Research Product 2001-03

Application of Cognitive Principles in Distributed Computer-Based Training

20010808 090

July 2001

Armored Forces Research Unit

U.S. Army Research Institute for the Behavioral and Social Sciences

U.S. Army Research Institute for the Behavioral and Social Sciences

A Directorate of the U.S. Total Army Personnel Command

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Research accomplished under contract
for the Department of the Army

Human Resources Research Organization

Technical Review by

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NOTICES

REPORT DOCUMENTATION PAGE

1. REPORT DATE (dd-mm-yy)	2. REPORT TYPE	3. DATES COVERED (from. . . to)
July 2001	Final	3 May 2000 – 2 May 2001

4. TITLE AND SUBTITLE Application of Cognitive Principles in Distributed Computer-Based Training	5a. CONTRACT OR GRANT NUMBER DASW01-99-D-0012 DO #8 5b. PROGRAM ELEMENT NUMBER 0602785A
6. AUTHOR(S) Richard C. Deatz and Charlotte H. Campbell (Human Resources Research Organization)	5c. PROJECT NUMBER A790 5d. TASK NUMBER 211 5e. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Human Resources Research Organization (HumRRO) 66 Canal Center Plaza, Suite 400 Alexandria, VA 22314	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army Research Institute for the Behavioral and Social Sciences ATTN: TAPC-ARI-IK 5001 Eisenhower Avenue Alexandria, VA 22333-5600	10. MONITOR ACRONYM ARI 11. MONITOR REPORT NUMBER Research Product 2001-03

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES
Contracting Officer's Representative: Bruce S. Sterling

14. ABSTRACT *(Maximum 200 words)*:

As the U.S. Army continues to develop more powerful and complex digital information systems, it is essential that both training needs and training opportunities are addressed to meet mission objectives. One way to address the training challenges of emerging digital systems is through the use of computer-based instruction (CBI), particularly because of the flexibility it offers in the way training can be delivered (e.g., embedded, distance learning, Internet). Another way is to improve learning by applying principles of cognitive psychology to the training design. This paper describes a research and development effort that incorporated a limited set of cognitive learning principles and techniques in the design of CBI for individual digital operator skills. To demonstrate the design features, four prototype training modules were developed for the Force XXI Battle Command Brigade and Below (FBCB2), the Army's vehicle-mounted digital system for distributing information to provide situational awareness. This paper describes how the selected instructional techniques and cognitive principles were used in distributed computer-based training. Pictures of screen layouts illustrate how the principles and techniques were instantiated in operator training for a digital system. Finally, this report provides a discussion of the lessons learned and issues for future research and development.

15. SUBJECT TERMS
Cognitive Principles   Computer-based Instruction   Distributed Training   Digital System Training
Cognitive Techniques   Prototype Training Module

SECURITY CLASSIFICATION OF			19. LIMITATION OF ABSTRACT	20. NUMBER OF PAGES	21. RESPONSIBLE PERSON (Name and Telephone Number)
16. REPORT	17. ABSTRACT	18. THIS PAGE			
Unclassified	Unclassified	Unclassified	Unlimited	31	Dr. Bruce S. Sterling DSN 464-2613

NSN 7540-01-280-5500   Standard Form 298

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Application of Cognitive Principles in Distributed Computer-Based Training

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July 2001

Army Project Number
20262785A790

Personnel Performance and Training Technology

FOREWORD

The Future Battlefield Conditions (FBC) Team of the Armored Forces Research Unit, U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) has a Science and Technology Objective (STO) entitled "Force XXI Training Strategies." This STO is also reflected in the FBC work package (2228) FASTTRAIN: Force XXI Training Methods and Strategies. The present research supports the objectives outlined in the statement of work (SOW) titled *Performance Evaluation, Training, and Future Requirements for Digital Skills*, Task 3: *Design, develop, and demonstrate prototype training techniques that incorporate principles of cognitive psychology and automated performance assessment and feedback* (ARI, 2000).

This report supports the goals of the SOW Task 3 research effort by developing prototype training modules that demonstrate principles of cognitive science that could be incorporated into Army training programs to enhance the acquisition, retention, and transfer of future (year 2012) digital command, control, communications, computers, and intelligence (C^4I) system commander and staff skills. The Task 3 work represents a logical extension and continuation of previous ARI skill retention research accomplished with the Army's Inter-Vehicular Information System (IVIS), where it was noted that a number of learning theory principles might be applied to modify training to enhance skill retention. The present work identifies opportunities to apply principles of cognitive science in developing prototype computer-based instructional modules for the Force XXI Battle Command Brigade and Below (FBCB2) digital information system.

The use of cognitive science principles in digital information system training design, as identified in this report, should be of value to training developers for a wide range of current and future systems. The prototype training modules clearly demonstrate the ease with which cognitive principles can be adopted in training, and their potential utility. The results of this research were briefed to representatives of the U.S. Army Armor School, Directorate of Training and Doctrine Development, and other Fort Knox agencies during an in-progress review on 1 February 2001.

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Technical Director

ACKNOWLEDGEMENTS

This report represents the efforts of an integrated team of research scientists, military experts, simulation technology experts, and administrative support personnel. In addition to the authors, team members directly involved with this effort include Mr. Mike Cobb of Human Resources Research Organization (HumRRO) and Mr. Neff Jenkins of Litton PRC, who provided military and digital system expertise. Providing administrative support was Ms. Kathleen Horn (Litton PRC) with Mr. William T. Holden, Jr. of HumRRO providing guidance as project manager.

Representing the U.S. Army Research Institute for the Behavioral and Social Sciences, Armored Forces Research Unit, Dr. Bruce Sterling, Contracting Officer's Representative, and Mr. William Sanders provided guidance and leadership throughout the project.

Additionally, technical support was provided by the following organizations and individuals:

- Mounted Maneuver Battlespace Lab (MMBL), Fort Knox, Kentucky

  Colonel Dennis J. Szydloski

- Lockheed Martin-Marietta

  Mr. Don Appler, Site Manager
  Mr. Paul Monday, Analyst
  Mr. Paul Colonna, Analyst

APPLICATION OF COGNITIVE PRINCIPLES IN DISTRIBUTED COMPUTER-BASED TRAINING

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INTRODUCTION

As the U.S. Army continues to develop more powerful and complex digital information systems, it is essential that both training needs and training opportunities are addressed to meet mission objectives. Initial training for operators, leaders, and staff members who use the information systems to conduct battlefield command and control is one training need. Equally important is the need for retraining those same individuals as highly technical information systems are periodically upgraded. These training needs present trainers and training developers with challenges such as keeping up with the software changes, delivering incremental training that highlights critical modifications, and providing support so that units can maintain and improve operational proficiency without incurring high training costs or extra wear and tear on those systems.

One way to address the challenges of emerging digital systems is through distributed training. Distributed training, as described in Brown (1991), is providing appropriate training and training support at the best location for effective training. Recent work in this area has focused on the use of computer-based instruction (CBI)[1], particularly because of the flexibility it offers in the way training can be delivered (e.g., embedded, distance learning, Internet). Additionally, the training potential of emerging systems includes not only technological capabilities, but also the ability to vary instructional methods and media to meet the cognitive demands of the learning tasks (Hooper & Hannafin, 1991). To improve learning, the application of principles of cognitive psychology to training design also can address the training challenges associated with new digital systems. By increasing the opportunities for distributed computer-based training that incorporates cognitive learning principles and techniques, it is expected that skill acquisition and retention can be improved.

