data in Figure 1, which shows the results of FBCB2 training by 25C MOS, who specialize in the SINCGARS radio and the PLGR. They were much more proficient at troubleshooting the SINCGARS and PLGR than they were with the FBCB2 display and disk-drive troubleshooting lessons. Note that the baseline FBCB2 simulation troubleshooting lessons were specific to subsystems and could easily be reused for subsystem training. This approach is useful for sustainment training where the lessons can be tailored to the equipment available to the unit (Waters et al., 2008).

Explanation

A starting point for explanation is a taxonomy of errors, where we associate an explanation template with each class of errors. An explanation can then be configured by substituting the details of a specific error into the explanation template.

A second level of explanation is to describe how multiple simulation-specific criteria are combined to define a result associated with a specific performance measure.

A third aspect of explanation is to capture cause and effect information. These cause and effect relationships are typically incorporated into the logic of the simulation and may not be easily inferred from a simulation log.

POSITIVE SPIN IN LESSON SEQUENCING

An ITS design goal is to keep the student constantly challenged, but not overwhelmed (Dweck, 2006; Clark, 2005) for the progression from novice to expert. As the student works through multiple scenarios, each scenario should be achievable given the student's current skill level, but should also challenge the student to achieve new skill levels. This requires a graduated level of difficulty for the lessons. We use four techniques to achieve this goal:

- Adjusting the complexity of the scenario
- Adjusting the extent of assessment
- Adjusting the level of free-play available to the student
- Adjusting the level of help available to the student as the scenario unfolds.

Adjusting the Complexity of the Scenario

One approach to adjusting the difficulty of a lesson is to adjust the complexity of the underlying scenario. As discussed above, we designed new prerequisite lessons for the FBCB2 ITS that were focused on a single subsystem. This approach is useful for remediation if the student is unfamiliar with a particular subsystem.

Another strategy is to shorten the scope of time for the lesson. We developed methods for generating initial conditions for scenarios by having an SME work with the simulation to achieve an appropriate initial condition. This initial condition was then referenced by a lesson manifest generated by the ITS. This approach allowed a student to start in the middle of a long procedure, thereby reducing frustration.

Adjusting the Extent of Assessment

One way of controlling the scope of the assessment is through the definition of the initial conditions of the scenario. In many cases, the scenario can be configured so that the student only needs to respond to a subset of the performance measures associated with the task. This difference is indicated in Figure 4, which shows that the Block Diagram lesson has one performance measure, whereas the Install lesson has six performance measures.

For the FBCB2 ITS, we looked at ways to provide more positive reinforcement for the most difficult lessons, namely the Install, Block Diagram, and Power-Up lessons. When we reviewed the session logs, we noticed that students were using the Block Diagram lesson as a way of preparing for the Install lesson. In a separate training session with the baseline simulation, we observed very high use of the Acquire mode Block Diagram lesson, as well as high numbers of attempts to successfully complete the Install lesson. Observation of the students indicated that they were switching between Install and Block Diagram lessons to learn how to solve subproblems in a simpler learning environment. As a result of these observations, we added new transition rules to the ITS between these related lessons.

Another design goal was to provide a sequence of scenarios with increasing levels of difficulty. This strategy ensures that there are successes to be reported as positive feedback early in the process. This data suggested a different sequence of lessons than the temporally logical sequence of Install, Operate, and then Maintain scenarios. As a result of the data, the ITS recommends that the Install scenarios be the last set of lessons attempted by the student.

Adjusting the Level of Free-Play

Differences between the Acquire mode and the Practice mode adjust the level of free-play. For example, in Acquire mode lessons, only one control may be active, which is the control necessary for the next step. During Acquire mode lessons, the student learns how to use the controls of the simulation and to observe a sequence of steps that will achieve the desired result.

Adjusting the Level of Help Available

Differences between the Practice mode and the Validate mode adjust the level of help available to the student. In the Practice mode, the student is given immediate feedback upon completing the requirements for a performance measure and is prevented from making irreversible errors (as well as being warned about such errors). During the Practice mode, the student has access to a help facility that tracks the steps needed to achieve success.

CONCLUSIONS

The ability of simulations to track details of student actions and simulation events in real-time gives the instructional designer many options for providing feedback to students. The challenge for implementing a good training system is reducing all the data down to the critical information needed by the student and in presenting that information in the most positive way possible.

One strategy for constructing interactive AARs is to hierarchically organize the data, summarize the results using roll-up rules, and then allow the student to drill down to detailed results. We compared four methods for organizing assessment data in different hierarchical structures, first in terms of their ability to help the student determine strengths and weaknesses, and then in their ability to provide a positive view.

Careful structuring and sequencing of the lessons in a course is important to ensure that positive and informative data is available for each AAR. The sequence of lessons in a course should provide a graduated level of difficulty as the student progresses from novice to expert.

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REFERENCES

Abell, M. (2000). Soldiers as distance learners: What army trainers need to know. *Proceedings of the 21st Interservice/Industry Training, Simulation and Education Conference,* Orlando, FL, pp. 609–620.

Clark, R. (2005). Guided Experiential Learning: Training Design and Evaluation. Presentation at a TRADOC Video Teleconference. Retrieved from http://www.knox.army.mil/center/qao/pdfs/GEL.ppt 21 August 2008.

Dargue, B., Morris, K., Smith, B., & Frank, G. (2006). Interfacing simulations with training content. *Proceedings of the NATO Modeling and Simulation Group Meeting*, *Rome, Italy*.

Dweck, C. (2006). *Mindset: The new psychology of success*. New York, NY: Ballantine Books.

Frank, G., Whiteford, B., Hubal, R., Sonker, P., Perkins, K., Arnold, P., Presley, T., Jones, R., & Meeds, H. (2004). Performance assessment for distributed learning using After Action Review reports generated by simulations. *Proceedings of the 26th Interservice/Industry Training, Simulation and Education Conference*. Orlando, FL, pp. 808–817.

Jensen, R., Nolan, M., Harmon, N, Caldwell, G. (2006). Visually Based Timeline Debrief Toolset for Team Training AAR. *Proceedings of the 28th Interservice/Industry Training, Simulation and Education Conference*. Orlando, FL.

Morrison, J.E., & Meliza, L.L. (1999). *Foundations of the after action review process* (IDA Document 2332). Alexandria, VA: Institute for Defense Analyses. (DTIC/NTIS AD-A368 651).

Nullmeyer, R., Golas, K., Logan, R, Spiker, V., Clemons, L. (2006). The Effectiveness of a PC-Based C-130 Crew Resource Management Aircrew Training Device. *Proceedings of the 28th Interservice/Industry Training, Simulation and Education Conference*. Orlando, FL.

Peat, M., Franklin, S., Devlin, M. & Charles, M. (2004). Revisiting associations between student performance outcomes and formative assessment opportunities: Is there any impact on student learning? *Beyond the comfort zone: Proceedings of the 21st ASCILITE Conference, Perth, Australia,* pp. 760–769.

Waters, H., McDowell, M., Krizowsky, P., Frank, G., Hubal, R., Page, C., & Tucker, P. (2008). Reusing simulation assets for qualification and sustainment training. To be published in the *Proceedings of the Interservice/Industry Training, Simulation and Education Conference*, Orlando FL.

Whiteford, B., Frank, G., Brown, R., Cooper, G., Evens, N., & Merino, K. (2003). Web-delivered simulations for lifelong learning. *Proceedings of the 25th Interservice/Industry Training, Simulation and Education Conference*, Orlando, FL, pp. 170–179.