Background

The U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) has initiated various research projects to address the training challenges associated with digitization. One such project, documented by Sanders (2001), proposes using specific cognitive learning principles and techniques as viable ways to improve training. The emphasis is on organizing and presenting information in ways that track with how learners learn – mirroring the way more complex information is received, stored, and retrieved by the mind. This approach could allow learners to acquire and retain digital system skills more readily and adapt as digital tasks evolve with system enhancements.

[1] Appendix A contains a complete list of the acronyms used in this report.

Purpose of the Research

As an outgrowth of Sanders' work, ARI initiated the present research focused on designing prototype training modules that incorporates cognitive learning principles and techniques in computer-delivered training. The primary goal was not to develop complete training modules, but to demonstrate the training design through the use of storyboards. The cognitive learning principles and techniques used in the design of the training modules are described in Table 1.

Table 1. Cognitive Principles and Techniques

Cognitive Principle or Technique	Description	Source
Learner control and learning styles	Active involvement by learners in the learning process and providing them a learning environment which best suits the way they acquire information	Ertmer & Newby (1993)
Hierarchical sequencing of information	The order in which information is presented, deliberately designed in terms of enabling and terminal skills	Ertmer & Newby (1993)
Realistic context	Training content delivered in a job-related context (how the learner will use the information), such as realistic examples, constructive or virtual simulations, or mission-based exercises	Means, Salas, Crandall, and Jacobs (1993); Cannon-Bowers, Salas, & Converse (1992)
Performance feedback and assessment	Learner performance-related information and evaluation provided for, and linked to, completed training tasks to help improve performance	Morrison & Meliza (1999)
Chunking	Organizing information for better comprehension and learning by ordering, classifying, or arranging	West, Farmer, & Wolff (1991)
Advance Organizer	New instructional content presented with explicit description of relationship to prior knowledge as an aid to comprehension	West, Farmer, & Wolff (1991); Ertmer & Newby (1993)
Metaphor	Analogies between the new instructional content and general background knowledge to improve comprehension	West, Farmer, & Wolff (1991)
Concept/Process Map	Graphical depiction of how concepts or processes are linked to aid comprehension	West, Farmer, & Wolff (1991)
Frames, Type 1	Matrix to contrast and compare information to aid recall	West, Farmer, & Wolff (1991)
Rehearsal	Active, repetitive use of instructional content to improve longer term recall	West, Farmer, & Wolff (1991)

Training Focus

The training focus was on the training of individual digital operator skills using the Force XXI Battle Command Brigade and Below (FBCB2) as the exemplar digital system. The FBCB2 is a key component of the Army Battle Command System (ABCS) and interfaces with the Army Tactical Command and Control System (ATCCS) at the battalion level. It comprises information technology equipment and software to visually display situational awareness (SA) information provided by weapon systems, sensors, and support platforms; prepare and distribute orders and graphics; and receive, develop, and distribute data based on a common battlefield picture. The FBCB2 supports SA down to the soldier/platform level across all battlefield functional areas and echelons. An FBCB2 screen is depicted in Figure 1.

The FBCB2 system is normally found in fighting vehicles, command vehicles, and command posts. For this effort, the audience was limited to a battalion battle staff.

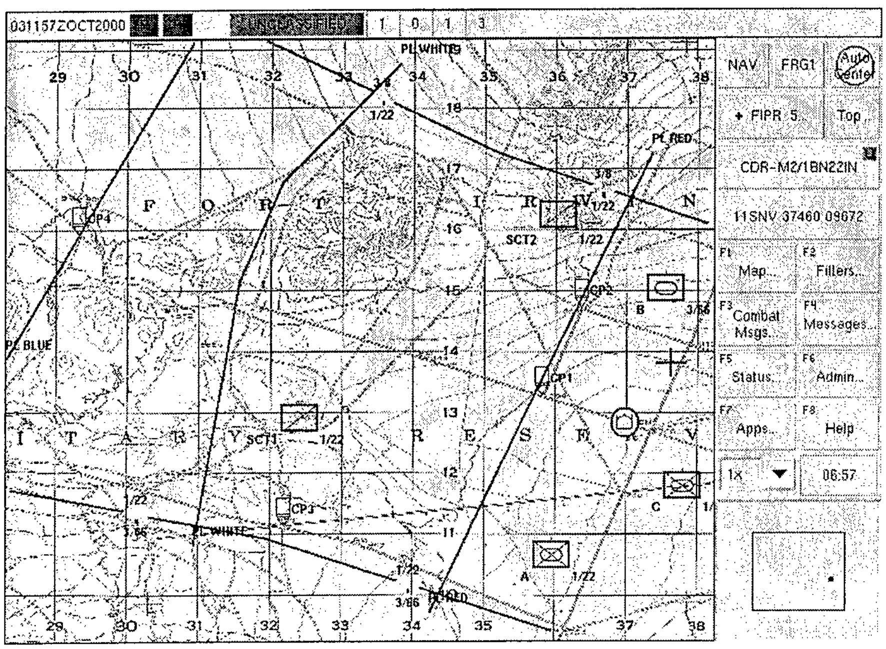


Figure 1. Force XXI Battle Command Brigade and Below system display picture.

Training Tasks

Instructional system design should begin with an in-depth analysis of the instructional content. However, since the focus of this project was on training design, the initial task analysis was used by the project team to select 4 of 10 possible FBCB2 tasks that would best demonstrate the design characteristics. The tasks were selected from the Army's Automated Systems Approach to Training (ASAT) database, a multi-user database that supports collective and individual task analysis along with Army publication and doctrine development. The selected ASAT tasks are identified in Table 2. It should be noted that after the task analysis, the task *Perform Information Management* was created as an alternative to the ASAT task of *Perform Message Management using FBCB2*. The original ASAT task was limited to processing E-mail messages and the project team felt it should be expanded to include related sub-tasks such as changing transmission settings and user groups. These sub-tasks not only apply to E-mail, but are also used to distribute overlays, reports, or orders.

An in-depth task analysis was conducted for each of the four FBCB2 tasks to identify the steps in the process. These task steps provided the training content to which the cognitive principles were applied. A copy of the task analysis was provided to the proponent (Armor) school Directorate of Training and Doctrine Development. A sample of the task analysis for *Reports* can be found in Appendix B.

Table 2. Force XXI Battle Command Brigade and Below Task List

Task Title	Abbreviated Task Title[a]
Perform Information Management[b]	Information Management
Prepare/Send Overlays using FBCB2	Overlays
Prepare/Send Reports using FBCB2	Reports
Prepare/Send Order/Request Messages using FBCB2	Orders

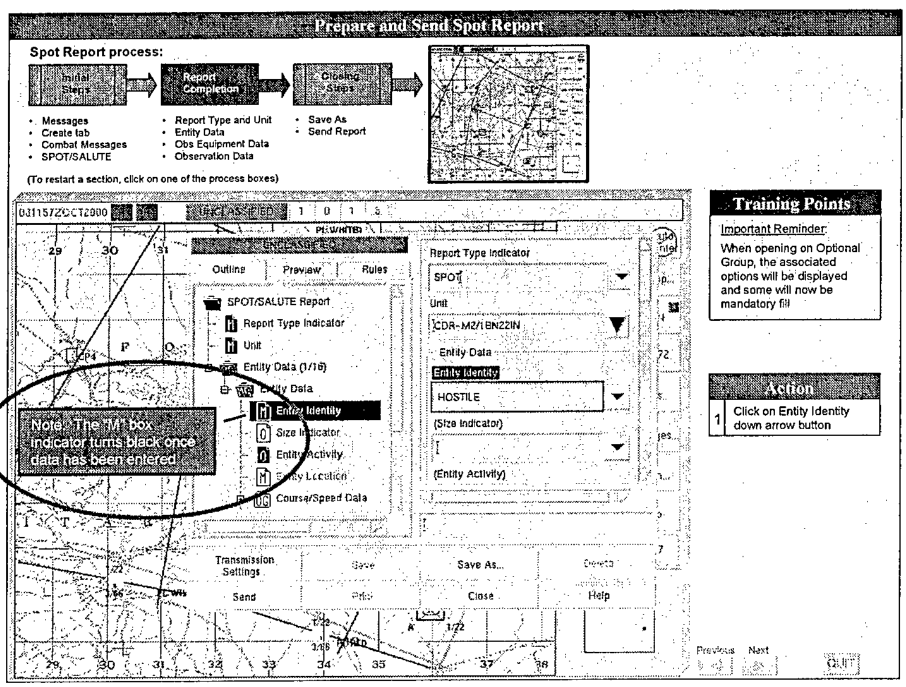
Note. FBCB2 = Force XXI Battle Command Brigade and Below.
[a]Abbreviated titles are used in the text for convenience.
[b]The task was originally the Automated Systems Approach to Training task, *Perform Message Management using FBCB2*.

PROTOTYPE TRAINING MODULES

Each training module was designed to train one FBCB2 task. Upon selecting a training module, the learner is presented with an introduction to the instructional content followed by a video and audio demonstration of the task. At the end of each section of the interactive training, a review of the material is provided in addition to a multiple-choice quiz. When all sections of the module have been completed, the learner is directed to a scenario-based practice exercise.

The training module screen displays combined digitally-captured FBCB2 screen pictures with a text-based description of how each task step is performed and supporting information that explains why or how system information is used to complete the FBCB2 task. The training module screen layouts were constructed in a Microsoft® PowerPoint® presentation graphics program as a way to storyboard the design characteristics. An example of a screen layout for a training module is shown in Figure 2.

The supporting text is displayed in Training Points boxes and in callout boxes that are timed to "fly in" and stop beside a particular screen attribute (refer again to Figure 2). By following the prompts in the Action box for the next step in the training and reading the supporting information as it appears on the screen, the learner is effectively participating in CBI for the FBCB2 system.



Note. Circled area highlights a callout box.

Figure 2. Prototype training module screen layout for the task *Reports* (Spot Report).

Demonstration of Cognitive Learning Principles and Techniques

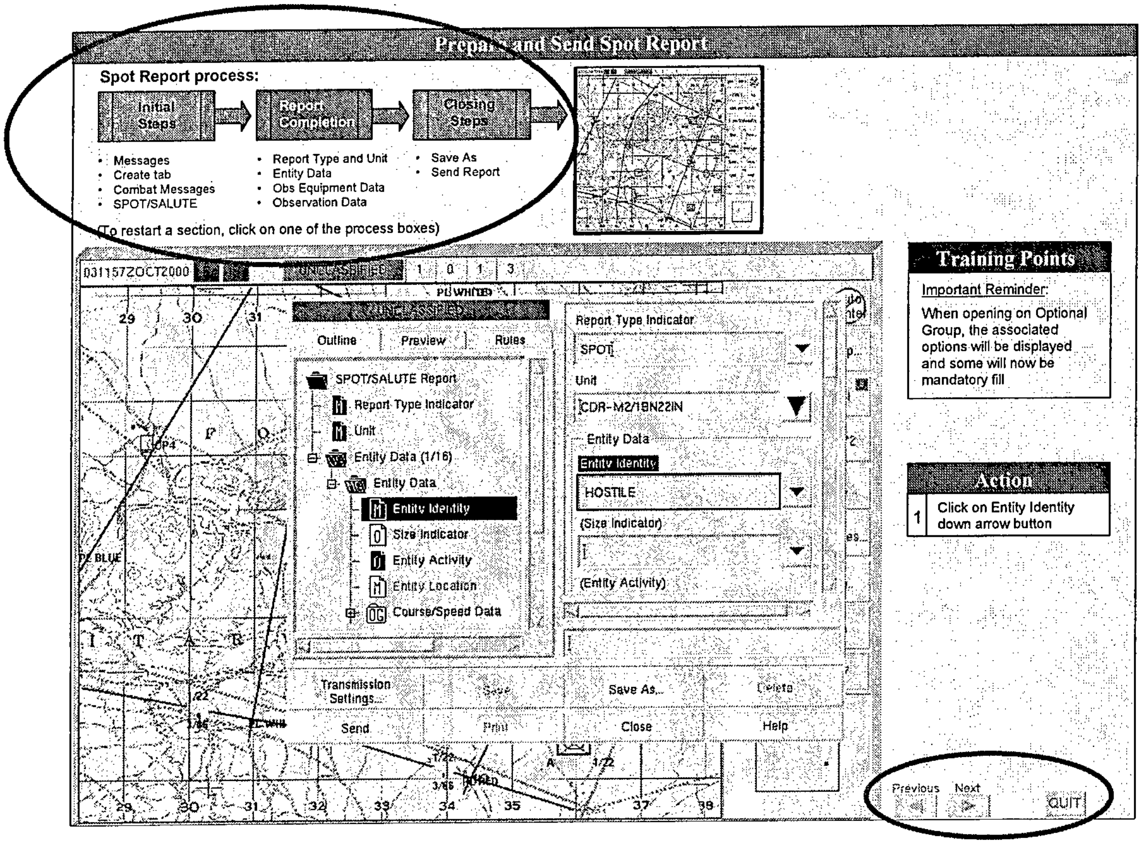
The remainder of this section provides descriptions and examples of how the cognitive learning principles and techniques were used in the prototype training module design. Although each principle or technique is discussed separately, the reader should not infer that they can or should be used separately. Often the power of the principles or techniques is amplified when they are combined (West, Farmer, & Wolff, 1991).

Where appropriate, the principles and techniques are illustrated in a figure by using a training screen picture. To highlight a training technique being discussed, a circle may be drawn around the particular feature.

Learner control and learning styles

The learner control principle is incorporated into the training design by providing learners the ability to move freely throughout the training program and modules. From the main menu screen, the learners may select the desired training module or practice exercise. They are able to either move to a specific section of a module (using process boxes at the top left portion of the screen) or page forward or back (using the "previous" or "next" button at the bottom of the screen) as shown in Figure 3. They can escape from the training module at any point by clicking the "quit" button.

To address a variety of potential learning styles, information is presented in three ways. First, the learner watches the task performed (albeit at a rapid pace) through the use of a video and audio demonstration prior to the start of each training module. Second, the learner begins to interact with the system by following the step-by-step procedures for completing the task. Third, the learner can train, with minimal guidance, using the practice exercise developed for each task.



Note. Circled areas highlight learner control.

Figure 3. Example of use of learner control in the prototype demonstration.

Hierarchical sequencing of information

The in-depth analysis of the FBCB2 tasks surfaced information and processes that suggested an order to the instructional content. Although some learning could occur by reading the description of each button's functionality, the buttons do not necessarily work independently. Those relationships between button functions would be found only through trial and error if not described or shown to the learners.

A sequence prescribed by the training design is imposed throughout the training modules. For example, the procedures for establishing the desired SA screen display attributes (e.g., unit icons, terrain features, area of operation) are presented prior to the training on the *Overlays*, *Reports*, or *Orders* task. The users must first customize the SA screen display to provide the information applicable to their role in order to perform the other tasks (*Overlays*, *Reports*, or *Orders*).

Realistic context

To ensure an accurate understanding of how a digital system will impact mission execution, it is important to provide instruction using real-life examples and situations. Gaining an acceptable understanding of the instructional content may not occur if learners are allowed to practice with a system without guidance or job context (Cannon-Bowers, Salas, & Converse, 1992).

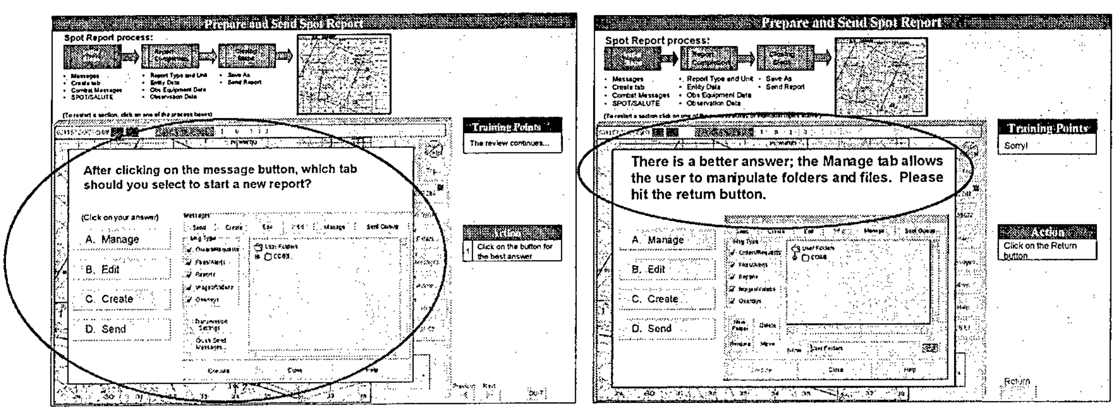
The use of this principle varied in several ways within the training design. First, the design incorporates actual FBCB2 screen pictures so the learner becomes familiar and comfortable with the location of information in preparation for using the FBCB2 system. Additionally, the scenario used in the practice exercises provides the learner an opportunity to analyze information while using the system, as they would when conducting a mission exercise.

Performance assessment and feedback

Performance assessment and feedback are critical aspects of training. In a summary of the performance feedback literature, Throne et al. (1999) stated "…research on the learning styles and knowledge structures of experts suggests that feedback, which helps the learner to analyze and categorize an experience, will result in more long-lasting performance improvement" (p. 17).

The use of performance assessment and feedback is demonstrated in the training design in several ways. First, feedback is provided for each menu navigation action made by the learner. Correct actions cause the screen to change so that the learner can progress to the next task step. Incorrect actions fail to bring a response from the system. In this way the training provides immediate feedback in response to learner actions.

Second, at the end of each section of instruction within a module, the learners are presented with a review and test question. Learners click on the button for the selected answer, as shown in Figure 4, picture A. If the answer is correct (in this example it is *Edit*), they are advised of the correct answer and are directed to advance to the next section of training. If an incorrect answer is selected (in this example *Manage,* as in picture B), learners are advised that a better choice is available and additional information regarding the answer they selected is provided. They are instructed to make another selection by clicking on the return button. This sequence is repeated until the correct answer has been selected.



A. Training module quiz page

B. Training Module incorrect answer example

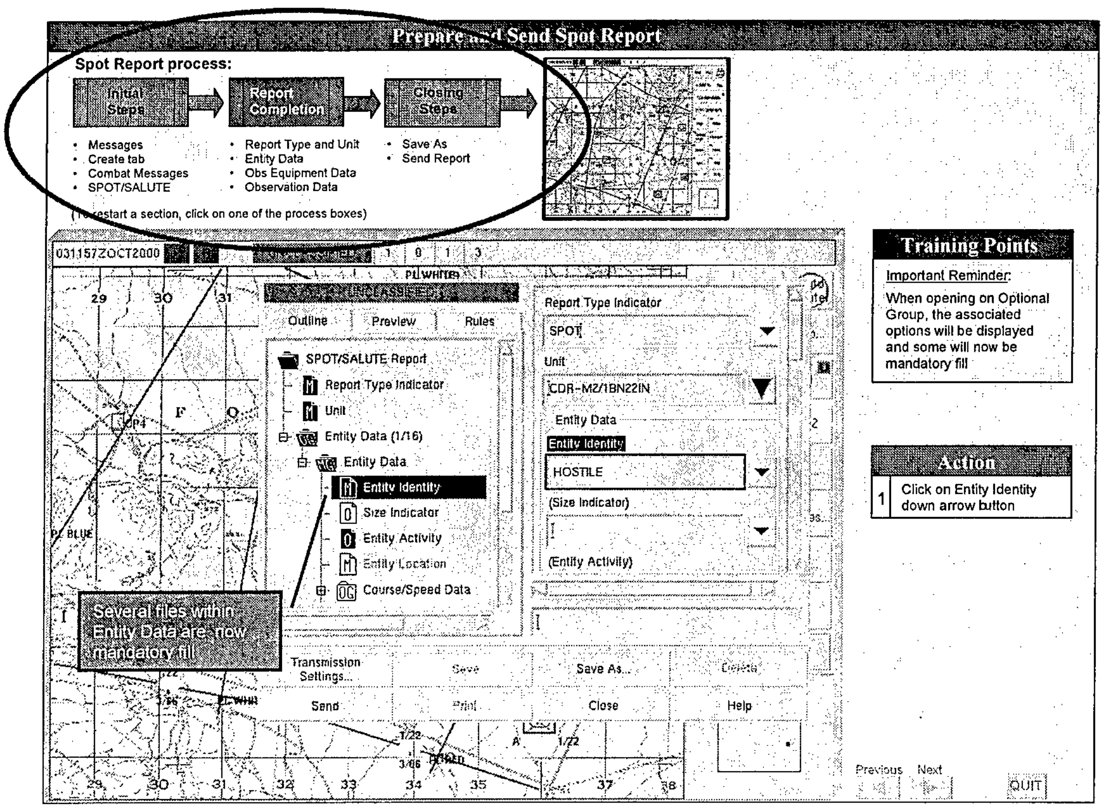
Note. Circled area highlights performance assessment screen attributes.

Figure 4. Examples of performance assessment and feedback in the prototype demonstration.

Chunking

Information chunking is the structuring of information using spatial or linear segments such as time and procedure, or classification segments such as taxonomies and sorting. One way chunking was used in the training modules, as shown in Figure 5, was to organize the FBCB2 task steps into three stages: the initial steps (how to get to the desired system screen), task completion (how to use the system to complete the task), and closing steps (what to do when the task is completed). This information is displayed at the top of the screen so learners can easily track their progress throughout training.

Another use of chunking is found in the training reviews at the end of each section of instruction. The numerous steps required for completing an FBCB2 task were grouped based on common output characteristics (e.g., observer location information, enemy data). These groupings provide learners with an organizing strategy that can aid retention. Additionally, the groupings are designed to closely resemble the way staff members would execute the task in their current non-digital operational environment.



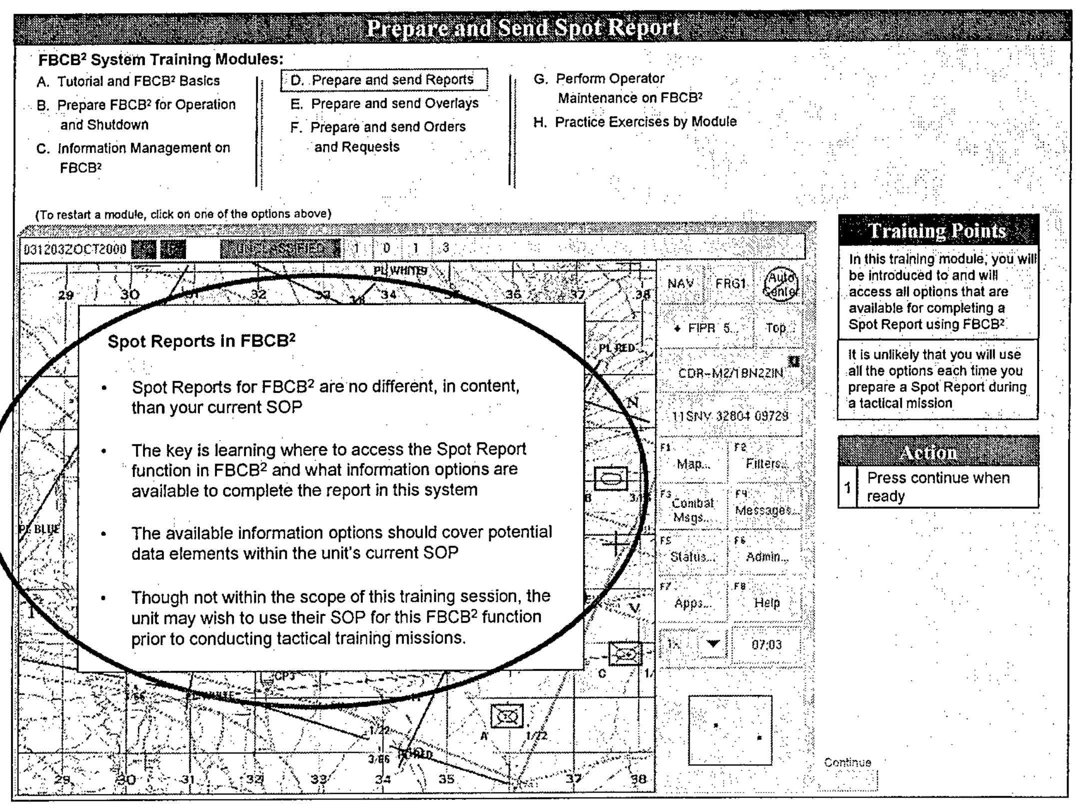
Note. Circled area highlights chunking.

Figure 5. Example of use of chunking in the prototype demonstration.

Advance organizer

Advance organizers provide an initial structure for new information that allows learners to organize and retain the instructional content. The advance organizer has a specific use by being presented just prior to the beginning of new instructional content. It is usually based on relevant concepts that are already established in the learner's mind and these concepts are used as part of the organizing framework.

In the example shown in Figure 6, the advance organizer is displayed at the start of the training module and points out that what the learner already knows about sending Spot Reports will also apply when using the FBCB2 system. What does change is the way the information is gathered and how it is used to create a Spot Report. The information within the text box (Figure 6) appears as bullets that are displayed sequentially, allowing time to read each bullet before the next one appears.



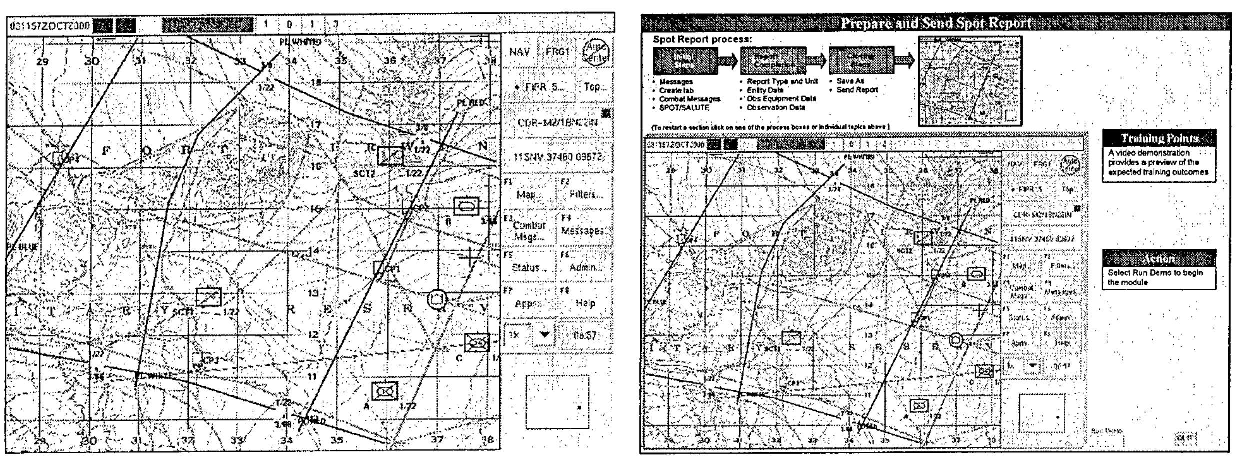
Note. Circled area highlights advance organizer.

Figure 6. Example of advance organizer presentation in the prototype demonstration.

Metaphor

This cognitive technique is like the advance organizer, bridging prior knowledge and new knowledge by emphasizing the similarities between them. Metaphor, however, is often based upon general knowledge and lacks the specific detail relevant to technical content found in the advance organizer.

Metaphor was used as the basis for the training screen layout. The FBCB2 system uses a map or SA display in the lower left corner of the monitor. Information is provided above the display with the available system function buttons to the right. The training module has employed a similar screen layout, as seen in the FBCB2 screen layout comparison in Figure 7. The FBCB2 screen picture is positioned in the lower left corner with supporting information above. The "Action" box to the right provides the cues for the next step to be taken during training while the "Training Points" box provides reasons why the action is required, how the system will respond, or other options available to the learner. With this screen layout, the learner becomes accustomed to viewing the system display to the left and looking to the right for the available actions.



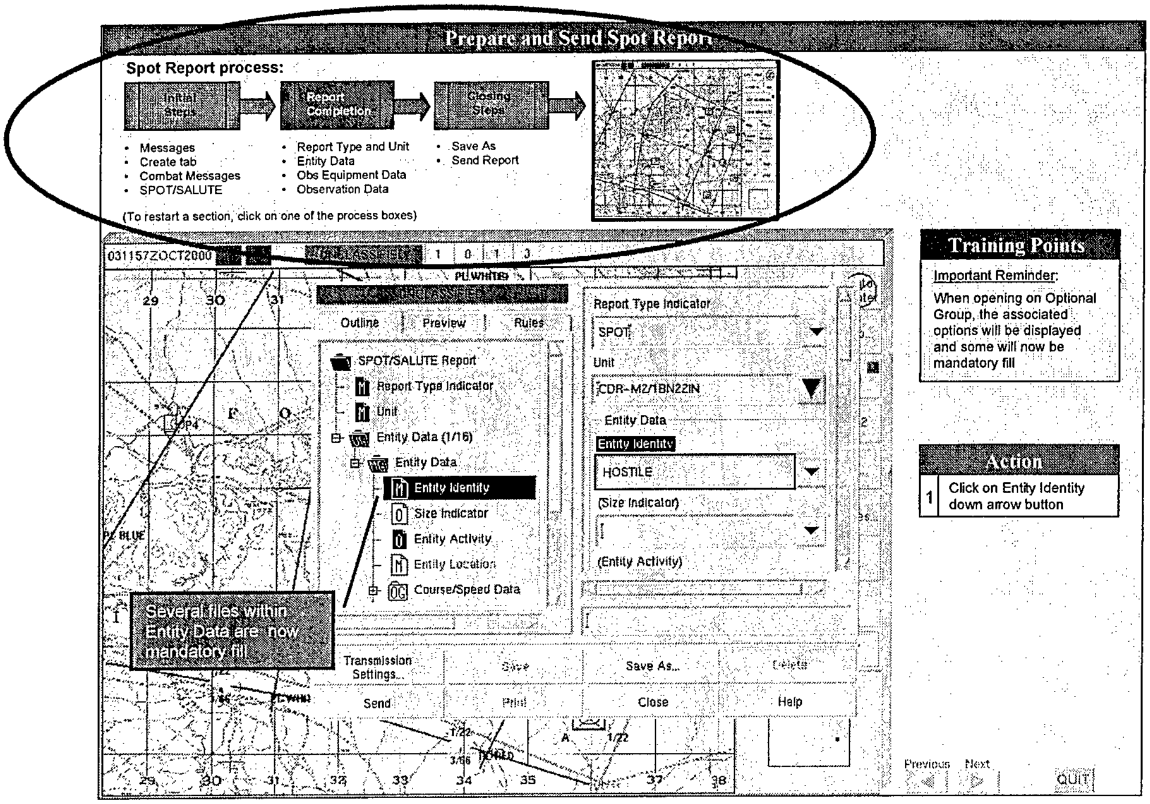
FBCB2 system

Prototype training module

Figure 7. Depiction of use of metaphor, showing comparison between Force XXI Battle Command Brigade and Below (FBCB2) system screen and prototype training module screen.

Concept/process map The concept or process map technique places information in a visual array, such as a chain map, spider map, or hierarchy map. Chunking is a prerequisite to developing a concept map (West et al., 1991).

In this training module, Figure 8 shows the technique (a chain map) being used to provide the learner with an overview of the entire process. It is displayed across the top of the screen through each step of training. As learners advance through the stages of the training module, the appropriate process box is highlighted with a solid color. The learner is provided a small picture of the expected outcome of the training next to the process map.



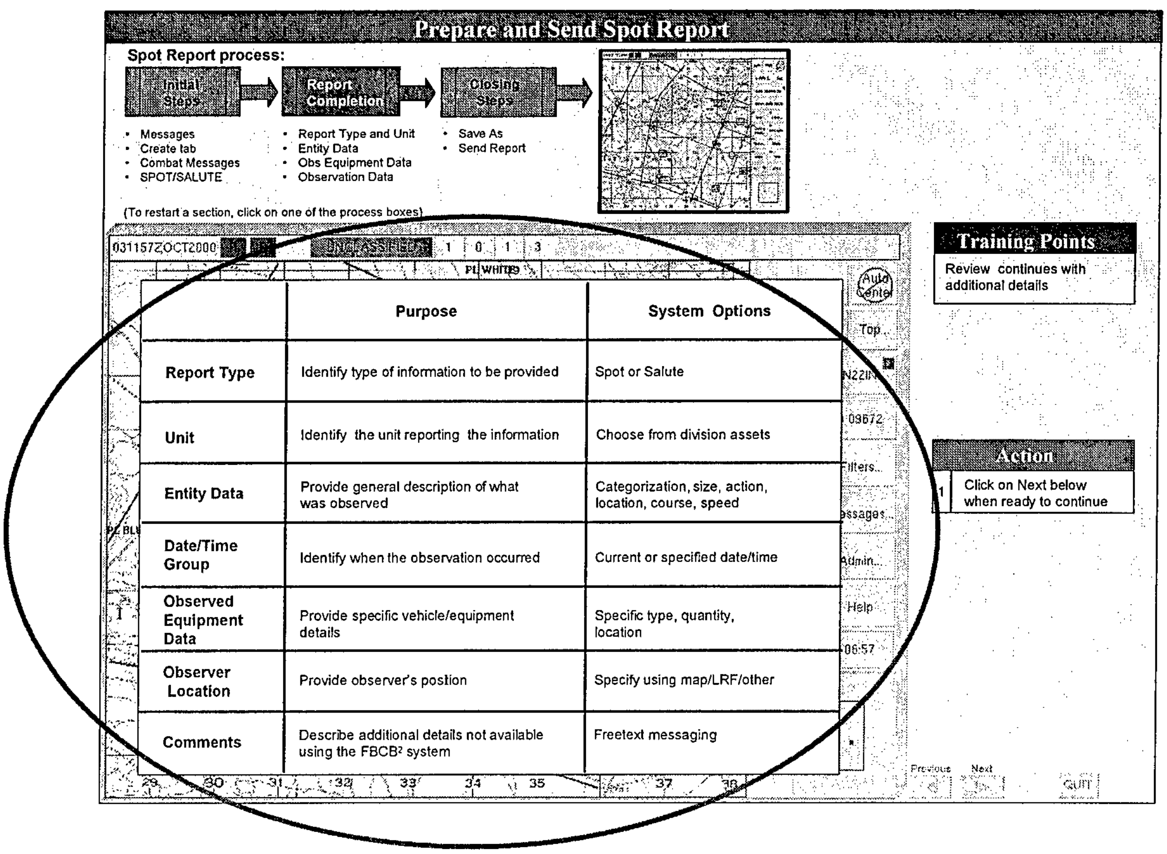
Note. Circled area highlights concept/process map

Figure 8. Example of use of concept/process map in the prototype demonstration.

Frames, type 1

The frames, type 1 matrix provides a visual array of the relationships between main ideas, like the concept/process map. The technique was used in the prototype to indicate the relationship between the various steps in the execution of an FBCB2 task.

In the example shown in Figure 9, the task is *Prepare/Send Reports using FBCB2* (in this case, a Spot Report). Although the Spot Report process is not especially difficult using FBCB2, it does involve numerous steps, making it awkward to remember. Those steps were reduced into seven general groups using chunking and were entered into the first column of the matrix. The purpose column describes or defines the general groupings followed by the third column providing the more detailed system options for each group. The key is to understand and recall what can be accomplished using the particular system function, not necessarily to recall each detailed step, since the system prompts the user with that information.



Note. Circled area highlights frames, type 1

Figure 9. Example of frames, type 1 matrix in the prototype demonstration.

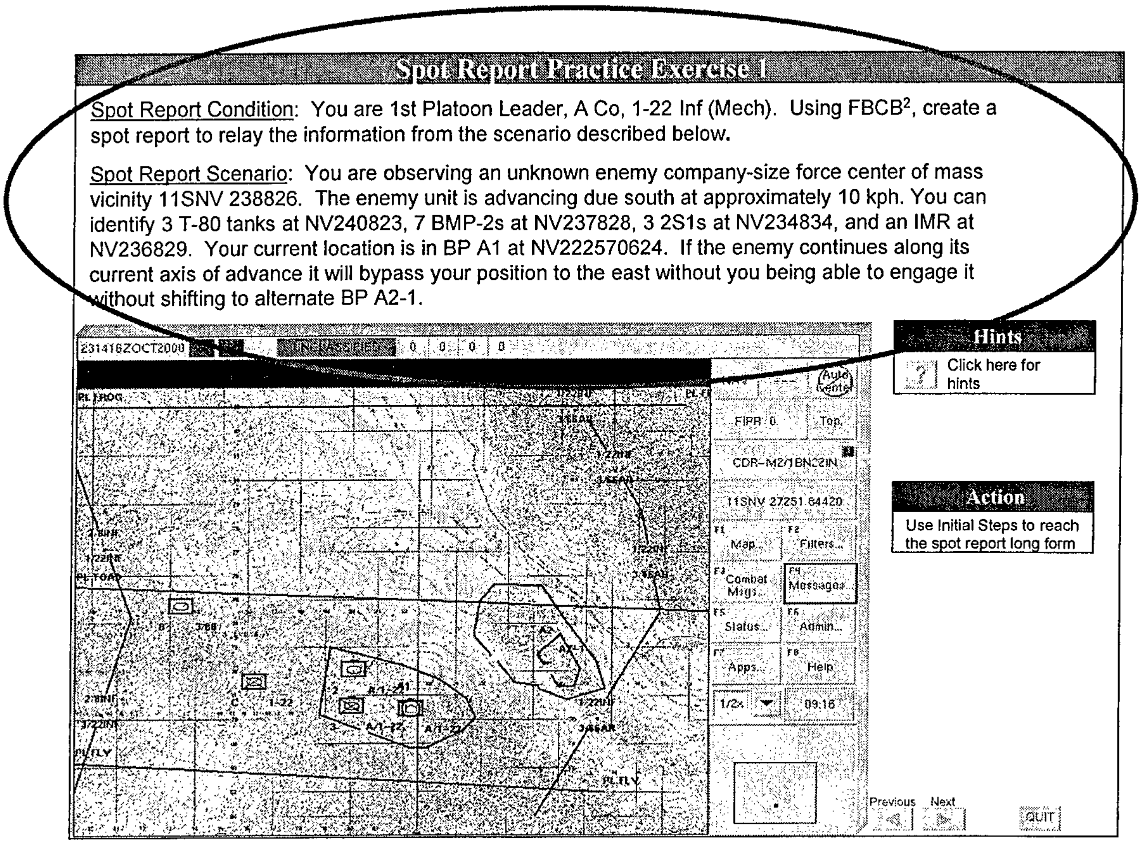
In this example, the frames technique was used as a review tool, summarizing the instructional content at the end of each stage of the training module. The rows of the matrix appear sequentially so the learner gradually receives the information. In addition to being used for review, the matrix is also used as a preview tool at the start of a practice exercise.

Rehearsal

Rehearsal is the repetitive use of instructional content and can take many different forms, such as note-taking, questioning, or paraphrasing in addition to the more common practice exercise. West et al. (1991) stated that rehearsal can also include repeated presentation or exposure to new material for it to be more deeply ingrained for long-term recall.

This technique appears in the training module as a practice exercise. The practice exercise is based on a tactical situation that requires users to analyze a situation and perform an FBCB2 task based on that analysis. In the example in Figure 10 the task is *Prepare/Send Reports using FBCB2* (specifically, a Spot Report). The scenario, circled in the figure, is displayed across the top portion of the screen as a reference throughout the exercise. Instead of providing the next step in the process, the “Action” box now references the stage (from the training module’s process map) of the process in which the step is found. There is also a “Hints” link, developed for the training module, should the learner need help with the process steps. By clicking on that link, learners can review a matrix containing the process steps to refresh their memory.

In addition to practice exercises, the rehearsal technique is used within each module by introducing the information several times and in several ways. When starting a training module, the learner first receives information through the video and audio demonstration of the task. The second time is in the step by step instruction, along with a summary of the information appearing in the process map at the top of the screen. Finally, the material is also summarized in the review at the end of each section of instruction.



Note. Circled area highlights the practice exercise scenario.

Figure 10. Example of rehearsal, using a practice exercise, in the prototype demonstration.

SUMMARY

The prototype training modules were designed to demonstrate the use of cognitive learning principles and techniques in distributed computer-based training. While the most highly developed training module, *Reports* (Spot Report), involves a sequence of steps reinforced by mandatory fields, this training method could also apply to more complex leader tasks as demonstrated by the less complete module, *Perform Information Management*. This approach was taken to address the training challenges of providing adequate and timely training for the Army's emerging digital systems. It is expected that digital skill acquisition and retention can be improved by leveraging the flexibility of delivering training through CBI with cognitive learning principles and techniques.

A formal evaluation was not required for this project. However, the project team members and ARI personnel conducted several informal design trials. Additionally, with the evolution of the prototype training module from a storyboard presentation to an emulated and functional training product, the project team had an opportunity to expand the design trials to include soldiers. Several soldiers, of varying rank and FBCB2 experience, reviewed the training modules and provided feedback for design revisions.

The experiences and comments from the project team members, ARI personnel, and soldiers have provided the basis for the lessons learned. The lessons learned are followed by a discussion of future considerations.

Lessons Learned

Several important points concerning the development, use, and delivery of digital systems training should be made. The first is that CBI can be developed with commonly used presentation software (e.g., Microsoft® PowerPoint®) as a "low cost" alternative or supplement to embedded training on tactical equipment. Although PowerPoint® may not be the optimum system for interactive training development, other, more powerful systems are less readily available in the field and require more expertise and time to develop and modify. As the project's storyboard presentation evolved, more capabilities were added so that it realistically emulated FBCB2 system functionality that was delivered through CBI. In support of this product, comments received from soldiers indicated they felt they received good training, and at times, forgot they were using an emulated FBCB2 system. Additionally, changes to the training would not require specific multimedia software expertise, allowing trainers who are familiar with slide presentation software to be able to update the modules.

Secondly, it appears the training design techniques would apply to fully or appended embedded training as well. On board systems or surrogate "White Box" systems, equipped with the objective embedded training capability, can provide the soldier with full system capability with current software already on the system. Although the training modules were demonstrated on a personal computer using a CD-ROM, the characteristics of the design (i.e., cognitive learning principles and techniques) do not limit development to that medium alone. In addition to being delivered through the Internet, the design attributes would work using an array of computer software and hardware, whether they are located in a vehicle or in the learner's office or home.

Another lesson learned is that it is difficult, if not impossible, to keep training current when emerging digital systems release updated versions several times a year. These system changes, like altering or streamlining the steps to complete a particular task, are often time consuming and expensive to update and distribute as revised training programs or manuals. Developing training using a "low-cost" method, as suggested in the first lesson learned, allows local trainers to quickly update the training package as system updates are fielded. Combining that approach with a sound computer-based design that is easily distributed (e.g., Internet) may offer a way to meet the soldier's training needs while these emerging systems mature and fully embedded training programs are developed.

Finally, CBI for digital systems, particularly using common slide presentation software, offers great flexibility as to the environments in which the training can be utilized. There are few limiting factors for this type of training due to unique equipment or software requirements. Additionally, the training programs are highly transportable through the Internet or CD-ROM.

Future Considerations

There are several future considerations that focus on training design evaluation, collective training, performance assessment and feedback, training management, and training development. The first, and most important consideration, is the need to evaluate the effectiveness of this training design. Although prior research has indicated that the use of cognitive principles may improve learning, the retention of skills acquired using the prototype training modules was not formally evaluated during this project. It is important that formal trials be conducted to gather data regarding the effectiveness of the training design.

The second consideration refers to the need to investigate ways to link users together, after completing individual training, in order to conduct collective, scenario-based practice exercises. Although this project focused on individual digital system skills training, it is difficult to escape the need for soldiers to be able to train collectively. This is becoming even more important with the advent of a lighter, faster digital army. Future efforts should determine if there are ways to allow learners using stand-alone CBI programs to connect together, perhaps through the Internet, to conduct a scenario-based practice exercise as a team.

Automated performance assessment and feedback continues to be a topic that spurs new research. The emerging digital command, control, communications, computers, and intelligence (C^4I) systems have unrealized potential to collect data automatically, and that feature is becoming more integral to the performance of individual and collective skills (Throne, Holden, & Lickteig, 2000). Particularly for CBI, without an instructor present, maximizing automated performance feedback is essential. Research efforts should continue to find new opportunities for more extensive feedback to the learner.

When designing CBI, consideration should be given to include a mechanism that can track a learner's progress through the training program and report that information to a training management database. Army units experience continual changes in personnel for a myriad of reasons. Ensuring that everyone is up-to-date with individual training requirements for various digital systems is a difficult process, particularly when it involves large numbers of soldiers. This CBI feature should be able to report information such as which training modules an individual has successfully completed and when that training last occurred. The training management database could use that information to provide customized reports as an aid for scheduling initial and sustainment training.

Another future consideration is to continue to look for ways to develop functional, yet inexpensive, CBI. A lesson learned in this project was that the use of a slide presentation software provided a potentially viable way to provide CBI. Although this approach has limitations in matching the sophistication of complex digital software programs with regard to user flexibility or free-play, it could be successful when the digital system training is highly structured. Further work in this area may find other simple, commonly used and easily updated software to provide the learner greater training flexibility.

Conclusion

The U.S. Army continually looks to identify what the future holds, in order to lay the groundwork required for successful operations. To this end, work is being conducted to develop new and more efficient digital systems, in addition to finding ways to improve the training needed to support those systems. Distributed training, based on solid design principles, can provide the soldier with the skills and knowledge to meet the challenges associated with emerging digital systems.

References

Brown, F. J. (1991). *A simulation-based intensified training readiness strategy for the reserve component* (IDA Paper P-2611). Alexandria, VA: Institute for Defense Analysis.

Cannon-Bowers, J. A., Salas, E., & Converse, S. (1992). Shared mental models in expert team decision making. In H. J. Castellan, Jr. (Ed.), *Current issues in individual and group decision making* (pp. 221-246). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Ertmer, A. P., & Newby, J. T. (1993). Behaviorism, cognitivism, contructivism: Comparing critical features from an instructional design perspective. *Performance Improvement Quarterly, 6* (4), 50-72.

Hooper, M. J., & Hannafin, S. (1991). Psychological perspectives on emerging instructional technologies: A critical analysis. *Educational Technology Research and Development, 26* (1), 69-95.

Means, B., Salas, E., Crandall, B., & Jacobs, T. O. (1993). Training decision makers for the real world. In G. A. Klien, J. Orasnu, R. Calderwood, & C. E. Zsambok (Eds.), *Decision making in action: Models and methods* (pp. 306-326). Norwood, NJ: Ablex Publishing Corporation.

Morrison, J. E., & Meliza, L. L. (1999). *Foundations for the after action review process* (ARI Special Report 42). Alexandria, VA: U. S. Army Research Institute for the Behavioral and Social Sciences.

Sanders, W. R. (2001). *Cognitive psychology principles for digital systems training* (ARI Research Report 1773). Alexandria, VA: U. S. Army Research Institute for the Behavioral and Social Sciences.

Throne, M. H., Deatz, R. C., Holden, W. T., Campbell, C. H., Sterling, B. S., & Lickteig, C. W. (1999). *Prototype staff training and evaluation methods for future forces* (ARI Research Report 1745). Alexandria, VA: U. S. Army Research Institute for the Behavioral and Social Sciences.

Throne, M. H., Holden, W. T., & Lickteig C. W. (2000). *Refinement of prototype staff evaluation methods for future forces: A focus on automated measures* (ARI Research Report 1764). Alexandria, VA: U. S. Army Research Institute for the Behavioral and Social Sciences.

U.S. Army Research Institute for the Behavioral and Social Sciences. (2000). *Performance Evaluation, Training, and Future Requirements for Digital Skills*, Task 3: *Design, develop, and demonstrate prototype training techniques that incorporate principles of cognitive psychology and automated performance assessment and feedback* (Statement of Work). Alexandria, VA: Author

West, C. K., Farmer, J. A., & Wolff, P. M. (1991). *Instructional design implications from cognitive science*. Needham Heights, MA: Allyn and Bacon.

Appendix A

Acronym List

ABCS	Army Battle Command System
ARI	U.S. Army Research Institute for the Behavioral and Social Sciences
ASAT	Automated Systems Approach to Training
ATCCS	Army Tactical Command and Control System
C^4I	command, control, communications, computers, and intelligence
CBI	computer-based instruction
FASTTRAIN	Force XXI Training Methods and Strategies
FBC	future battlefield conditions
FBCB2	Force XXI Battle Command Brigade and Below
HumRRO	Human Resources Research Organization
IVIS	Inter-Vehicular Information System
MMBL	Mounted Maneuver Battlespace Lab
SA	situational awareness
SOW	statement of work
STO	Science and Technology Objective

Appendix B

FBCB2 Task Analysis Sample

This appendix provides a sample of the task analysis worksheet (first two pages) used to identify the process steps of the FBCB2 task, *Prepare and Send Reports using FBCB2*. A worksheet was completed for each of the four FBCB2 tasks used to demonstrate the training design.

Task to Step Analysis

Training Program	**Function**	**Task #**	**Audience**
Prototype		171-145-0008	
Task Name: Prepare and Send Reports using FBCB2			

Step	**Action**	**Additional Information**
1	Select MESSAGES from the function bar or F4 on the keyboard.	<u>Notes</u>. 1. The virtual keyboard, when activated, may be used with either an operating touch screen or a mouse.
2	Select the CREATE tab.	
3	Select the REPORTS radio button.	The display box lists 21 different report options: Airborne Artillery FCR, Bridge Report, Chemical Downwind Report, Contact Report, Effective Downwind Message, Engagement Report, Free Text Message, Log Report, Land Minefield Laying Report, Land Route Report, Medical SITREP, Mortuary Affairs, NBC 1 Report, NBC 3 Report, NBC 4 Report, Obstacle Report, Personnel Report, Position Report, Situation Report, Spot Report, and Supply Point Status Report. The reports are in alphabetical order. <u>Note</u>. You must set your default settings for each type message before that message may be sent.
4	Prepare a report/message.	Determine the report or message request to create. Highlight the desire report or message request template in the display box. The Report/Message Toolbox is displayed. <u>Notes</u>. There are three tabs in the toolbox (except for the FREE TEXT MESSAGE). 1. Outline: displays the order template. 2. Preview: displays the prepared order for review. This tab can be selected at any point during orders production to review what has been entered to date. 3. Rules: no function as of yet – it does nothing. After you highlight the desired report or message request, select the EXECUTE button to display the desired order/request temple.
4a	Highlight Free Text Message.	The Free Text Message is used to provide information that doesn't fall into a structured message format.
4a.1	Select the EXECUTE button.	This displays the Free Text Dialogue Box. <u>Notes</u>. 1. There is no mandatory field. 2. The cursor appears automatically within the text box.
4a.2	Enter message.	Either the standard or virtual keyboards may be used to enter the message. To use the virtual keyboard to enter data, select the VIRTUAL KEYBOARD button below the text box. <u>Note</u>. Message content is limited to 1200 alpha numeric characters.